Submission to An Coimisiún Pleanála

TIRAWLEY WIND FARM

ACP CASE REFERENCE: PAX16.324258

24TH JUNE 2026

Prepared and submitted by ;

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AN COIMISIÚN PLEANÁLA
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24 JUN 2026
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"Parties should, when taking action to address climate change, respect, promote and consider their respective obligations on human rights, the right to health, the rights of indigenous peoples, local communities, migrants, children, persons with disabilities and people in vulnerable situations and the right to development, as well as gender equality, empowerment of women and intergenerational equity"

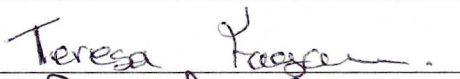
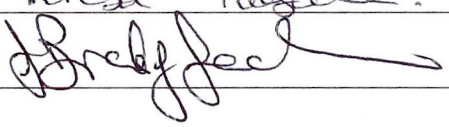
(UNFCCC, Paris Agreement 2015)

As part of the planning and environmental assessment process it is acknowledged that the use of such phrases as "noise-sensitive receptor", "Residential amenity" and "vulnerable receptor".

We want to make the board fully aware that when the term "receptor" is used, this is our community members home, it is there safe place, it is where they are "entitled to the peaceful enjoyment of his possessions" (European Convention on Human Rights (ECHR) Article 1, Protocol on the Convention). The application documents at no stage use the terms "individuals", "Family" or "homes", this is a common theme thought the application, whereby the applicant have completely dismissed the community of Lacken and its population of over 500 people. This is alarming when we consider that the UNFCCC, Paris Agreement 2015 on which a project such as this are portrayed as for the being for the betterment of human health and wellbeing, yet this applicant has given no consideration to the cumulative negative effect that our community faces from this development and similar all within a 10-20km radius.

For the avoidance of confusion only our submission will use the terms as per the applicants documents, but we remind the board that this community is made up of homes and families who will be irreversibly negatively impacted by the proposed development.

Signature page

Teresa Fagan	
Jackie Brady Jackson	
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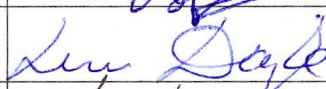
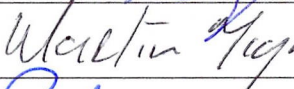
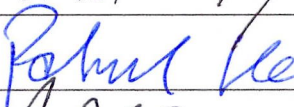
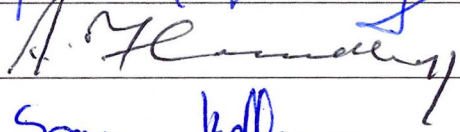
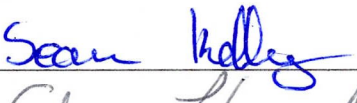
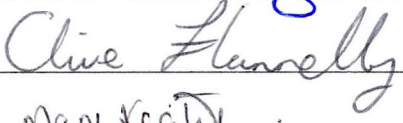
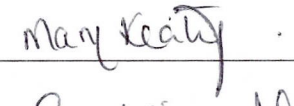
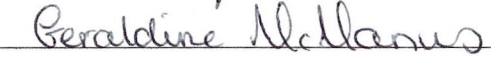
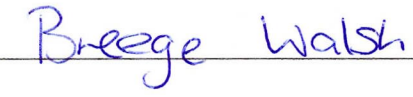
Liam Donoghue	
Martin Tighe	
Patrick Kearney	
Aiden Flannelly	
Sean Kelly	
Clive Flannelly	
Mary Keating	
Geraldine McManus	
Breege Walsh	

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INTRODUCTION

The Lacken Ballycastle Community Landscape Protection Group respectfully submits this objection to An Coimisiún Pleanála in relation to the proposed Tirawley Wind Farm development by Constant Energy Limited (Planning Reference PAX16.324258).

This submission represents the views, concerns and aspirations of a significant proportion of the residents, families, community organisations, landowners, business owners and stakeholders who live, work and invest in the future of the Lacken and Kilcummin parish. We firmly reject this proposal and contend that it does not constitute proper planning and sustainable development for our community.

Lacken and Kilcummin are not simply locations identified on a planning map. They are living communities with a rich cultural, archaeological, environmental and historical legacy. Our parish forms an integral part of one of Ireland's most significant archaeological landscapes. From the internationally recognised Céide Fields complex, one of the oldest known field systems in the world, to the historic landing place of General Humbert and the French forces in 1798, our landscape tells a story of national and international importance. The Rathlacken Court Tomb, a National Monument of exceptional significance, together with the extensive archaeological remains found throughout the parish, demonstrates that this area is not merely a development location but an irreplaceable cultural landscape that must be protected for future generations.

Contrary to the applicant's repeated characterisation of the development area as a "site", this proposal is not confined to a contained location. The proposed turbines, Battery Energy Storage System (BESS), substation, access roads, forestry clearances, spoil deposition areas and associated infrastructure would extend for approximately six kilometres across the parish, effectively stretching from one end of the community to the other. This development is not proposed in an isolated industrial location. It is proposed within the heart of an established rural community where people live, work, raise families, operate businesses and participate in community life.

The people of Lacken and Kilcummin have spent decades working to create a sustainable future for the area. Community organisations, local volunteers and residents have invested thousands of hours developing tourism initiatives, recreational amenities, biodiversity projects, heritage conservation programmes and community facilities. Significant progress has been made in establishing the area as a destination for visitors seeking to experience the unique landscape, archaeology, biodiversity and cultural heritage of North Mayo. The Wild Atlantic Way, the Humbert heritage trail, dark skies initiatives, the emerging Céide Coast tourism offering, biodiversity projects and local walking trails all form part of a long-term vision for sustainable economic development based upon the area's natural and cultural assets.

The strength of community opposition to this proposal is unprecedented. The principal community organisations operating within the parish have each made submissions to the Board outlining their opposition to this development and the reasons for that opposition. The overwhelming message from residents, businesses and community groups is clear: this development is not wanted, it is not supported and it is not considered compatible with the future vision of our area. This application is rejected by the community upon which it is proposed to be imposed.

The proposed development would directly impact recreational amenities that are actively used by local residents and visitors. Walking routes such as the Gazebo Trail and other established community trails pass through the areas proposed for development and are regularly used by local walking groups and visitors alike. Furthermore, as part of the Biodiversity Action Plan currently being developed for the parish, additional walking and nature trails are proposed to promote sustainable tourism, environmental education and outdoor recreation. The industrialisation of this landscape would significantly undermine these initiatives and jeopardise future opportunities for community-led development.

We are deeply concerned that the applicant has failed to engage meaningfully with the community as envisaged by national planning guidance and international best practice. The Wind Energy Development Guidelines 2006 emphasise the importance of early and meaningful engagement with affected communities. Evidence submitted as part of this objection demonstrates that many residents were never contacted by the developer, while community organisations throughout the parish have confirmed that no meaningful engagement took place. In our opinion, the applicant has failed to satisfy both the spirit and intent of meaningful public participation as envisaged by the Aarhus Convention. The limited consultation undertaken cannot reasonably be described as adequate for a development of this scale, significance and potential impact.

The community further rejects the applicant's assessment of the environmental sensitivities of the area. In our opinion, the mitigation measures proposed are wholly inadequate to safeguard the integrity of the Lacken/Kilcummin Salt Marsh SAC, the Killala Bay/Moy Estuary SPA, and the wider network of protected habitats and species that define this landscape. Throughout the application documentation there is a recurring tendency to minimise the importance of these protected areas and to understate the potential risks arising from the scale and extent of the proposed works. We believe that insufficient weight has been afforded to the significance of these protected areas and the ecological connectivity that exists between the proposed development and the receiving environment.

We are also deeply concerned about the impacts that this development will have on the health, wellbeing and residential amenity of those living throughout the parish. Significant concerns exist regarding operational turbine noise, amplitude modulation, low-frequency noise and shadow flicker. As detailed elsewhere in this submission, our review of the applicant's assessments identifies a number of locations where residents will continue to experience significant effects despite the mitigation measures proposed by the developer. Of particular concern is the fact that, even after mitigation is applied, predicted noise levels at certain receptors exceed the night-time noise levels recommended by the World Health Organization for the protection of human health and wellbeing. The community rejects the suggestion that compliance with outdated national guidance alone is sufficient where internationally recognised health guidance indicates a greater level of protection is required. The potential impacts on sleep quality, mental wellbeing, enjoyment of property and overall quality of life cannot be dismissed or minimised. Similarly, shadow flicker has the potential to significantly affect homes and community amenities, particularly given the scale and geographic spread of the proposed development across an inhabited rural landscape. We submit that the applicant has failed to adequately demonstrate that the long-term impacts of noise and shadow flicker on residents can be effectively avoided or reduced to an acceptable level.

The impact on local infrastructure is another matter of serious concern. Mayo County Council has expressed significant concerns regarding the potential effects of the development on the local road network. Residents share these concerns and believe that the scale of construction traffic required for this proposal would place unacceptable pressure on roads, bridges and infrastructure that were never designed to accommodate such activity. The resulting damage and disruption would have significant consequences for residents, businesses, emergency services and visitors to the area.

The Board must also consider the wider implications for the future of the Céide Fields landscape. Lacken forms a significant and inseparable component of the broader Céide Fields archaeological landscape. The prospect of future UNESCO World Heritage designation represents an opportunity of national and international significance. It is our view that the introduction of large-scale industrial wind energy infrastructure throughout this landscape would seriously undermine that potential and compromise the long-term protection, promotion and international recognition of one of Ireland's most important cultural assets.

The Board must also consider whether this proposal is compatible with the future vision that local people have worked tirelessly to create for the parish. Through community-led initiatives, tourism development, biodiversity enhancement projects, heritage conservation programmes and recreational amenities, the community has established a clear pathway towards sustainable growth and development. The Biodiversity Action Plan currently being prepared for the area seeks to expand nature-based tourism, habitat restoration, environmental education opportunities and recreational infrastructure. Significant effort has also been invested in promoting the wider Céide Fields landscape, the Humbert heritage route, dark skies tourism, coastal recreation, biodiversity enhancement and the Wild Atlantic Way visitor experience. The proposed development is fundamentally incompatible with these ambitions. Rather than supporting the future development of the parish, it would undermine and potentially eliminate many of the opportunities upon which the long-term economic and social sustainability of the community depends.

Particular regard must also be had to the unique characteristics of the receiving environment. This is an elevated and highly exposed coastal landscape surrounded by the Atlantic Ocean and recognised for its scenic, ecological and archaeological significance. The applicant's own documentation confirms that wind speeds within the development area are substantially higher than those typically associated with wind farm assessments, exceeding the 9 metres per second benchmark by approximately 35%. These elevated wind speeds have direct implications for turbine operation, noise generation, shadow flicker effects and the overall intensity of the development experienced by residents. Furthermore, the proposal requires the extensive felling of large areas of established forestry, resulting in the permanent alteration of landscape character, habitat structure and environmental conditions throughout the area. Concerns also arise regarding the lack of a sufficiently detailed and site-specific assessment of the proposed Battery Energy Storage System. In our opinion, the application fails to adequately assess the implications of locating a large-scale industrial energy storage facility within a rural community and does not sufficiently consider the cumulative impacts associated with combining a major wind energy development, electrical substation and industrial-scale BESS facility within a highly sensitive coastal landscape.

This community does not oppose progress, renewable energy or climate action. However, we strongly oppose the industrialisation of a highly sensitive archaeological, ecological and cultural landscape where the costs to the community, environment and heritage far outweigh any claimed local benefits. The proposed development would damage the very assets upon which the future prosperity of our area depends. It threatens tourism, recreation, biodiversity, heritage, landscape character and community wellbeing, while offering little tangible benefit to those who must live with its consequences.

For all of the reasons outlined in this submission, and having regard to the deficiencies identified throughout the applicant's documentation, including inadequate community engagement, unacceptable impacts on residential amenity arising from noise and shadow flicker, risks to protected habitats and species, adverse effects on heritage and tourism assets, the industrialisation of a unique coastal landscape, damage to local infrastructure, inadequate assessment of the proposed BESS facility, and the failure to demonstrate that this proposal constitutes proper planning and sustainable development, we respectfully request that An Coimisiún Pleanála refuse permission for the Tirawley Wind Farm development in its entirety.

This document has being prepared on a collaborative basis, as a result writing styles differ.

EXECUTIVE SUMMARY OF COMMUNITY CONCERNS

This submission has been prepared on behalf of the Lacken Ballycastle Community Landscape Protection Group and represents the concerns of a substantial number of residents, community organisations, businesses, land users and stakeholders within the Lacken and Kilcummin area. Having undertaken a detailed review of the planning application, Environmental Impact Assessment Report (EIAR), Natura Impact Statement (NIS), supporting technical documents and associated appendices, we respectfully submit that the proposed Tirawley Wind Farm development should be refused permission.

The concerns raised throughout this submission are not confined to a single issue or discipline. Rather, they demonstrate a pattern of deficiencies, omissions, factual inaccuracies and inadequate assessment across multiple aspects of the application. Collectively, these deficiencies prevent An Coimisiún Pleanála from reaching a reasoned conclusion that the development would constitute proper planning and sustainable development or that significant adverse environmental effects can be avoided.

A recurring theme throughout the application is the failure to properly recognise the host community of Lacken. The application repeatedly describes the development as being located between Ballycastle and Killala while largely omitting reference to the community that will experience the most significant impacts. Important community facilities, including St Patrick's Secondary School, St Patrick's Church and Tithe Cois Trá, have been incorrectly identified within the assessment process, resulting in concerns that the true impacts on community infrastructure, vulnerable populations and social amenity have not been adequately assessed.

The consultation process undertaken by the applicant falls significantly short of what would reasonably be expected for a development of this scale and duration. Evidence gathered by the community demonstrates that many residents received no direct engagement from the developer, while numerous community organisations operating within the parish were never consulted. The Battery Energy Storage System (BESS), electrical substation and revised project design were not the subject of meaningful public consultation, raising concerns regarding compliance with the principles of effective public participation.

Serious concerns also arise regarding human health, residential amenity and quality of life. The noise assessment relies upon disputed baseline data, excludes important receptors and contains assumptions that may underestimate operational impacts. Shadow flicker assessments rely heavily on operational mitigation measures after consent and fail to adequately address impacts on all affected properties and community facilities. The submission identifies concerns that internationally recognised health guidance, including World Health Organization recommendations, has not been given sufficient weight in the assessment process.

The proposed development would introduce major industrial infrastructure into a highly sensitive rural landscape of exceptional archaeological, ecological and cultural significance. The wider Céide Fields landscape, Rathlacken Court Tomb, historic monuments, heritage sites and the area's future UNESCO World Heritage aspirations all have the potential to be adversely affected by the scale and visual prominence of the development. The industrialisation of this landscape is fundamentally at odds with ongoing efforts to protect and promote North Mayo's unique heritage assets.

The submission further identifies significant concerns regarding biodiversity, protected habitats and species. Particular attention is drawn to the hydrological connectivity between the development area and the Lacken Saltmarsh SAC and Killala Bay/Moy Estuary SPA, the adequacy of ecological survey data, impacts on protected bird species, bat populations, badgers, otters, amphibians and invertebrates, and the cumulative effects arising from multiple wind energy developments across North Mayo. The assessment relies in several instances upon survey information that is now several years old and may no longer accurately reflect current ecological conditions.

Water protection represents another major concern. Questions arise regarding groundwater vulnerability, protection of private wells and springs, potential impacts on fisheries, pollution risks, drainage management and the adequacy of emergency response procedures. The review identified deficiencies within the Emergency Response Plan and associated management plans, including incomplete information and errors that call into question the robustness of the proposed mitigation measures.

Traffic, transport and construction impacts are also significant. The development would require extensive road upgrades, abnormal load deliveries, forestry felling, excavation works and prolonged construction activity across the parish. Residents are concerned about road safety, impacts on local businesses and farming operations, emergency service access, bridge capacity, environmental effects and the long-term condition of local infrastructure.

The proposed Battery Energy Storage System introduces a further layer of complexity and risk which, in our view, has not been adequately assessed. Concerns arise regarding fire safety, emergency response capability, cumulative impacts, noise, visual intrusion, environmental risks and the absence of detailed consultation with key stakeholders, including the local fire service.

The submission also highlights the likely adverse consequences for tourism, recreation and the local economy. The Lacken and Kilcummin area forms part of the wider Wild Atlantic Way experience and benefits from its association with the Céide Fields, coastal landscapes, heritage attractions, walking routes, biodiversity initiatives and recreational amenities. The scale and visibility of the proposed development risks undermining many of the assets upon which sustainable tourism and community-led economic development depend.

When considered individually, each of these concerns warrants careful scrutiny by An Coimisiún Pleanála. When considered collectively, they reveal a development that has not been demonstrated to be environmentally acceptable, socially sustainable or compatible with the long-term interests of the host community. It is therefore the position of the Lacken Ballycastle Community Landscape Protection Group that permission for the Tirawley Wind Farm development should be refused in its entirety.

Reference: Submission to An Coimisiún Pleanála, Tirawley Wind Farm, ACP Case Reference PAX16.324258.

GROUNDS FOR REFUSAL SUMMARY

Ground 1 – Breach of Article 6(3) of the Habitats Directive

The Appropriate Assessment fails to rule out adverse effects on the integrity of European sites connected to the Lacken salt marsh **SAC** and Killala Bay / Moy Estuary **SPA** system beyond reasonable scientific doubt . It relies on uncertain mitigation and post-consent management measures rather than clear, evidence-based conclusions, contrary to Article 6(3) requirements and its Irish transposition.[1]

Ground 2 – Breach of Article 6(3) of the Habitats Directive

Regulation 42 requires that an appropriate assessment be undertaken based on complete, precise and definitive evidence capable of removing all reasonable scientific doubt as to the effects on the European site. As the survey findings in this application are several years old, we make the argument that the assessment is not based on the best scientific knowledge and therefore does not satisfy Regulation 42.

Ground 3 – Breach of Articles 4 & 5 of the Birds Directive

The project gives rise to collision and disturbance risks for Annex I and Special Conservation Interest bird species, including Whooper Swan, without demonstrating that such impacts will be avoided or reduced to non-significant levels. Mitigation and management lands are speculative and unenforceable in practice, contrary to obligations to safeguard protected bird populations.[2]

Ground 4 – Breach of the EIA Directive (inadequate assessment)

The EIAR does not furnish a complete, coherent and sufficient assessment of the likely significant effects on population, human health and the environment. Key topics such as noise, infrasound, shadow flicker, air quality and cumulative impacts are treated in a fragmented way, falling below the minimum information standards of Articles 3 and 5.[3]

Ground 5 – Breach of the Water Framework Directive 'no deterioration' obligation

Borrow pits, access tracks, foundations and drainage works risk causing hydro morphological alteration and pollution of surface waters connected to the Killala Bay Moy Estuary. The project fails to demonstrate that water body status will not deteriorate or that WFD objectives will be achieved, as required by EU and Irish law.[4]

Ground 6 – Breach of the Environmental Noise Directive and associated obligations

Predicted operational noise levels, including the potential for tonal components and amplitude modulation, are not shown to keep exposure at noise-sensitive receptors as low as reasonably achievable. Failure to acknowledge our community, Secondary school and Church. This conflicts with the Directive's aim to avoid harmful effects from environmental

Ground 7 – Breach of the Aarhus Convention and EIA public participation requirements

The EIAR defers essential details of mitigation and monitoring to post-consent plans, thereby preventing the public from understanding and commenting on the full extent of impacts at the decision stage. This undermines effective public participation under the Aarhus Convention and Article 6 of the EIA Directive.[6]

Ground 7 – Breach of the precautionary principle in biodiversity protection
Significant scientific uncertainty remains regarding impacts on protected habitats, bats, otter, badger and key bird species. In such circumstances, the precautionary principle requires refusal rather than reliance on optimistic predictions and post-consent adaptive management.[7]

Ground 8 – Breach of obligations under the Bonn Convention and AEWA
The development poses collision and disturbance risks to migratory birds using flight paths at a coastal elevated site in North County Mayo, system and its environs. It fails to demonstrate that favourable conservation status of these populations will be maintained, contrary to international commitments under the Bonn Convention and AEWA.[8]

Ground 9 – Breach of Planning and Development Act 2000, s.34(3) (proper planning)
Because of its likely adverse impacts on human health, residential amenity, landscape, biodiversity and water quality, the project would be contrary to the proper planning and sustainable development of the area. The Board cannot be satisfied that the benefits outweigh the significant environmental and amenity costs.[9]

Ground 10 – Breach of Planning and Development Regulations (EIA)
The EIAR does not comply with the detailed content requirements in the Planning and Development Regulations. Baseline data, assessment methods and cumulative analyses are incomplete, preventing the competent authority from carrying out a lawful EIA.[10]

Ground 11 – Breach of European Communities (Birds and Natural Habitats) Regulations 2011
The Natura Impact Statement and associated biodiversity documentation do not dispel reasonable scientific doubt about adverse effects on European sites and protected species. Reliance on uncertain mitigation and management plans fails to satisfy the strict protection regime in the 2011 Regulations.[11]

Ground 12 – Breach of the Wildlife Acts 1976–2018
Badger sett disturbance, potential otter holt disturbance and impacts on other protected fauna are not robustly avoided or mitigated. The proposals risk the destruction or disturbance of breeding and resting places contrary to the strict protections afforded by the Wildlife Acts.[12]the potential for TB Outbreak and spread of Black leg in Bovine.

Ground 13 – Breach of Water Pollution Acts and related WFD regulations
Surface water management, particularly in relation to excavations, borrow pits and construction runoff, is insufficiently designed to prevent pollution of nearby streams and drains. The project therefore risks offences under the Water Pollution Acts and non-compliance with water quality objectives.[13]

Ground 14 – Breach of human health protection obligations under EIA law
The EIAR does not provide a robust assessment of likely impacts on human health arising from noise, including infrasound, shadow flicker, dust and traffic. Health pathways are not quantified or assessed against accepted thresholds, in breach of obligations to consider population and human health as key receptors.[14]

Ground 15 – Breach of national noise and amenity standards
Given the quiet rural baseline, the predicted turbine noise levels, including low-frequency and modulation components—are likely to cause sleep disturbance and loss of amenity for nearby

residents. This is inconsistent with WHO noise guidelines and the planning authority's duty to protect residential amenity.[15]

Ground 16 – Breach of EU ambient air quality requirements
Construction traffic, dust and machinery emissions are not properly modelled against statutory air quality standards. Without such modelling, compliance with limit values for PM and NO2 cannot be demonstrated, contrary to the Ambient Air Quality Directive and national regulations.[16]

Ground 17 – Breach of EU and Irish waste management obligations
The Construction Environmental Management Plan does not provide enforceable arrangements for the handling of excavated material, borrow pit arisings or invasive species-contaminated soils. This fails to meet the requirements of the Waste Framework Directive and its Irish implementing regulations.[17]

Ground 18 – Breach of Irish noise and vibration guidance (EPA and WHO)
Noise predictions omit a robust assessment of low-frequency noise and amplitude modulation, and do not convincingly demonstrate compliance with EPA guidance and WHO health-based noise limits. This renders the conclusions on noise effects unreliable.[18]

Ground 19 – Breach of EIA Directive obligations regarding human health
The EIAR treats human health in a cursory manner and fails to integrate health outcomes across noise, air quality, flicker and stress. This falls short of Article 3 requirements to comprehensively assess effects on population and human health.[14]

Ground 20 – Breach of traffic and road safety obligations
The traffic assessment does not convincingly address the safety and amenity impacts of abnormal loads, construction traffic and grid connection works along rural roads. It therefore fails to meet the planning authority's duty to ensure road safety and protect local communities from undue disturbance.[20]

Ground 21 – Breach of flood risk requirements (failure to carry out a Justification Test)
Elements of the project are located within Flood locations. Local knowledge compliant Justification Test under the Flood Risk Management Guidelines has not been carried out. This is contrary to guidelines and the flood risk policies of the Mayo County Development Plan 2022-2028.[21]

Ground 22 – Breach of ambient air quality requirements (lack of modelling)
The EIAR does not model PM10, PM2.5 or NO2 concentrations at nearby dwellings or other sensitive receptors. Without receptor-based modelling, compliance with EU and Irish air quality standards cannot be demonstrated.[16]

Ground 23 – Failure to quantify construction dust and emissions
Dust and particulate emissions from major construction activities are assessed only qualitatively, without deposition or concentration modelling. This fails to provide the level of detail required for a lawful EIA.[3]

Ground 24 – Breach of human health obligations in relation to air quality
The EIAR provides no exposure assessment or comparison with WHO air quality guidelines for residents near construction and haul routes. Human health impacts from air pollutants are therefore not adequately assessed.[14]

Ground 25 – Improper scoping out of operational air quality effects
Operational air quality impacts are dismissed solely on the basis of traffic thresholds, with no receptor-specific analysis. This approach is inconsistent with EIA requirements to assess likely significant effects on the environment.[3]

Ground 26 – Over-reliance on post-consent shadow flicker mitigation
The EIAR acknowledges significant exceedances of guideline thresholds for shadow flicker at many dwellings but proposes to address these solely through programmable turbine controls after consent. Such post-consent mitigation cannot cure an inadequate assessment at EIA stage.[26]

Ground 27 – Exceedance of national shadow flicker limits
Shadow flicker modelling indicates that houses within the study area will exceed the 30 hours per year and 30 minutes per day thresholds as set out in national wind energy guidelines, absent mitigation. This represents an unacceptable impact on residential amenity.[15]

Ground 28 – Scientifically unrealistic shadow flicker modelling inputs
The shadow flicker model assumes 100% sunshine, constant rotor operation and ideal geometry, while omitting vegetation and other real-world shielding effects. Such assumptions undermine confidence in the conclusions and do not meet the requirement for robust, scientifically sound methods.[19]

Ground 29 – Failure to assess health impacts of shadow flicker
Despite acknowledging shadow flicker as a potential pathway to affect human health and wellbeing, the EIAR provides no assessment of annoyance, stress or neurological impacts on residents. Human health risks from flicker are therefore left unexamined.[30]

Ground 30 – Failure to assess combined effects of air, noise and shadow flicker
Air quality, noise and flicker are each discussed in isolation, without considering their combined or synergistic effects on human health. This approach fails to meet EIA requirements for cumulative and combined impact assessment.[25]

Ground 31 – EIAR incomplete and non-compliant with Article 5 and Annex IV
The EIAR omits essential baseline data, methodological detail and modelling outputs for key topics including human health and shadow flicker. These omissions mean the report does not satisfy the minimum information requirements of Article 5 and Annex IV of the EIA Directive.[19]

Ground 32 – Failure to assess human health as required by the EIA Directive
Although human health is identified as a topic, the EIAR does not provide quantitative assessments of exposure, risk or health outcomes arising from project-related stressors. This is contrary to the explicit requirement to assess population and human health effects.[14]

Ground 33 – Failure to assess impacts on vulnerable population groups
The project's impacts on vulnerable groups – such as disabled persons, children, older people or those with pre-existing medical conditions – are not identified or assessed, particularly in relation to noise and flicker. This breaches the requirement to consider vulnerable receptors in the EIA.[22]

Ground 34 – Missing data restricts effective public participation
The absence of raw modelling data, detailed methodologies and up-to-date receptor lists prevents the public from independently evaluating the project's effects. This undermines the right to informed participation under EU EIA law and the Aarhus Convention.[23]

Ground 35 – Failure to use up-to-date and authoritative scientific evidence
The EIAR does not provide up-to-date scientific sources or full model documentation to substantiate its conclusions, especially in relation to health and flicker. This is contrary to the Directive's requirement that assessments be based on the best available scientific knowledge.[24]

Ground 36 – Failure to assess cumulative impacts in accordance with EIA law
Cumulative effects with other existing, permitted or proposed wind farms and infrastructure are not systematically assessed. This omission breaches the obligation to consider cumulative and combined effects on receptors.[25]

Ground 37 – Mitigation vague, unenforceable and deferred to post-consent
Many mitigation measures are expressed in general terms, without clear performance criteria or binding commitments, and are often left to future plans and approvals. This approach does not meet EU requirements for specific, enforceable mitigation at the EIA stage.[26]

Ground 38 – Reasonable alternatives not properly assessed
The EIAR does not provide a meaningful assessment of reasonable alternatives in terms of site location, layout, scale, turbine heights or grid connection options that might reduce environmental impacts. This falls short of Article 5(1)(d) requirements.[27]

Ground 39 – Multiple health-related breaches of the EIA Directive
The project fails to assess the health effects on the population, the specific impacts on vulnerable groups, the use of up-to-date science and the demonstration that significant adverse effects can be avoided or reduced. These combined failures mean significant health impacts cannot be ruled out, requiring refusal of consent.[28]

Ground 40 – Shadow flicker modelling and baseline data materially deficient
The EIAR provides no raw shadow flicker modelling files or parameters, omits dwellings built or permitted after the baseline date, and fails to document key assumptions. This breaches minimum information standards for modelling and prevents a lawful assessment of significant effects.[29]

Ground 41 – Breach of Article 94 and Schedule 6 of the planning and Development regulations, 2001.
The applicant's document makes reference to 31 or 21 turbines contradicting the description of the proposed development, which provides for 16 no turbines as set out in the public notice.

Ground 42 - Risk to European Protected Sites (SAC/SPA)
Failure to demonstrate beyond scientific doubt that the development will not adversely affect the integrity of the Lacken Saltmarsh SAC and Killala Bay/Moy Estuary SPA.

Ground 43 - Outdated Ecological Survey Data
Biodiversity assessments rely on survey information that is several years old and may no longer reflect current ecological conditions.

Ground 42 - Impacts on Protected Bird Species
Collision, displacement and disturbance risks to Whooper Swan, Hen Harrier and other protected bird species are inadequately assessed.

Ground 43 - Inadequate Environmental Impact Assessment
The EIAR is incomplete, fragmented and fails to comprehensively assess likely significant environmental and human health effects.

Ground 44 - Risk to Surface Water and Groundwater
Construction activities, borrow pits, drainage works and turbine foundations could adversely affect water quality and water supplies.

Ground 45 - Human Health Impacts Not Properly Assessed
Insufficient assessment of potential health effects from noise, shadow flicker, low-frequency noise, infrasound, dust and traffic.

Ground 46 - Noise Assessment Deficiencies
Noise modelling is based on flawed baseline data, excludes important receptors and may underestimate operational impacts.

Ground 47 -Potential Exceedance of WHO Noise Guidelines
Predicted turbine noise may exceed levels recommended by the World Health Organization for the protection of health and wellbeing.

Ground 48 -Shadow Flicker Impacts
Significant shadow flicker effects are predicted at multiple properties and rely on post-consent mitigation measures.

Ground 49 - Failure to Assess Vulnerable Receptors
Schools, Churches, community facilities, elderly residents and other vulnerable groups have not been adequately considered.

Ground 50 - Inadequate Community Engagement
The developer failed to undertake meaningful consultation with the host community and local organisations.

Ground 51 - Misidentification of Community Facilities
Important community assets including St Patrick's Secondary School, St Patrick's Church and Tithe Cois Trá were incorrectly classified as residential dwellings.

Ground 52 - Failure to Properly Identify the Host Community
Lacken Parish is largely omitted from the application documentation despite being the community most affected.

Ground 53 -Emergency Response Plan Deficiencies
The submitted Emergency Response Plan appears incomplete, contains missing information and includes incorrect emergency contacts.

Ground 54 - BESS Assessment Inadequacies
The Battery Energy Storage System has not been assessed in sufficient detail regarding safety, fire risk and cumulative impacts.

Ground 55 -Traffic and Road Safety Impacts
Construction traffic, turbine deliveries and road upgrades will significantly impact local roads, bridges and road safety.

Ground 56 - Grid Connection Uncertainties
Grid connection impacts and associated infrastructure have not been fully assessed.

Ground 57 - Impacts on Private Wells and Springs
The assessment fails to adequately identify and protect local groundwater-fed domestic water supplies.

Ground 58 - Risk to Fisheries and Aquatic Ecology
Potential impacts on salmon, trout and downstream aquatic habitats are inadequately assessed.

Ground 59 - Forestry Felling Impacts
Large-scale forestry removal will alter habitats, landscapes, hydrology and wildlife movement patterns.

Ground 60 - Biodiversity Impacts
Potential adverse effects on bats, badgers, otters, Marsh Fritillary butterflies, amphibians and other protected species.

Ground 61 - Bovine Tuberculosis (bTB) and Wildlife Disturbance Risks
Construction and habitat disturbance may increase the risk of bovine tuberculosis transmission through wildlife movement.

Ground 62 - Archaeological Heritage Impacts
Significant concerns regarding impacts on the wider Céide Fields landscape, Rathlacken Court Tomb and other archaeological features.

Ground 63 - Impact on UNESCO World Heritage Potential
The development could undermine future UNESCO World Heritage designation aspirations for the wider Céide Fields landscape.

Ground 64 - Landscape and Visual Impacts
Significant adverse effects on an elevated coastal landscape of high scenic value.

Ground 65 - Impacts on Tourism
Potential damage to the Wild Atlantic Way, Céide Coast initiatives, walking trails, heritage tourism and recreation.

Ground 66 - Cumulative Effects with Other Wind Farms
The cumulative impact of existing, approved and proposed wind farms across North Mayo has not been adequately assessed.

Ground 67 - Failure to Properly Assess Alternatives
The applicant has not adequately considered alternative locations, layouts, scales or infrastructure options.

Ground 68 - Air Quality and Dust Impacts
Construction dust, emissions and potential particulate impacts have not been properly quantified.

Ground 69 Microplastics, Polymer and Heavy Metal Concerns
Potential environmental accumulation and bioaccumulation effects have not been adequately investigated.

Ground 70 - Flood Risk Assessment Deficiencies
Flood risk considerations and justification requirements have not been fully addressed.

Ground 71 - Reliance on Post-Consent Mitigation
Many key environmental protections are deferred to future plans rather than demonstrated at application stage.

Ground 72 - Failure to Assess Combined Human Health Effects
Noise, shadow flicker, air quality and stress impacts are considered separately rather than cumulatively.

Ground 73 - Errors and Inconsistencies Throughout the Application
Multiple factual errors, inconsistent turbine numbers and document quality issues undermine confidence in the assessment.

Ground 74 - Failure to Demonstrate Proper Planning and Sustainable Development
The development would adversely affect residential amenity, biodiversity, heritage, tourism and landscape to an extent that outweighs any claimed benefits.

OMISSION OF LACKEN FROM THE APPLICATION

Description of the Lacken Community

Throughout the application documentation, the proposed development is described as being located "between Ballycastle and Killala village in the north of County Mayo." While geographically broad, this description omits a key fact: the development is situated within the parish of Lacken.

The absence of any meaningful reference to Lacken in the project website, Planning Statement, and associated documentation is concerning. Lacken is not merely "between" Ballycastle and Killala. It is a defined rural community with its own identity, residents, amenities, and heritage, and it will experience the primary visual, environmental, and social impacts of the proposed development.

Despite this, the application repeatedly refers only to surrounding settlements, effectively overlooking the community most closely associated with the site.

This is not a minor issue of terminology. The way a development is described helps define the receiving environment and informs public understanding of who will be affected. By presenting the site simply as being located between Ballycastle and Killala, the documentation fails to acknowledge the presence of an established rural community with its own population, social infrastructure, heritage, and sense of place.

Evidence of a Wider Lack of Community Recognition

The omission of Lacken appears to be reflected elsewhere in the application.

For example, Figure 2.3 incorrectly identifies a number of community facilities, including St. Patrick's College, Saint Patrick's Church and the Fáilte Rooms based at Tithe Cois Trá, as residential dwellings. These are important community assets rather than private residences, and their misclassification suggests that insufficient attention has been given to understanding the local area and its character.

In addition, Chapter 1 of the EIAR states that engagement took place with local community groups. However, the documentation does not identify any groups representing the Lacken Parish area, nor does it provide evidence that such groups were consulted. Given that Lacken is the community most directly affected by the proposal, this raises questions regarding the scope and adequacy of the consultation process.

It should be noted by the board that all the following community groups in Lacken have filed submissions objecting to the development

- Lacken Enterprise Centre Association
- Humbert development Association
- Kilcummin Swimmers Group
- Lacken Community Care
- Tithe Cois Trá
- Lacken Sensory Garden
- Lacken Community Garden club
- Lacken, Ballycastle, Killala, Kilfian (LBK) Walking Group
- Lacken GAA

- Lacken Biodiversity Action Plan Group
- North Mayo Hillwalkers
- Lacken Graveyard Committee

The above groups were not engaged with by the applicant in regards this development, all are opposing and concerned about the various negative impacts that the development would have on the amenities in the area.

The application also refers to community investment and community benefit initiatives. Yet it remains unclear which community these measures are intended to support. Without clearly identifying Lacken as the host community, the basis on which such benefits have been considered or allocated is difficult to understand. No community fund will be sufficient to mitigate the negative impact of this development. This development will negatively impact the future of this community.

Assesment of sensitive "receptors"

We want to bring to the Boards attention to a systemic, recurring failure to identify sensitive community receptors and a severe factual and procedural breach within Chapter 5 ("Population and Human Health") and Chapter 13 ("Traffic and Transport") of the applicant's Environmental Impact Assessment Report (EIAR).

The applicant has incorrectly identified the following properties as standard residential dwelling houses

- St Patricks Secondary School (labelled as Receptor ID H102 on the applicant's maps)
- St Patricks & St Cuimín Catholic Church (labelled as Receptor ID H110)
- Tithe Cois Trá Fáilte Rooms – Office (labelled as Receptor ID H132).

This mischaracterization of these properties constitutes a direct breach of the EPA Guidelines on information to be contained in as EIAR. The applicant has demonstrated a complete lack of rigorous on-the-ground verification. Because a highly sensitive educational institution has been treated as a simple residential dwelling, the applicants, noise, shadow flicker, and construction traffic assessments are fundamentally flawed and built on false data. The specific impacts on a vulnerable population – namely, hundreds of school children – have been entirely ignored. Also a community church and commercial office building have vastly different sensitive profiles to a house. A church accommodates large congregations of vulnerable demographics (such as elderly) during specific times. An office building supports a continuous daytime workforce.

Because the applicant misidentified these major hubs of community life and economic activity, the noise, shadow flicker, and structural vibration models are entirely invalid. The applicant has failed to assess the true human impact on the day-to-day operations of both churchgoers and workers.

Consequently, the EIAR is legally deficient, factually misleading, and do not reflect the reality of the host community.

Conclusion

It is the opinion of this group that the applicant has committed a significant procedural and environmental breach by failing to provide an accurate description of the host community

(Lacken) in the application documentation. Specifically, Chapter 5 of the Environmental Impact Assessment Report (EIAR) ('Population and Human Health') and the accompanying Community Report fail to accurately reflect the true density, layout, and human reality of the local area. A clear and accurate description of the host community is essential to ensuring transparency, meaningful public participation, and a robust assessment of environmental and social effects. The failure to identify Lacken throughout the application risks understating the local context of the development and overlooks the community that will experience its most significant impacts.

We request that An Coimisiún Pleanála refuse planning permission on the grounds that the Board cannot safely or lawfully assess the true environmental and human health impacts of this development based on factually incorrect data.



NOTE – ALL PRICTURES PROVIDED BY ANGELA KELLY PERMISSION WAS OBTAINED

COMMUNITY ENGAGEMENT

Public Information Day Advertisement Discrepancy

An apparent inconsistency exists between the Public Information Day advertisement reproduced in Appendix 1.6 of the Community Engagement Report and the advertisement that was published in the *Western People* newspaper.

The advertisement included in Appendix 1 within Appendix 1.6 contains an extensive list of local townlands, giving the impression of a highly targeted notification strategy directed towards communities in the vicinity of the proposed development. However, the advertisement published in the *Western People* appears to refer only to the Barony of Tirawley, incorporating Lacken and Ballycastle, and does not contain the same level of localised detail.

The Applicant should clarify which version of the advertisement was actually published and explain the reason for the difference between the advertisement reproduced in the PACC Report and the version that appeared in the newspaper.

This matter is important because the inclusion of numerous local townlands in the Appendix version creates the impression that a more detailed and locally focused public notification exercise was undertaken than is evident from the published advertisement itself. The discrepancy therefore raises questions regarding how the consultation process has been presented and whether the documentation accurately reflects the information that was made available to the public at the time.

The below is taken from Appendix 1.6 in the EIAR and is Appendix 1

Appendix 1: Western People – Newspaper Advertisement

Tirawley Wind Farm
Public Information Event



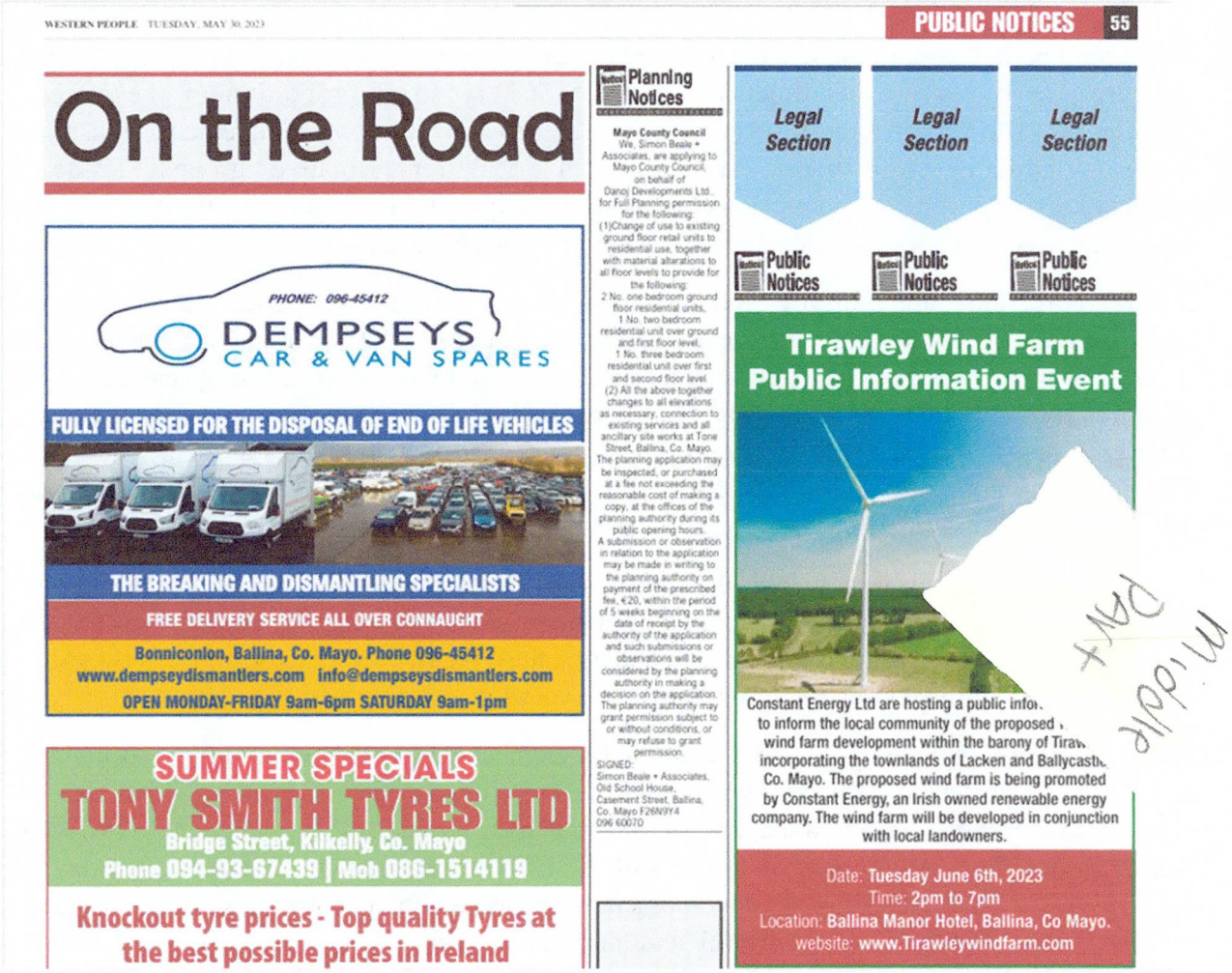
Constant Energy Ltd. are hosting a public information event to inform the local community of the proposed Tirawley wind farm development within the townlands of:

Conaghra, Barroe, Lissadrone East, Lissadrone West, Billoos, Lecarrowntemple, Lackanhill, Ballymurphy, Carrowmore, Castletown, Castlelackan Demense, Aghaleague, Carrowneden, Ballynaleck, Carrowmachshane, Carn, Carrowmore, Glebe, Doonadoba, Carrowcor, Cloonanass, Barnhill Lower, Barnhill Upper, Cloonavarry and Carrickanass, Ballina, Co. Mayo.

The proposed wind farm (Tirawley Wind Farm) is being promoted by Constant Energy, an Irish owned renewable energy company. The wind farm will be developed in conjunction with local landowners.

Date: **Tuesday June 6th, 2023**
Time: **2pm to 7pm**
Location: **Ballina Manor Hotel, Ballina, Co Mayo.**

The below is the actual advertisement placed in The Western People 30th May 2023



WESTERN PEOPLE TUESDAY, MAY 30, 2023

PUBLIC NOTICES 55

On the Road

PHONE: 096-45412
DEMPSEYS
CAR & VAN SPARES
FULLY LICENSED FOR THE DISPOSAL OF END OF LIFE VEHICLES
THE BREAKING AND DISMANTLING SPECIALISTS
FREE DELIVERY SERVICE ALL OVER CONNAUGHT
Bonniconlon, Ballina, Co. Mayo. Phone 096-45412
www.dempseydismantlers.com info@dempseysdismantlers.com
OPEN MONDAY-FRIDAY 9am-6pm SATURDAY 9am-1pm

SUMMER SPECIALS
TONY SMITH TYRES LTD
Bridge Street, Kilkelly, Co. Mayo
Phone 094-93-67439 | Mob 086-1514119
Knockout tyre prices - Top quality Tyres at the best possible prices in Ireland

Planning Notices

Mayo County Council
We, Simon Beale + Associates, are applying to Mayo County Council, on behalf of Danoj Developments Ltd., for Full Planning permission for the following: (1)Change of use to existing ground floor retail units to residential use, together with material alterations to all floor levels to provide for the following: 2 No. one bedroom ground floor residential units, 1 No. two bedroom residential unit over ground and first floor level, 1 No. three bedroom residential unit over first and second floor level. (2) All the above together changes to all elevations as necessary, connection to existing services and all ancillary site works at Tone Street, Ballina, Co. Mayo. The planning application may be inspected, or purchased at a fee not exceeding the reasonable cost of making a copy, at the offices of the planning authority during its public opening hours. A submission or observation in relation to the application may be made in writing to the planning authority on payment of the prescribed fee, €20, within the period of 5 weeks beginning on the date of receipt by the authority of the application and such submissions or observations will be considered by the planning authority in making a decision on the application. The planning authority may grant permission subject to or without conditions, or may refuse to grant permission.
SIGNED:
Simon Beale + Associates,
Old School House,
Casement Street, Ballina,
Co. Mayo F26N9Y4
096 60070

Legal Section | Legal Section | Legal Section

Public Notices | Public Notices | Public Notices

Tirawley Wind Farm
Public Information Event

Constant Energy Ltd are hosting a public info... to inform the local community of the proposed ... wind farm development within the barony of Tiraw... incorporating the townlands of Lacken and Ballycastle, Co. Mayo. The proposed wind farm is being promoted by Constant Energy, an Irish owned renewable energy company. The wind farm will be developed in conjunction with local landowners.

Date: Tuesday June 6th, 2023
Time: 2pm to 7pm
Location: Ballina Manor Hotel, Ballina, Co Mayo.
website: www.Tirawleywindfarm.com

Inadequate and Unrepresentative Community Consultation Process

In Appendix 3.1 Scooping Opinion the Health Service Executive (West) (Environmental Health Service) stated the following *"Public Consultation The applicant should consider the appointment of a community liaison officer. Early and meaningful public consultation with the local community should be carried out to ensure all potentially significant impacts have been adequately addressed."*

The community have not been made aware of any appointment of a community liaison officer. As far as we are aware no one has been appointed.

The Community Engagement Report presents the Public Information Day (PID) held on 6 June 2023 as evidence of meaningful consultation with the local community. However, the report itself highlights several significant shortcomings which call into question whether the consultation process can reasonably be described as comprehensive, representative, or compliant with the spirit of the 2016 Code of Practice for Wind Energy Development in Ireland – Guidelines for Community Engagement. The report confirms that the entirety of the

consultation process was centred around a single information event held in Ballina Manor Hotel and attended by only 31 people.

For a rural parish comprising in excess of 600 residents across the Lacken and Kilcummin area, participation by only 31 individuals represents a very small proportion of the affected population. The report identifies no evidence of any door-to-door engagement, household visits, community workshops, meetings with local representative groups, residents' associations, sporting organisations, tourism groups, heritage organisations, schools, community centres, or other established community stakeholders.

Furthermore, the Public Information Day took place in June 2023 when the project was substantially different from the development now before An Coimisiún Pleanála. The information displays provided at the event related to a wind farm proposal comprising up to 24 turbines and associated infrastructure. The consultation material did not include the Battery Energy Storage System (BESS) now proposed, nor did it adequately consult the public on the scale, location, operational impacts, fire safety considerations, noise characteristics, or visual effects of the proposed electrical substation and associated infrastructure.

It is therefore difficult to conclude that those who attended the event were consulted on the development currently under consideration. The proposal has evolved significantly since 2023, yet no further public consultation has been undertaken on the revised scheme, the BESS facility, the substation, or the cumulative impacts of the overall project.

While the report repeatedly refers to "meaningful engagement" and "community consultation", the evidence presented demonstrates a single information event attended by 31 individuals, advertised through one newspaper notice and held outside the immediately affected communities. This falls considerably short of the level of engagement that would reasonably be expected for a major industrial development proposed within a community such as Lacken, of significant cultural, environmental and tourism importance. Accordingly, little weight should be attached to the applicant's assertion that the views of the local community have been adequately sought, understood, or incorporated into the design of the current development proposal.

Evidence Demonstrating the Absence of Meaningful Community Engagement

The applicant repeatedly states that meaningful engagement was undertaken with the local community and that the views of local stakeholders were considered during the evolution of the project. The experience of residents within the affected area does not support this assertion.

The Lacken Ballycastle Community Landscape Protection Group has undertaken its own independent survey of local residents. As part of this process, we have obtained signed declarations from in excess of 100 individuals living within the wider Lacken and Kilcummin area who confirm that they have never been contacted by Constant Energy Limited, either through door-to-door engagement, direct correspondence, community meetings, household visits, or any other form of direct consultation regarding the Tirawley Wind Farm proposal.

Scanned copies of these signed declarations are enclosed with this submission and are available for inspection by An Coimisiún Pleanála.

This evidence is particularly significant when considered alongside the applicant's Pre-Application Community Consultation Report. The report identifies a single information event held in Ballina in June 2023, attended by only 31 individuals. No evidence has been provided of any systematic effort to engage directly with residents most affected by the development. There is no evidence of door-to-door consultation, no engagement with representative community groups, no engagement with local tourism organisations, and no meaningful engagement with many of the households who stand to experience the greatest impacts from the proposed turbines, BESS facility and substation.

The fact that over 100 local residents have formally confirmed that they received no direct contact from the developer fundamentally undermines the applicant's contention that the local community was afforded meaningful opportunities to participate in the development process. It also raises serious questions as to how the applicant can credibly claim that community views informed the design of the project when a substantial proportion of the affected population was never consulted in the first instance.

For a development of this scale and duration, involving 16 industrial-scale wind turbines, a large Battery Energy Storage System, electrical substation, extensive road works and a proposed operational lifespan of 35 years, a single information event attended by 31 individuals cannot reasonably be characterised as comprehensive community engagement. The evidence before An Coimisiún Pleanála demonstrates that the consultation process was limited, unrepresentative and failed to meaningfully engage with a large number of residents directly affected by the proposed development.

POPULATION, HUMAN HEALTH AND EMERGENCY RESPONSE DEFICIENCIES

Introduction

This section examines the findings of a detailed review of Chapter 5 (Population and Human Health) of the Environmental Impact Assessment Report (EIAR) for the proposed Tirawley Wind Farm development. The review included a cross-check of Chapter 5 against Volume VI Appendix 1 of the application, specifically:

- Construction Environmental Management Plan (CEMP) Management Plan 1 – Emergency Response Plan; and
- CEMP Management Plan 2 – Water Quality Management Plan.

The review identified significant deficiencies relating to emergency preparedness, document quality control, omission of important community receptors and inaccuracies within the baseline population data. Of particular concern is the discovery that the Emergency Response Plan submitted as part of the planning application appears to be an incomplete template containing numerous unfilled sections and missing critical operational information.

Under the requirements of the Planning and Development Act 2000 (as amended), the Planning and Development Regulations 2001 (as amended), and the Environmental Impact Assessment Directive 2011/92/EU as amended by Directive 2014/52/EU, the EIAR must contain complete, accurate and up-to-date information sufficient to allow An Coimisiún Pleanála to carry out a lawful Environmental Impact Assessment.

The deficiencies identified below call into question whether this standard has been achieved.

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1. Emergency Response Plan Submitted as an Incomplete Template

Finding

The most significant issue identified during the review concerns the Emergency Response Plan contained within CEMP Management Plan 1.

The document expressly states that it:

- Identifies key staff and 24-hour emergency contacts;
- Provides an inventory of chemical products and waste stored on site;
- Provides an inventory of pollution prevention equipment;
- Identifies personnel trained in the use of spill kits and pollution control equipment.

However, upon examination, these sections do not appear to have been completed.

The section entitled **"Key Holders for Site"** contains no names, positions or contact details. Numerous fields throughout the document remain blank, including:

- Overview of site activities;
- Staffing numbers during various operating periods;
- Date and version of the plan;
- Name of the person responsible for preparing or approving the plan;
- Review date;
- Date of next emergency exercise;
- List of organisations consulted during preparation of the plan.

Throughout the emergency procedures, staff are repeatedly instructed to notify the **"Site Manager/Main Contact"**, yet no individual is identified anywhere within the submitted document.

Significance

The result is that the Emergency Response Plan, as submitted, could not be effectively implemented during a real emergency event.

In circumstances involving:

- Fuel spills;
- Watercourse contamination;
- Peat instability incidents;
- Fire events;
- Chemical releases; or
- Construction accidents,

the plan provides no named individual responsible for initiating or coordinating emergency actions.

This represents a serious procedural deficiency in a document intended to protect public safety, water quality, ecological receptors and local communities throughout a construction programme expected to last approximately 21 months.

Planning Concern

The absence of essential operational information raises questions regarding whether the document constitutes a completed management plan at all, or merely a draft template submitted in error.

An Coimisiún Pleanála should require the submission of a fully completed Emergency Response Plan prior to any determination of the application.

2. Northern Ireland Emergency Contact Number Included in Emergency Response Plan

Finding

A further review of Section 7.4 of the Emergency Response Plan identified that the emergency contact number provided for blocked or flooded roads is: **0300 2000 100**

This number is not associated with Mayo County Council or any authority operating within the Republic of Ireland.

Instead, it is the publicly available contact number for the Department for Infrastructure Roads Service in Northern Ireland.

Significance

The inclusion of a Northern Ireland emergency contact number within a County Mayo construction emergency plan strongly suggests that the document was adapted from a template originally prepared for another jurisdiction and was not adequately reviewed prior to submission.

In the event of:

- Flooding;
- Road collapse;
- Construction-related obstruction;
- Traffic emergencies; or
- Public safety incidents,

contractors following the plan could potentially contact an authority with no jurisdiction over the project area.

Planning Concern

This error is readily verifiable and raises broader concerns regarding document quality control throughout the submitted management plans.

It reinforces concerns that the Emergency Response Plan was not properly localised or project-specific.

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3. Water Quality Management Plan Relies on the Defective Emergency Response Plan

Finding

Section 2.4 of the Water Quality Management Plan states that pollution incidents will be managed through implementation of mitigation measures contained within the Emergency Response Plan.

The Water Quality Management Plan therefore relies directly upon Management Plan 1 for emergency actions following:

- Fuel spills;
- Sediment releases;
- Watercourse contamination;
- Chemical incidents; and
- Pollution events affecting downstream receptors.

Significance

Because the Emergency Response Plan lacks named contacts, identified responsible personnel and completed emergency information, the effectiveness of the Water Quality Management Plan is similarly compromised.

A water pollution incident requiring immediate intervention would trigger procedures that depend upon personnel who have not been identified within the submitted documentation.

This represents a clear inconsistency between two interdependent management plans forming part of the same application.

Planning Concern

The deficiencies identified within Management Plan 1 directly undermine confidence in the effectiveness of Management Plan 2.

Both documents should be completed, cross-checked and resubmitted before they can be relied upon as mitigation measures within the Environmental Impact Assessment process.

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4. Failure to Identify Important Community Receptors

Lacken Sensory Garden

Lacken Church

Lacken Cross Secondary School

A review of Chapter 5 confirms that none of the following community facilities are identified anywhere within the Population and Human Health assessment:

- Lacken Sensory Garden;
- Lacken Church;
- Lacken Cross Secondary School.

This omission is particularly notable because other chapters of the EIAR identify specific community receptors.

For example:

- The Traffic and Transport chapter identifies schools as sensitive receptors.
- The Landscape and Visual chapter identifies specific viewpoints, cemeteries and community locations.

However, the chapter specifically responsible for assessing impacts on people and human health does not identify any named local community facilities.

Significance

The Lacken Sensory Garden serves children and adults, including potentially vulnerable users who may be more sensitive to:

- Construction noise;
- Visual intrusion;
- Disturbance;
- Changes in environmental quality.

Similarly, Lacken Cross Secondary School is understood to be located in proximity to Turbines AT02, AT03, AT04 and the proposed meteorological mast.

Schools are widely recognised as sensitive receptors due to the presence of:

- Children;
- Educational activities;
- Outdoor recreation areas;
- Staff working environments.

Potential impacts may include:

Construction Phase

- Traffic disruption;
- Noise;
- Dust;
- Construction disturbance.

Operational Phase

- Noise impacts;
- Shadow flicker;
- Visual dominance effects;

- Cumulative amenity impacts.

Planning Concern

The omission of these facilities from the Population and Human Health assessment constitutes a material gap in the receptor baseline.

An Coimisiún Pleanála should require specific assessment of:

- Lacken Sensory Garden;
- Lacken Church;
- Lacken Cross Secondary School;

as named sensitive receptors.

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5. Baseline Population Data Error – Killala Population

Finding

Chapter 5 states that Killala has a population of **58,710 people**.

This figure is attributed to CSO data.

Significance

The figure is plainly incorrect.

Killala is a small settlement and its actual population is a small fraction of the stated number.

The reported figure exceeds the population of any town in County Mayo and appears likely to result from a transcription or data-entry error.

Although this may be an isolated mistake, baseline population data forms part of the foundation upon which the chapter's assessment of social and population effects is based.

Planning Concern

The presence of such an obvious factual error raises concerns regarding:

- Data verification;
- Quality assurance procedures;
- Reliability of other baseline figures used within the chapter.

The applicant should be required to correct the figure and verify the accuracy of all other population statistics contained within the assessment.

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6. Reliance on Health Studies More Than a Decade Old

Finding

The chapter's discussion of human health impacts relies primarily on:

- Australian National Health and Medical Research Council Review (2013); and
- Knopper et al., Frontiers in Public Health (2014).

Both sources conclude that properly sited wind farms have not been demonstrated to cause direct adverse health effects.

However, the Knopper paper acknowledges associations between noise annoyance and reported effects including:

- Sleep disturbance;
- Reduced wellbeing;
- Stress-related symptoms.

Significance

While these publications remain recognised sources, they are now approximately 12–13 years old.

Elsewhere within the EIAR, the applicant emphasises the use of current planning guidance, including:

- Wind Energy Development Guidelines (2006);
- Draft Revised Wind Energy Development Guidelines (2019).

A similar expectation should apply to the health evidence base.

Planning Concern

The applicant should clarify whether more recent peer-reviewed research, particularly studies published since 2020, was reviewed and considered.

This is particularly relevant in relation to:

- Sleep disturbance;
- Chronic noise exposure;
- Community annoyance;
- Quality of life impacts.

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7. Elevated Topography and Human Health Assessment

The development site occupies elevated ground reaching approximately 186 metres Above Ordnance Datum at Knockboha Hill.

While the chapter acknowledges this topography, it does not assess whether elevated turbine positions may contribute to increased health-related impact pathways through:

- Greater visual dominance;
- Enhanced perception of industrialisation;
- Increased community annoyance;
- Altered noise propagation characteristics.

This omission is notable because the chapter itself cites research recognising annoyance and visual impacts as relevant considerations when assessing human wellbeing.

The elevated nature of the site has been identified elsewhere in the EIAR as a defining characteristic of the development and should therefore have been considered within the human health assessment.

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8. Residents in Close Proximity to Turbines

The chapter confirms that the nearest non-associated dwelling is located approximately 554 metres from a proposed turbine.

The chapter notes that this marginally exceeds the project's stated setback criterion of four times turbine tip height:

- Turbine tip height: 135 metres
- Four times tip height: 540 metres
- Distance to nearest dwelling: 554 metres

This provides a margin of only 14 metres.

The Population and Human Health chapter does not consider whether residents located at such close distances may experience materially greater combined exposure to:

- Noise;
- Shadow flicker;
- Visual dominance;
- Construction disturbance;

than the wider population considered in the assessment.

This is particularly relevant where other chapters identify receptors operating close to compliance thresholds and requiring mitigation measures to achieve predicted compliance.

Conclusion

The review of Chapter 5 and its associated CEMP management plans identifies a number of significant shortcomings relating to document completeness, quality control, receptor identification and evidential currency.

The most serious concern is the submission of an Emergency Response Plan that appears to remain substantially incomplete, despite forming a key mitigation document relied upon by other environmental management plans.

When considered collectively, these issues raise legitimate concerns regarding the robustness of the Population and Human Health assessment and the adequacy of supporting mitigation measures relied upon by the applicant.

An Coimisiún Pleanála should require these deficiencies to be addressed before the application can be considered compliant with the requirements of the Environmental Impact Assessment process.

ORNITHOLOGY

Impact on the ornithology of the area

The ecological surveys relied upon by the applicant are no longer sufficiently current to provide the complete, precise and definitive findings required for an Appropriate Assessment under Regulation 42 of the European Communities (Birds and Natural Habitats) Regulations 2011–2021. In the absence of up-to-date survey information, An Coimisiún Pleanála cannot be satisfied, beyond reasonable scientific doubt, that the proposed development will not adversely affect the integrity of European sites, their qualifying interests, or their conservation objectives.

The surveys the developer has include in its application were carried out between April 2021 and June 2023 at this stage -June 2026 these are by the developers own admission "approaching 3 years of age or more than 3 years of age" by reference to the CIEEM lifespan guidance. We strongly contest the developers conclusion that the data is still an accurate prediction of the effects that a development like this would have on the birdlife in Lacken. The data included in the applicants application may not represent current site conditions accurately and the proposed pre-construction surveys may be insufficient or too late to mitigate impacts effectively.

Constant Energy in this instance cannot be permitted to rely on outdated surveys to dismiss effects on mobile and conservation-sensitive bird species. As stated above the developer is aware that the surveys are outdated and proceeded to submit an application based on out of date data. It is our contention that as a result of this permission for this development should be refused. The board cannot make any decision without updated 2025/2026 ornithology surveys. Given that the developer made the decision to knowingly file an application with out-of-date data it would not constitute fair and proper planning to afford the developer even more time to prepare updated surveys and therefor the board should refuse this application permission.

The developers assessment treats the turbine site as a self-contained survey unit. The study area focuses primarily on the redline Boundary of the development plus a 500m buffer. The board must ensure that the developers' assessments are properly prepared in the context of the landscape it is proposed for. A coastal Mayo bird population does not use the landscape in a manner that is confined to particular sections of the coast. The board must ensure that any and all assessments examine the wider functional, ecological network between Lacken Bay, Killala Bay, inland wet grassland, bog, forestry edge, feeding fields and roosting areas.

The surveys the developer has carried out do not produce results that would provide any reassurance relating to our concerns of the impact on the flight paths of birds that come to the area. The surveys provided show that birds do not remain confined to the shoreline. The EIAR downplays the significance of this by stating that only one inland flight from Lacken Bay was recorded. The heights recoded by the developer for the inland flight that was noted overlap with or are close to the turbine collision risk zone, given the Vestas V117 turbines assessed has a 117m rotor diameter, 76.5m hub height and 135m blade tip height. The EIAR records Golden Plover activity at heights directly relevant to turbine collision risk, however because the frequency at which levels were recorded the developer has dismissed any potential risk. The developer has not allowed for in their assessment that Golden Plover movements can be episodic, weather-driven, tidal and seasonal. Monthly shoreline surveys as carried out by the developer are very likely to miss peak movement events. Lacken Bay is part of the of the Killala Bay / Moy Estuary EPA and as a result any developments in the area have to adhere to very strict restrictions. It is incumbent upon the board to ensure that the SPA site is protected and

that the species which rely on the habitat are not understate because they did not appear in high numbers on the days that the developer carried out their surveys.

The EIAR's Chapter 7 conclusion that the site is close to Killala Bay / Moy Estuary SPA "none of the Special Conservation Interest of the SPA utilise the area of the Wind Farm" is a significant lack of understanding on the developers behalf as to the ful extent of the SPA. As per the national parks and wildlife Lacken Bay is considered part of the Killala Bay / Moy Estuary SPA – the developer cannot simply dismiss this because it does not fit with their plans.

Included in the EIAR Chapter 7 is the acknowledgement that

- Lacken Bay is regularly used by wetland birds.
- Inland feeding occurs during high tide and sever weather.
- Curlew was recorded feeding inland.
- Golden Plover were recorded flying/circling inland.
- Whooper Swan was recorded in I-WeBS for Lacken Bay but not in the developer's own surveys. This raises the level of uncertainty in relation to the developers surveys and that they could be lacking in their assessment of the area, and the reliance that should be placed on same given that they are out of or close to being out of date.

Under the precautionary principle, uncertainty should not be resolved in favour of the developer.

The EIAR used five vantage points and says these gave full coverage of the 16 turbine locations. Again this is in our opinion a sever lack of understanding of the requirement of the surveys requirements. The site extends around 6km north to south and up to 2km east to west. The selection of only 5 vantage points creates the possibility of under-recording issues. Taking into consideration that the turbines are in clusters either end of the site the 5 vantage points may have visibility of the turbines but it is likely that it will miss

- Low level flights hidden by topography;
- Weather driven coastal movements;
- Dawn / dusk activity;
- Irregular Hen Harrier or Merlin Hunting routes;
- Golden Plover and Curlew movement during sever weather;
- Flightlines between roosting and feeding areas;
- Displacement around turbine clusters rather than direct turbine-centre use.

Our concern is that the survey design underestimate mobile weather-dependant and low-frequency species.

The developer has excluded Merlin from meaningful assessment because only two qualifying flights were recorded. Given our concerns relating to the extend of the surveys carried out we do not believe that Merlin should have been excluded. For rare, mobile and difficult-to-detect raptors, low detection should increase caution rather than justify a finding of zero risk. It is incumbent upon the board to ensure full and comprehensive surveys are carried out before a decision is made in relation to this development. It is our opinion due to the out of date nature of the surveys they cannot be relied upon to make when making the boards decision.

In relation to Red listed species such as kestrel the developer while accepting that there is a "long-term Slight Adverse" collision effect has not proposed any specific measures that will be engaged to prevent any collisions. There is no detail on what will actually be done or where.

The EIAR does not identify who will enforce the measures that the developer will take or who will oversee any measures – this raises questions as to what legal enforcement there will be if permission is granted. No evidence has been provided by the developer to make the conclusion that they can be relied upon to ensure full and proper measures are implemented and adhered to. There is no detail as to how long measures would be engaged for and given that the application if for a 35 year lifespan there is no detail or confirmation that measures would be initiated for the lifespan of the development. Or how these measures would be recorded if the developer was to sell upon receiving a grant of approval. This will leave our community and the habitats that are present in the area at the mercy of the developer who has not shown any intention of willingness to engage with the community up to this point. There is no evidence that the developer will in any way work with the community to address any concerns should the board find in favour of this development.

For green listed birds such as the buzzard the developer has used national conservation status as a reason to dismiss local mortality. No assessment has been made in to relation of how losses may effect local breeding pairs and the local ecological balance. Again the developer has used surveys results that despite the acknowledgement of the inevitability of collisions it is an acceptable loss in order to proceed with the development. Local population-level effects and cumulative raptor mortality should be assessed, especially over a 35 -year operational life.

The detailed collision risk assessment is potentially flawed as Passerines, despite some being Red or Amber listed (e.g. meadow pipit, skylark, willow warbler) were largely excluded for detailed collision risk assessment on the basis that they are "generally considered not significantly impacted" by wind farms underestimates impacts on the local biodiversity of the Lacken area.

The uncertainties and assumptions in CRM, especially avoidance rates and flight height accuracy, may lead to underestimation of collision risks, notable for less frequently observed but sensitive species. It should also be noted that no account appears to have been given to the fact the turbines are on an elevated site ranging from approx. 120m to 180m above sea level. This is particularly significantly give the coastal location to the proposed development.

The developer has not provided any site-specific evidence in relation to reduction of habitation loss over time. Displacement should be regarded as habitat loss, particularly for Hen Harrier, Golden Plover, Curlew, Snipe and other species using wet grassland, bog and coastal farmland.

The developers reliance on future surveys and compliance creates serious uncertainty at the decision stage. The board is being asked to approve the development before it knows where nests will be, what exclusion zones will apply, and whether turbine construction, roadworks, felling, drainage or BESS/Substation works can actually avoid disturbance. There is also an issue as to what regulatory authority will be responsible for ensuring that sufficient mitigation measures will be put in place and adhered to.

No assessment has been carried out in relation to the Grid Connection Route (GCR) or Turbine Delivery Route (TDR). The assumption that roadside works are low impact without proper assessment, given the extensive works involved in this project, is a significant flaw in the

application. Insufficient survey coverage of the GCR and TDR potentially overlooks significant effects on birds using these corridors.

No cumulative collision, displacement, habitat loss and barrier effects across the wider north Mayo wind-energy landscape has, being carried out. Given the proliferation of wind farms along the north west cost of Mayo this is a serious flaw in the developers' documents. Only seven days after this most recent application was made the Glenora wind farm site was approved. Also the Keerglen wind farm site was approved by Mayo County Council in November 2025, while this application is under appeal to An Coimsiun Pleanala it is our opinion that the applicant in this case should have taken regard of these wind farms and consider the cumulative effects more stringently.

The assessment is particularly weak in its treatment of Lackan Bay, Killala Bay/Moy Estuary SPA, Golden Plover, Curlew, Whooper Swan, Hen Harrier, Merlin, Kestrel, Snipe and other species associated with coastal, wet grassland, bog and farmland habitats. The applicant's own data records inland feeding by wetland birds and Golden Plover flights at heights relevant to turbine collision risk, yet the report proceeds to dismiss significant effects.

The assessment relies heavily on assumptions that mitigation, future surveys, nest buffers, habitat management and post-construction monitoring will reduce effects. These measures do not remove uncertainty at decision stage. The planning authority cannot lawfully rely on uncertain future mitigation to fill gaps in the baseline assessment.

Before the board can make any decision in relation to this development we stenously request that comprehensive surveys and impact assessments covering the GCR and TDR and wider landscape beyond the 500m buffer are carried out and provided for assessment.

Our group would insist that the developers surveys are revised to include passerine species in collision risk and disturbance assessments due to local conservation importance.

In addition we refer you to submission made by Peter Leonard specifically in relation to concerns raised regarding the Hen Harrier a species that we contend the developer has not given sufficient regard for. The following is a synopsis of the concerns raised by Peter Lenoard.

We would also refer the Board to Stephen Meanys Submission. Stephen is a local birdwatcher with many years' experience and is highly regarded in the area of ornithology. Stephen has provided detailed research with regards to winter roosting habitat for Hen harrier. He also carried out a detailed extensive survey over a 3-month period of December '25 to February '26. Stephen has provided the results of this work in his submission; it is this groups opinion that there is convincing evidence that the area is of high importance to a wide variety of bird species. As a well-respected and recognised birdwatcher Stephen's work speaks for itself. Stephens survey work with birdwatch Ireland and IWEBs is evidence of his expertise and familiarity in this area. It should be noted that the applicant has already shown their regard for Stephen's expertise in the area as the applicant has made reference to him in CH7.

Hen Harrier Assessment – Reliance on Outdated Baseline Data and Underestimation of Displacement Effects

The assessment of impacts on Hen Harrier (*Circus cyaneus*), an Annex I species under the Birds Directive, raises significant concerns regarding the adequacy and currency of the baseline data

used to determine the significance of displacement effects arising from the proposed development.

The applicant's own assessment acknowledges that the Lackan Bay winter Hen Harrier roost has increased in size during the period between the original survey work and the preparation of the application. Chapter 7 records that the roost supported approximately 1–2 birds during the original survey period in winter 2022/23, while local observer (Stephen Meany) data cited and relied upon within the chapter indicates that the same roost supported approximately 3–4 birds by winter 2025/26.

This represents a material increase in the local wintering population and demonstrates that conditions on the ground have changed since the original baseline surveys were undertaken. Notwithstanding this documented increase, the displacement assessment presented in Section 7.4.3.2 continues to conclude that disturbance and displacement effects on Hen Harrier would be of only "Slight Significance".

The assessment does not appear to explain whether this significance rating has been recalculated using the most recent population information. Rather, it appears to remain calibrated to the lower population figures recorded at the commencement of the survey programme several years earlier. This approach is difficult to reconcile with the precautionary principle and with accepted ecological impact assessment practice, which requires assessment to be based upon the best and most up-to-date information available at the time of determination.

The issue is particularly important given the conservation status of Hen Harrier and its recognised sensitivity to disturbance. The chapter itself identifies Hen Harrier as a species requiring detailed assessment, while disturbance and displacement sensitivity ratings adopted from Madders and Whitfield (2006) acknowledge at least a low-to-medium level of sensitivity even outside the breeding season. A growing winter roost population occurring in proximity to the development site warrants reassessment of the significance of displacement impacts using current population levels rather than historical baseline figures that are now several years old.

The concern is compounded by the applicant's own admission regarding survey age. Chapter 7 states:

"As the site surveys for ornithology commenced in summer 2021 and were largely concluded in summer 2023, the survey data are approaching 3 years of age or are more than 3 years of age (with reference to the CIEEM Advice Note 'On the Lifespan of Ecological Reports & Surveys', April 2019)."

This acknowledgement is highly significant. By the time An Coimisiún Pleanála determines this application in 2026, the oldest ornithological baseline data will be approaching five years old. This mirrors concerns identified elsewhere within the EIAR regarding the age of biodiversity survey data and demonstrates a wider issue affecting the reliability of the ecological baseline.

Importantly, the documented increase in the Lackan Bay roost population provides direct evidence that bird usage of the area has changed since the original survey period. Consequently, this is not simply a theoretical concern regarding survey lifespan. It is evidence that the baseline conditions upon which the impact assessment was originally based have measurably altered.

In these circumstances, the conclusion that displacement impacts on Hen Harrier would be of only slight significance cannot be accepted without further justification. The applicant should be required to reassess the displacement significance rating using the most recent available population information and to demonstrate that the conclusions remain valid when current roost numbers are considered.

Reliance on Scottish Guidance Without Clear Justification

A further concern arises regarding the methodological framework adopted throughout Chapter 7.

The vantage point survey methodology, survey effort requirements, collision risk assessment parameters, and disturbance/displacement sensitivity ratings are derived extensively from guidance published by Scottish Natural Heritage (SNH) and its successor, NatureScot. These publications are widely respected and are frequently used throughout the UK and Ireland where equivalent guidance is unavailable. Their use in principle is therefore not objected to.

However, the EIAR does not clearly explain why Scottish guidance was selected as the primary methodological framework for an Irish planning application being assessed under Irish planning legislation, Irish environmental legislation and EU nature conservation law.

Scotland and Ireland differ in a number of relevant respects, including land-use patterns, habitat distributions, breeding bird populations, designated site networks and regulatory frameworks. While cross-jurisdictional guidance may be entirely appropriate in some circumstances, good assessment practice would require the applicant to explain whether Irish-specific guidance was considered and, if so, why it was not adopted as the primary assessment framework.

No explicit discussion was identified within Chapter 7 regarding whether guidance produced by the National Parks and Wildlife Service (NPWS), or any other Irish-specific guidance relating to wind energy developments and bird assessment, was reviewed and considered during preparation of the assessment.

The absence of such an explanation creates uncertainty regarding whether the assessment methodology adopted represents the most appropriate framework for evaluating impacts on Irish bird populations and Irish designated sites.

Cumulative Assessment and Assumptions Regarding Winter Hen Harrier Movements

The cumulative assessment contains a further assertion that merits closer examination.

The chapter states that the Tirawley winter Hen Harrier roost and a separate winter roost identified within the Oweninny Phase 3 study area are located more than 15 kilometres apart and concludes that interchange between the two locations would not normally be expected.

While this appears at first sight to be a reasonable distance-based judgement, the conclusion is presented as an assertion rather than being supported by reference to any specific scientific evidence relating to wintering Hen Harrier ranging behaviour in Ireland.

No Irish study has been cited demonstrating that birds using winter roosts separated by approximately 15 kilometres would not utilise overlapping foraging areas or move between roost locations. Nor does the assessment provide evidence demonstrating that interchange is sufficiently unlikely to be discounted from the cumulative assessment.

Given that wintering Hen Harrier can travel considerable distances between roosting and foraging areas, and given the acknowledged increase in the Lacken Bay roost population, this assumption should not be accepted without supporting evidence. The applicant should be required to provide the scientific basis for the conclusion that interchange would not normally occur between the two roosts and demonstrate that cumulative effects have not been underestimated as a consequence.

Curlew – November 2025 Lacken Beach



Confirmed and Proposed Wind Farms 2026				
Project	**County**	**Developer**	**Status / Planning Body**	**Key Details and Location**
Kingsmountain & Dun neill Wind Farms	Sligo	SSE Renewables	Operational; Repowering Plan	Located near Dromore West; ongoing repowering under the Crumhach project .
Bunnyconnell Wind F arm + Hydrogen Plant	Mayo/ Sligo border	Mercury Renewables	Approved (ABP 317560-23)	13 Turbines (78MW) plus hydrogen plant (80MW), at Carrowleagh (Bonniconlon) and Castleconnor
Tirawley Wind Farm	Mayo	Constant Energy Ltd	Strategic Infrastructure Developmen t submitted (ABP 324258)	16 Turbines in Lacken total 93– 96 MW; grid connection to Tawnaghmore su bstation .
Keerglen Wind Farm	Mayo	ABO Energy Ireland L td	Under assessment (MCC Ref 24605 37)	8 turbines (max 180 m), Ballinglen region be tween Belderrig and Ballycastle .
Firlough Wind Farm & Hydrogen Plant	Mayo / Slig o border	Mercury Renewables (Carrowleagh Ltd)	ABP 317560- 23 (Same hydrogen corridor)	Cross-county renewable complex integrating wind and hydrogen production .
Croagh Wind Farm	Sligo / Leit rim	Coillte	Proposed (submission pending)	Up to 10 turbines (~170 m tip), upper Ox Mo untains area .
Lackan Extension & L eitrim–Sligo Cluster	Sligo	Private applicant	Under evaluation (SCC PL 20/251)	Ten-turbine project with cross- county elements to Leitrim; EIAR and NIS s ubmitted .
Glenora	Mayo	Glenora windfarm DAC	Granted	22 turbines

Cummulative effect of wind farm from Sligo to Achill Island

The proposed Tirawley Wind Farm cannot be assessed in isolation. It forms part of a rapidly expanding network of operational, consented, proposed and emerging wind energy developments extending along the Atlantic coastline from County Sligo to Achill Island in County Mayo.

As of June 2026, multiple wind farm developments are either operational, approved, under consideration by An Coimisiún Pleanála, or progressing through the planning process within this coastal region. When viewed collectively, these developments create a renewable energy corridor extending approximately 100–105 kilometres along the western seaboard from Dromore West in County Sligo to Achill Island in County Mayo.

The significance of this cumulative development pattern is that it coincides with one of Ireland's most important ecological corridors for migratory birds, breeding seabirds, wintering waterfowl and protected bat species. The cumulative environmental consequences of this concentration of wind energy infrastructure must therefore be considered at a regional scale rather than on a project-by-project basis.

The Emerging Sligo–Mayo Wind Energy Corridor

When mapped sequentially from east to west, the principal operational, approved and proposed wind energy clusters include:

Kings Mountain / Dunneill Cluster (Dromore West)

Bunnyconnellan / Carrowleagh / Castleconnor developments

Tirawley Wind Farm

Glenora Wind Farm

Keerglen Wind Farm

Bellacorick Cluster and associated developments

Future high-potential wind resource areas identified towards Belmullet and Achill.

Collectively these developments create what is effectively a near continuous wind energy corridor extending across approximately 90–95 kilometres of the Atlantic coastline, with many projects situated within 5–10 kilometres of the coast. Major active planning applications currently include Tirawley Wind Farm, Glenora Wind Farm, Keerglen Wind Farm and Muingmore Wind Farm in addition to existing operational developments.

The cumulative result is one of the most densely developed or proposed renewable energy landscapes in Ireland. The scale of development now extends far beyond individual project assessment and raises legitimate concerns regarding regional ecological carrying capacity, cumulative landscape effects and the long-term conservation status of protected species.

Importance of the Mayo–Sligo Coast for Migratory Birds

The Mayo and Sligo coastline forms part of the East Atlantic Flyway, one of the world's most significant migratory bird routes. Millions of birds use this flyway annually during spring and autumn migration periods.

The coastal region between Killala Bay, Broadhaven Bay and the Mullet Peninsula supports internationally important populations of migratory seabirds, wildfowl and waders and contains numerous Special Protection Areas designated under the Birds Directive.

Key migration characteristics of the region include:

Major spring and autumn movements of shearwaters, petrels, skuas, gannets, terns and auks.

Winter migration routes for Barnacle Goose, Greenland White-fronted Goose and Whooper Swan.

Significant breeding colonies of Kittiwake, Guillemot, Fulmar and Razorbill.

Important intertidal feeding areas around Killala Bay, Lacken and Inishcrone.

Regular movements of swans and geese through the corridor at altitudes intersecting turbine rotor swept areas.

The Tirawley Wind Farm Environmental Impact Assessment itself recorded regular activity by species including Whooper Swan, Greenland White-fronted Goose, Golden Plover and Lapwing within the Ballycastle–Killala area during migration periods.

Protected and Threatened Species

The coastal corridor supports numerous species protected under the Birds Directive, the Wildlife Acts and Birds of Conservation Concern in Ireland (BoCCI).

Species of particular concern include:

Curlew

Lapwing

Golden Plover

Greenland White-fronted Goose

Whooper Swan

Corncrake

Kittiwake

Razorbill

Common Scoter

Arctic Tern

Red-throated Diver

Peregrine Falcon

Short-eared Owl

Black Guillemot.

Many of these species are listed as Red List species in Ireland, are included on Annex I of the Birds Directive, or are considered internationally vulnerable due to population declines. Several depend directly on habitats located within or adjacent to the proposed wind farm corridor extending through North Mayo and into Sligo.

Bat Species and Ecological Connectivity

The region is also important for bats. Species including Leisler's Bat, Common Pipistrelle and Nathusius' Pipistrelle utilise the coastal landscape, wetlands, rivers and forest edges for foraging, commuting and seasonal dispersal.

Riparian corridors associated with the River Moy and other river systems provide important ecological connectivity across the region. Nathusius' Pipistrelle in particular is recognised as a migratory species whose movements may overlap with proposed wind energy developments.

The concentration of multiple wind farms within a relatively confined geographical area increases the potential for cumulative collision risk, habitat fragmentation and barrier effects affecting both bird and bat populations.

Cumulative Ecological Impacts

The principal cumulative risks arising from the combined effect of existing, approved and proposed developments include:

Collision Mortality

Large birds such as Whooper Swan, Greenland White-fronted Goose and Curlew are particularly vulnerable to turbine collision due to their size, flight characteristics and regular use of migratory corridors. Multiple wind farms increase the overall exposure of these species to collision risk across a much larger geographical area.

Displacement and Barrier Effects

The cumulative presence of turbines can create barriers within migration routes, causing birds to alter flight paths, expend additional energy and lose access to traditional feeding or resting areas. These effects become increasingly significant as individual developments merge into a continuous corridor.

Habitat Fragmentation

Wind farm construction, associated roads, substations, battery storage facilities and forestry clearance can contribute to the fragmentation of habitats used by birds and bats. While each development may appear manageable in isolation, the cumulative effect across the region becomes increasingly significant.

Flyway Disruption

Of particular concern is the creation of a sequence of wind energy developments extending from Sligo Bay through Killala Bay, Ballycastle, Broadhaven Bay and onwards towards Achill. The cumulative effect may be to create repeated obstacles across a recognised Atlantic migratory corridor.

European Conservation Obligations

Under Article 6 of the Habitats Directive (92/43/EEC) and Article 4 of the Birds Directive (2009/147/EC), competent authorities are required to ensure that projects, either individually or in combination with other plans and projects, do not adversely affect the integrity of protected sites or the conservation status of protected species.

The European Court of Justice has repeatedly confirmed that these obligations extend beyond the boundaries of designated sites where species depend on surrounding habitats and ecological networks.

The cumulative assessment obligation is therefore particularly relevant in the context of the North Mayo and Sligo coastline, where multiple wind farm developments are being progressed simultaneously within the same ecological landscape and migratory corridor.

Conclusion

The proposed Tirawley Wind Farm must be assessed not simply as an individual development but as one component of a rapidly expanding wind energy corridor extending approximately 100 kilometres along Ireland's north-west coast.

The concentration of operational, approved and proposed wind farms between Sligo Bay and Achill Island creates overlapping and potentially significant cumulative impacts on internationally important migratory bird routes, protected species, bat populations and ecological connectivity.

Particular concern arises in relation to Annex I bird species, Red List species and internationally protected migratory populations that utilise the Killala Bay, Broadhaven Bay and wider North Mayo coastal landscape. While individual developments may propose mitigation measures, the cumulative effect of multiple projects across the same ecological corridor raises serious questions regarding compliance with the Birds Directive, Habitats Directive and the precautionary principle.

In the absence of a comprehensive regional assessment of the cumulative impacts of all existing, approved and proposed wind energy developments across this corridor, it cannot be concluded with confidence that the integrity of protected ecological networks, migratory routes and conservation objectives will be maintained over the lifetime of these projects.

Below is a table detailing bird sightings from 2024 to 2026

Record Date	Common Name	Location Name	Latitude	Longitude	Taxon Image	Abundance	Activity	Additional information
9/6/2026	Buzzard	Ballycastle, mayo	54.23166487	-9.28864195	https://records.bio	1	Summering non-br	Add Comment
28/4/2026	Marsh Harrier	Lacken, mayo	54.28642385	-9.34123085		1	Flying over	Add Comment
18/4/2026	American Mink	Killala	54.22469629	-9.27720023		1		Add Comment
4/4/2026	Kestrel	Ballycastle, mayo	54.29488848	-9.32430494		2	Pair seen	Add Comment
14/3/2026	Kestrel	Ballycastle, mayo	54.29208272	-9.33203309	https://records.bio	1	Flying over	Add Comment
8/3/2026	Hen Harrier	Kilbride, ballycastle	54.29522798	-9.32310251	https://records.bio	2	Pair seen	Add Comment
26/2/2026	Kestrel	Ballycastle, mayo	54.29514033	-9.32442568	https://records.bio	2	Pair seen	Add Comment
30/12/2025	Kestrel	Ballycastle, mayo	54.29539984	-9.32385001	https://records.bio	1	Present	Add Comment
30/12/2025	Kestrel	Ballycastle, mayo	54.29535966	-9.32387297			Present	Add Comment
30/12/2025	Kestrel	Ballycastle, mayo	54.29148408	-9.33828147		1	Flying over	Add Comment
29/12/2025	Peregrine	Ballycastle	54.28709443	-9.34033654		1	Flying over	Add Comment
29/12/2025	Buzzard	Ballycastle, mayo	54.26208816	-9.33172326	https://records.bio	1	Flying over	Add Comment
20/12/2025	Kestrel	Ballycastle, mayo	54.29512579	-9.32302638		1	Flying over	Add Comment
6/12/2025	Kestrel	Ballycastle, mayo	54.29514166	-9.32305745	https://records.bio	1	Flying over	Add Comment
20/11/2025	Barn Owl	Lacken	54.24032233	-9.29914196		1	Flying over	Add Comment
20/10/2025	Long-eared Owl	Lacken, mayo	54.27931335	-9.31362564		1	Present	Add Comment
13/10/2025	Buzzard	Ballycastle, mayo	54.28655641	-9.34109003		1	Flying over	Add Comment
8/10/2025	Buzzard	Ballycastle, mayo	54.29506278	-9.32308333	https://records.bio	1	Flying over	Add Comment
5/10/2025	Buzzard	Ballycastle, mayo	54.29511799	-9.32305507		1	Flying over	Add Comment
20/9/2025	Buzzard	Lacken, mayo	54.30620744	-9.31576495	https://records.bio	1	Flying over	Add Comment
7/9/2025	Buzzard	Ballycastle, mayo	54.29154288	-9.32260291	https://records.bio	1	Present	Add Comment
3/9/2025	Kestrel	Ballycastle, mayo	54.29242353	-9.33268951	https://records.bio	1	Flying over	Add Comment
3/9/2025	Buzzard	Ballycastle, mayo	54.29244241	-9.33275797	https://records.bio	1	Flying over	Add Comment
25/8/2025	Buzzard	Ballycastle, mayo	54.29180931	-9.32046163	https://records.bio	1	Present	Add Comment
24/8/2025	White-tailed Eagle	Ballycastle, mayo	54.29512903	-9.32307575	https://records.bio	1	Present	Add Comment
8/7/2025	Sparrowhawk	Ballycastle, mayo	54.29514417	-9.32300502	https://records.bio	1	Flying over	Add Comment
12/6/2025	Buzzard	Ballycastle, mayo	54.28912131	-9.33901048	https://records.bio	1	Present	Add Comment
1/6/2025	Kestrel	Ballycastle, mayo	54.29549911	-9.32380134		1	Flying over	Attacking a larger black bird - like a common crow or raven.
22/2/2025	Kestrel	Ballycastle	54.29509926	-9.32299899		2	Flying over	Add Comment
7/2/2025	Golden Plover	Ballycastle, mayo	54.2951358	-9.32302249		4	Flying over	Add Comment
1/1/2025	Kestrel	Ballycastle, mayo	54.29537593	-9.3238177	https://records.bio	1	Present	Open faced shed
27/12/2024	Kestrel	Ballycastle	54.29548924	-9.32351018	https://records.bio	1	Present	Trapped in shed. Unwilling to fly out open door
15/12/2024	Buzzard	Crott	54.29056583	-9.32927353		1	Flying over	Add Comment
16/11/2024	Kestrel	Ballycastle	54.29526026	-9.32328109	https://records.bio	1	Flying over	Add Comment
12/10/2024	Kestrel	Ballycastle mayo	54.29410921	-9.3231743	https://records.bio	2	Flying over	Add Comment
28/9/2024	Kestrel	Ballycastle, mayo	54.29406788	-9.32327626	https://records.bio	2	Flying over	Add Comment
6/9/2024	Corncrake	Ballycastle, mayo	54.29511099	-9.3230569			Singing male	Add Comment

1/7/2024	Kestrel	Ballycastle, mayo	54.29501174	-9.32159314		2	Flying over	Add Comment
1/7/2024	Kestrel	Ballycastle, mayo	54.29446222	-9.31993495	https://records.bio	2	Pair seen	2 kestrels searching area. Hard to get a
1/7/2024	Kestrel	Ballycastle, mayo	54.29541704	-9.32093952	https://records.bio	2	Flying over	Add Comment
19/6/2024		Ballycastle, mayo	54.30728733	-9.50108321		1000		Whole hillside of it
15/4/2024	Kestrel	Ballycastle	54.29524035	-9.32298093		1	Flying over	Add Comment
28/3/2024	Buzzard	N5	53.88134101	-9.211064		1	Flying over	Add Comment
27/3/2024	Kestrel	Ballycastle, mayo	54.29507238	-9.32290147		1	Present	Add Comment
21/3/2024	Kestrel	Ballycastle, mayo	54.29528951	-9.32392113	https://records.bio	1	Flying over	Add Comment
18/3/2024	Kestrel	Ballycastle	54.29525301	-9.32337488		1	Flying over	Add Comment
2/12/2023	Snipe	Ballycastle	54.28698657	-9.31712106			Present	Add Comment
15/10/2023	Snipe	Ballycastle Co. Mayo F26 A061	54.28927399	-9.31504126				Add Comment
15/10/2023	Snipe	Ballycastle Co. Mayo F26 A061	54.29120987	-9.3140273		1	Present	Add Comment
30/9/2023	Merlin	Ballycastle Co. Mayo F26 A061	54.29186433	-9.33665869	https://records.bio	1	Flying over	Add Comment
25/9/2023	Grey Heron	Palmerstown	54.22727355	-9.26437902		2	Flying over	Add Comment
19/8/2023	Golden Eagle	Crott, Ballycastle Co. Mayo	54.28549865	-9.34311116	https://records.bio	1	Present	Hanging around this area the last few days
18/8/2023	Golden Eagle	Ballycastle Co. Mayo F26 A061	54.28534711	-9.34343697	https://records.bio	1	Present	Was resting in a recently harvested meadow in Crott. Took flight and flew westward. Slowly Circled over forestry and continued further west out of sight
10/8/2023	Kestrel	Ballycastle Co. Mayo F26 A061	54.28530872	-9.34349114		1	Present	Add Comment
5/8/2023	Kestrel	Ballycastle Co. Mayo F26 A061	54.29502678	-9.32313533		1	Flying over	Add Comment
18/6/2023	Kestrel	Ballycastle Co. Mayo F26 A061	54.29180662	-9.32126365		1	Present	Add Comment
7/6/2023	Kestrel	Kilbride, Ballycastle	54.29121193	-9.32030694	https://records.bio	1	Flying over	Add Comment
12/5/2023	Irish Hare	Kilbride	54.2908238	-9.32655104	https://records.bio	1		Add Comment
10/2/2023	Irish Hare	Ballycastle Co. Mayo F26 A061	54.29283239	-9.33203501		1		Add Comment
10/2/2023	Irish Hare	Ballycastle Co. Mayo F26 A061	54.28594516	-9.34216392		2		Add Comment
2/2/2023	Irish Hare	Ballycastle Co. Mayo F26 A061	54.29201801	-9.3356475				Add Comment
25/11/2022	Irish Hare	Ballycastle Co. Mayo	54.2929423	-9.33175008		1		Add Comment
10/11/2022	American Mink	Lacken	54.23132235	-9.28834431		1		Add Comment
4/10/2022	Kestrel	Ballycastle Co. Mayo	54.28554903	-9.34327796		1	Flying over	Add Comment
20/5/2022	Irish Hare	Ballycastle, mayo	54.29508898	-9.3231755	https://records.bio	1		Add Comment
3/5/2022	Grey Wagtail	Ballycastle Co. Mayo	54.29459122	-9.31914177		1	Present	Add Comment
3/5/2022	Irish Hare	Ballycastle Co. Mayo	54.29464478	-9.32393923		1		Add Comment
27/4/2022	Pied Wagtail	Ballycastle Co. Mayo	54.29457888	-9.31971775		3	Present	Add Comment
27/4/2022	Small White	Ballycastle Co. Mayo	54.28642508	-9.34155093		1		Add Comment
26/4/2022	Cuckoo	Ballycastle Co. Mayo	54.27737648	-9.43192054		1	Singing male	Add Comment
26/4/2022	Cuckoo	Ballycastle Co. Mayo	54.27738495	-9.43196977			Singing male	Add Comment
25/4/2022	Grasshopper Warb	Ballycastle Co. Mayo	54.2950042	-9.32484265	https://records.bio	1	Present	Add Comment

25/4/2022	Irish Hare	Ballycastle Co. Mayo	54.29516223	-9.32324455	https://records.bio	1		A big one and a small one hanging
23/4/2022	Dock Bug	Ballycastle Co. Mayo	54.28707449	-9.34257958	https://records.bio	20		Add Comment
23/4/2022	Dock Bug	Ballycastle Co. Mayo	54.28705635	-9.34256615	https://records.bio	3		Add Comment
23/4/2022	Dock Bug	Ballycastle Co. Mayo	54.28701642	-9.34285894	https://records.bio	10		Add Comment
23/4/2022	Dock Bug	Ballycastle Co. Mayo	54.28651279	-9.34266747	https://records.bio	50		Field heavily populated with them.
19/4/2022	Irish Hare	Ballycastle Co. Mayo	54.29522263	-9.32303702	https://records.bio	1		Add Comment
2/4/2022	Common Frog	Ballycastle Co. Mayo	54.29523386	-9.32397696	https://records.biodiversityireland.ie/storage/record-ima			Add Comment
27/3/2022	Pheasant	Ballycastle Co. Mayo	54.29462179	-9.32523656	https://records.bio	1	Present	Add Comment
27/3/2022	Pheasant	Ballycastle Co. Mayo	54.29443924	-9.32522687	https://records.biodiversityireland.ie/storage/record-ima			Add Comment
21/10/2021	American Mink	Ballycastle Co. Mayo	54.27986367	-9.31596283		1		Add Comment
4/9/2021	Kestrel	Kilbride	54.29171337	-9.33901596		1	Flying over	Add Comment
13/7/2021	Starling	Kilbride	54.29480322	-9.32000874		150	Flying over	Add Comment
26/6/2021	Pine Marten	(54.2859374, -9.3744915)	54.29539372	-9.32277164	https://records.bio	1		Juvenile
25/6/2021	Pine Marten	Kilbride	54.2948979	-9.32278597	https://records.bio	1		Add Comment
23/6/2021	Fox	Kilbride	54.29633486	-9.31870191	https://records.bio	1		Add Comment
16/6/2021	Blackbird	Kilbride	54.2949845	-9.32309506	https://records.bio	20	Present	Add Comment
14/6/2021	Irish Stoat	Kilbride	54.29598334	-9.32788755		1		Moved away before i could photograph it. Lots of hares in this area
8/6/2021	Shrimp	Kilbride	54.29571435	-9.31913902	https://records.biodiversityireland.ie/storage/record-ima			Add Comment
8/6/2021	Common Frog	Kilbride	54.29575799	-9.31918389	https://records.biodiversityireland.ie/storage/record-ima			Add Comment
23/5/2021	Brown Hare	Kilbride	54.29513397	-9.3230319	https://records.bio	1		Add Comment
7/5/2021	Grey Wagtail	Kilbride, ballycastle	54.29522643	-9.32272104	https://records.bio	1	Present	Like a grey wagtail, but it Has a dark band across the face
23/4/2021	Golden Plover	Kilbride	54.29352304	-9.32434167	https://records.bio	3	Summering non-br	Add Comment
23/4/2021	Jackdaw	Kilbride	54.29504014	-9.3231892	https://records.bio	1	Present	Add Comment
17/4/2021	Golden Plover	Kilbride, ballycastle	54.29508989	-9.32298017	https://records.bio	100	Present	Flock
8/4/2021	Irish Hare	Kilbride, ballycastle, mayo	54.29522063	-9.32311939	https://records.biodiversityireland.ie/storage/record-ima			Add Comment
1/3/2021	Irish Hare	Ballycastle Co. Mayo	54.29492899	-9.32315353	https://records.bio	1		Add Comment
1/3/2021	Irish Hare	Ballycastle Co. Mayo	54.29493682	-9.32322887		1		Add Comment
24/2/2021	Common Frog	Conachry, ballycastle, mayo	54.28053249	-9.30540861	https://records.biodiversityireland.ie/storage/record-ima			Add Comment


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A composite of diving Ganet – August 2025



Bar tailed godwits, Jan 2024



CornCrake May 2025



Golden Plover April 2022



Golden Plover April 2022



Jay Bird March 2023

ARCHAEOLOGY

Cultural Heritage Section

1.Deficiencies in applicant's assessment.

The cultural heritage section of the application completely fails to recognise the exceptional archaeological sensitivity and national and international importance of the landscape proposed as the location for this development. The analysis presented by the applicant is fundamentally deficient, comprising only the most basic and cursory review of recorded monuments within a limited framework. The methodology adopted is predominantly based on a visual walkover survey and desk top studies which cannot identify peat-covered or sub-surface archaeology characteristic of this area. No proper investigative analysis has been carried out. As we will demonstrate, the basic fundamental methodological flaws and substantial omissions in this section cast serious doubt on the ability of the applicant to appreciate the significance both nationally and internationally of the cultural heritage of the Lacken area.

The location proposed for the development is close to the world renowned Ceide Fields complex – whose Neolithic field systems and dwellings extend invisibly beneath blanket bog for several kilometres and right into the Lacken area. As explained below, archaeological studies confirm this fact. The applicant has not carried out a geophysical survey, test trenching or archaeological monitoring in order to establish if the Ceide field -system lies underneath the soil.

At a preplanning consultation held with Mayo County Council in August 2023, the council explained one of the reasons why the application could not be supported as follows:

"The turbines will be visible from the Ceide Fields which is on tentative UNESCO Tentative World Heritage Site. The development plan seeks to protect the Ceide Fields from inappropriate development. The full extent of the Ceide Fields archaeology site is unknown and may reach as far as the windfarm site. "

Given the supreme national and international value of the Ceide Fields system, it was remiss of the applicant to adopt a weak methodology such as desk reviews and walkovers to attempt to assess the archaeological profile of the area. Planning legislation requires the full identification, protection and assessment of archaeological and architectural heritage and their settings. The applicant has failed to do this.

The applicant failed to highlight the archaeological significance of monuments in the area such as the megalithic monument, the Rathfran Court Tomb which is exceptionally well preserved with rare features. It is one of the finest examples of court tombs in the country located as it is within a prehistoric landscape of dwelling houses and megalithic tombs within a countryside of stone walled fields preserved beneath bogland constructed 5,300 years ago. Many archaeologists believe that the potential exploratory excavation of the Lacken Hill/Rathlacken area excavation could reveal a repository, a goldmine of valuable artefacts

2.Cultural Heritage Treasure of the Lacken Area

In this section, we demonstrate the vital importance of this area in terms of cultural heritage and ancient history to explain why such an ancient sacred landscape should not be despoiled and degraded by a large-scale windfarm.

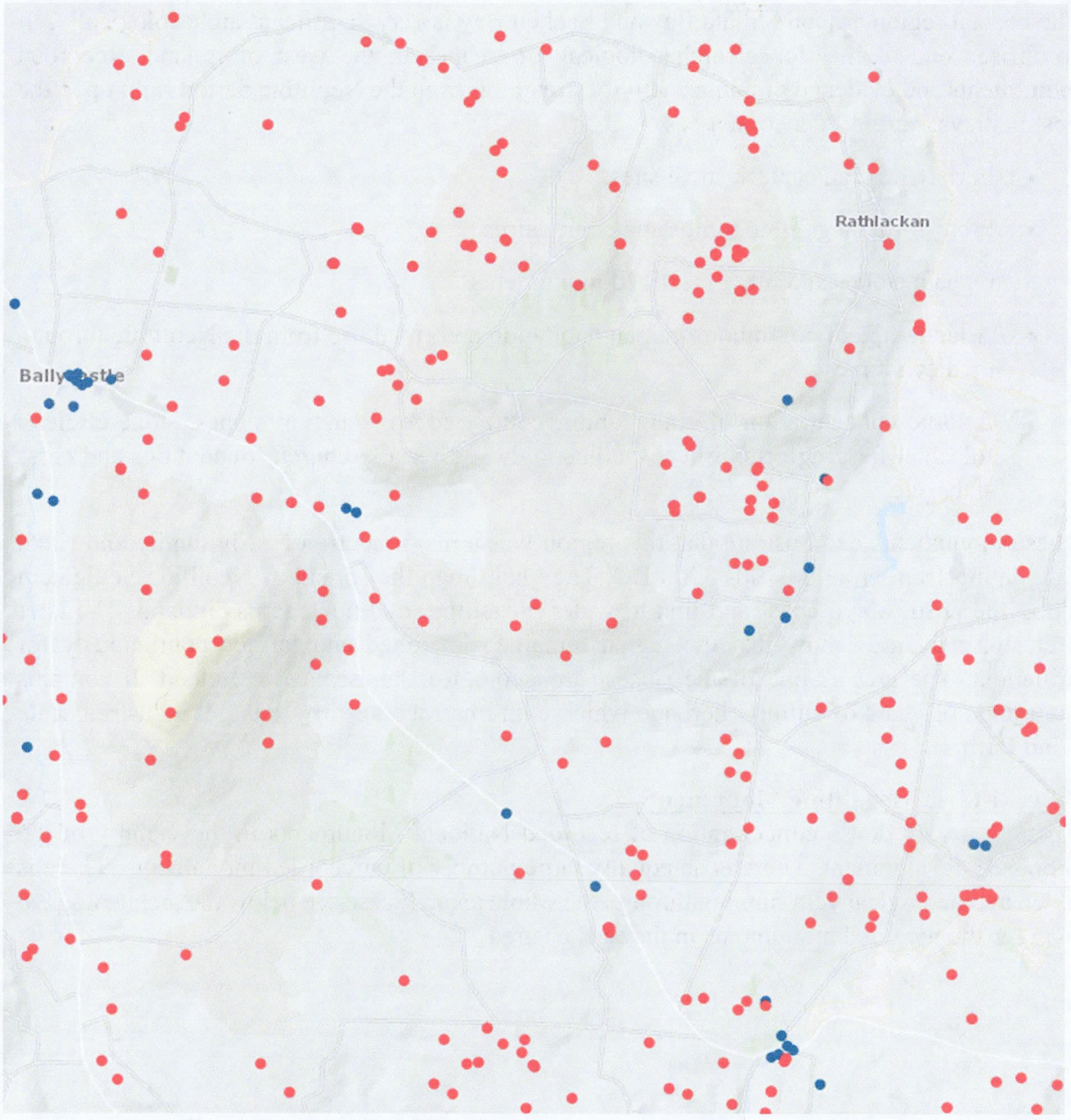
The coastal region around Killala Bay and Lacken Bay is very significant archaeologically. It comprises one of the richest archaeological landscapes in the west of Ireland. Recorded monuments and evidence of human activity stretching from the Neolithic period right up to the postmedieval period; it encompasses:

- Early Christian ecclesiastical sites.
- Prehistoric megalithic tombs and court cairns.
- Ogham stones and other inscribed monuments.
- A landscape of continuous human habitation and ritual use from the Neolithic through medieval times.
- A large concentration of court tombs, court wedges, standing stones, stone circles , fulachtai fia, ringforts, lisheens, cilins, holy wells, early church foundations and cross slabs, etc

These monuments demonstrate that this region was a major centre of early family and ritual life, dating from around 3700- 3200 BC. They help map the spread of Neolithic Settlement along the north Mayo coast and link to wider megalithic traditions across Ireland. The later prehistoric features show that the region remained inhabited and farmed continuously for millennia. The area is one of the richest archaeological landscapes in Ireland. It contains thousands of years of cultural heritage which could be sabotaged by a large, industrial scale wind farm.

3.Prehistoric Megalithic Monuments

There is a very dense concentration of recorded National Monuments in the vicinity of the proposed development. There is an equally large number of unrecorded monuments. There is a rich archaeological vein running through the whole area. Please see below the archaeological map for the recorded monuments in the Lacken area.



- Rathlackan court cairn (near the proposed wind site) is an extremely well-preserved court-cairn set within field walls, dating from the Neolithic period.
- Carbad More (south Lacken) is a double court tomb (Neolithic) and a National Monument.
- Breastagh Ogham Stone (Breastaigh 2k from proposed wind farm) is an Ogham-inscribed standing stone with a nearly medieval inscription and National Monument.
- Rathfran Wedge Tomb was built c. 2500-2000 BC in the Bronze Age. A stone circle stood close to this tomb.

These show that the area has very early ritual/burial landscapes (Neolithic) evolving through later prehistoric/early historic periods.

4. Early Christian and Medieval Ecclesiastical sites.

Rathfran Dominican Friary overlooking the Palmerstown River. Founded in 1274 Well preserved with many notable features.

St Cuimins Church and Holy Well, Kilcummin. The church and graveyard date to prior 700AD. There are two tall Christian standing stones and a sun dial located here.

The holy well is an ancient pilgrimage site which attracted thousands of visitors from as far away as the Erris region each year. Mass and prayer rituals are practised to the present day.

St Patricks Statue and Holy Well at Foghill. Most patrician academic scholars are now satisfied that St Patrick spent his youth here in Foghill, The Wood of Focult. This has been a place of pilgrimage for generations.

The Druids Chair at Mullagh na Croise . This place was believed to be the centre of Druidry in Connacht. The location has panoramic views in all four directions. (Just 2k from nearest proposed turbine.) These attest to the long-standing Christian and pre-Christian occupation and its importance in ecclesiastical networks in the Lacken area.

The Old Lacken Hill Church. This is one of the oldest ecclesiastical centres in the area located on elevated ground overlooking Lacken Strand and Bay. It is considered to be of great antiquity and predated the nearby Kilogeary Church which is a significant structure in its own right. The new Lacken cemetery is located across the road. Both are within metres of the proposed windfarm.

5. Landscape and historic context

Saint Patrick described his captivity in the "Wood of Foclut" at Foghill. This is the only place in Ireland that Saint Patrick actually named in his writings. St Cuimin's Church and Grave at Kilcummin and St Gabriels Well at Beltra and the Druids Chair gives the area a mythic and historic resonance. Foghill in Lacken is a renowned sacred landscape. Beside the well stands Leac Balbeni, a bronze age standing stone, a significant landmark. (This is less than 2k from the windfarm site).

- The combination of coastal, bog, and upland terrain means that ancient field systems, tombs and ritual places are well preserved. For example, the Neolithic field system of Céide Fields extends into Rathlacken, Gallows Hill and the area of the proposed windfarm site.
- Because of this layering of prehistoric, early and late medieval history, the area provides exceptional continuity of human use and archaeological depth. This is rare in Ireland.
- The Lacken "Gazebo" is one of the most unusual and distinctive landmarks to be found in County Mayo. Forming a double arch of rough stones, the structure stands on the summit of Lacken Hill at the back of Castlelacken. It was erected in 1794 by Sir John Palmer and is believed to have "masonic "connections. There are remarkable views from this site. On a clear day you can see the mountains of Donegal, Ben Bulben and south to Croagh Patrick. A view handed down through the generations is that it may be astrologically aligned with other local structures such as the Ogham Stone at Breastaigh , The Druids Chair at Mullagh and the Stone Circle/Wedge tomb at Rathfran Park. The

concept of two large turbines being erected on both sided of the Gazebo is unfathomable and an insult to anyone with a modicum of concern for our cultural heritage.

- Beneath the Gazebo stands of the ruins of Castlelacken House.The site originally contained an older castle which stood on the lands of the MacEgan family and was thought to be a medieval fortress. The Gazebo and the Castlelacken were designed as part of the same landscape. Important artefacts have been discovered in the Castlelacken area. The Castle ruins are within stones throw of the proposed windfarm.
- Summerhill House, an architecturally substantial Georgian house with magnificent views over the Rathfran Estuary and Killala Bay stands near the ruins of Rathfran Abbey. It was an mid- eighteenth-century country house and was the seat of the Palmer family.
- Lissadrone House. This was an old eighteenth century country house, the seat of the Pugh family with an estate of two thousand years. It was a notable estate house in its time. Its demesne walls and old trees are still visible. Several wind turbines are proposed to within 600 metres of this site.
- Kilogeary Church of Ireland. This old church is visible from the main road set beside an ancient graveyard. Samuel Lewis in 1837 described the church as "a small ancient building ". Earlier ecclesiastical buildings are believed to have existed here for centuries. This church building is located less than 1km from the windfarm site.

Castlenageeha (Castlemagee). This was an old coastal castle overlooking Killala Bay with one of the most dramatic viewpoints in the county. It was built in a strategic position to observe the bay and prevent seaborne attacks. It is believed to be several centuries old.

- St Cuimins Church. This was an eight century Christian church founded by St Cuimin a revered local saint thought to have lived in the seventh century. Close to the church are two tall early Christian cross pillars, a sun dial and a holy well. It is an old pilgrimage site which in olden times was visited by thousands of pilgrims many coming from the Erris region on foot. Nearby is Kilcummin Harbour where the historic landing of French forces under General Humbert took place in August 1798.
- Kilbride Church (just 2km west of the wind farm site) is an ancient ecclesiastical site beside the old Kilbride graveyard. It was a penal era church which closed circa 1808. Closeby stands an early Christian standing stone dating back to the 7th century.
- Leac Balbeni is a tall imposing standing stone beautifully located at Foghill near Lacken strand. Nearby is a souterrain with a large underground chamber.
- Greenhill Mound. At Beltra, is located a large circular mound close to the seashore. Erosion in the 1950's revealed numerous human bones that had been buried in long stone cists thought to be from the early medieval times
- Rathfran Stone Circle. This is located close to Summerhill House and Rathfran Abbey. Archaeologists have recorded two related stone circles here. They are dated to 2,500 BC , the late neolithic period.

- Rathfranpark Wedge Tomb dates to 2500 Bc and comprises of a megalithic burial monument built from enormous boulders, standing on elevated ground overlooking the Rathfran estuary and Killala Bay. It is very impressive prehistoric monument important and archaeologically very significant.

- Carbad Mor Court Tomb is a double court cairn dating to 4000Bc. It is unique because it contains two burial courts at opposite ends. It is thought to have been a communal burial place and a ritual gathering place. It is a National monument of considerable archaeological merit.

- The Breastagh Ogham Stone is one of the most important ever medieval inscribed stones in Ireland. It comprises of a large, tall standing stone carved in ornate ogham script. It is particularly significant because it preserves a long royal genealogy in primitive Gaelige. Moreover, it anchors the early medieval landscape of Tirawley all around it. This area of Rathfran/Summerhill is of supreme importance in cultural heritage terms as the entire area constitutes a major ceremonial and burial landscape for prehistoric communities five thousand years ago. It is within 2.5km of the proposed development.

6. Reasons for its Archaeological Importance.

- **Rarity and preservation**: Some of the monuments (court cairns, double court tombs, standing stones and Ogham stones) survive well in this area and are renowned for their uniqueness and originality. The area contains one of the highest densities of Neolithic court tombs in Ireland. This was confirmed by de Valera and O Nuallain in their seminal work "Survey of the Megalithic Tombs of Ireland.

- **Chronological sweep**: From Neolithic (c. 4000–2500 BC) through Bronze/Iron Age, early Christian, to medieval times, unbroken occupation. The area contains a rich, multi-period landscape that tells the story of Mayo's human history from the first farmers to modern times.

- **Landscape integration**: The monuments are not isolated; they are part of a vast neolithic field system, settlement patterns, and the natural environment (bogs, coast, uplands).

- **Cultural significance**: Sites like the Round Tower in Killala and Rathfran Abbey, St Cuimins Church, and the Church of Ireland building at Killogeary link to early bishoprics and ecclesiastical history; the strong connection to St. Patrick and St Cuimin adds legendary value. The area is a major centre of pre and early Christianity. Killala and surrounding areas were an important centre of freemasonry in the eighteenth and nineteenth centuries.

- **Important Artefacts**: Many artefacts have been found locally, are now in the National Museum many of these in the Lissadrone area which is earmarked by the applicant for several turbines. These artefacts suggest continuity of occupation and evolving social structures.

Some of the most notable Bronze Age artefacts are replicated in the Céide Fields visitor centre. Including the Bronze halberd with oak handle from Carn (N.M.I. 1939:146), the gold torc from Lissadrone (N.M.I. 1888:14) and the copper flat axehead from Castletown (N.M.I. 1929:1338).



- **Tourism & heritage**: The region is recognized for its archaeological heritage and features in heritage literature and visitor guides. The area around Lacken is of very high importance in terms of archaeological monuments.
- The area is more than locally important; it contributes significantly to global prehistoric and early medieval heritage. If you are studying archaeology, heritage management, or interested in ancient landscapes, this region is a key area.

7.Ceide Fields.

The Céide Fields complex in County Mayo, Ireland, is one of the most archaeologically significant prehistoric landscapes in Europe and is world renowned. Its significance lies in its age, preservation, and the insights it provides into Neolithic life and land use. We set out below its key features

- The Céide Fields Complex date to around 5,700–5,500 years ago (c. 3700–3500 BCE), placing them firmly in the Neolithic period.
- This makes the site older than the Egyptian pyramids and among the earliest known examples of a planned agricultural landscape anywhere in the world.
- The complex preserves a large-scale network of stone walls, field boundaries, enclosures and dwelling sites.
- These are buried beneath a blanket of peat up to 4 metres deep, which has protected the original Neolithic landscape almost perfectly.
- The field system covers Belderrig to Lacken suggesting a well-organized farming community with clear land division and long-term settlement planning.

- The fields were used for cattle grazing and mixed farming, indicating a stable, sedentary agricultural economy rather than transient or shifting cultivation.
- The organization of the fields reflects communal planning and cooperation-evidence of social complexity among Neolithic farmers.
- Artefacts and pollen analyses show that woodlands were cleared for agriculture, giving us a vivid picture of early environmental management.
- The overlying peat growth tells a story of climate change and landscape transformation.
- The shift from fertile farmland to blanket bog around 3000 BC likely reflects cooler, wetter conditions that made farming unsustainable linking the site to wider patterns of environmental change in prehistoric Europe.
- The Céide Fields are often cited as the world's oldest known field system. It is older than the pyramids and Stonehenge.
- Together with the Bogs of North and West Mayo, it was, until recently, a UNESCO World Heritage Site nominee (on Ireland's Tentative List) and was central to discussions of Neolithic land division and early farming communities in northwestern Europe.
- Excavations and surveys by archaeologist Professor Seamus Caulfield and his team from the 1970s onward transformed our understanding of Ireland's prehistory.
- The on-site Céide Fields Visitor Centre interprets the landscape through archaeology, ecology, and climatology, making it an educational resource as well as a heritage monument.

The Céide Fields are archaeologically significant because they represent one of the earliest and best-preserved examples of a planned farming landscape in the world. They provide a rare, holistic view of how early agricultural societies lived, organized their land, and responded to environmental change. Given that the Ceide Fields system extends into Lacken, any windfarm here would seriously compromise this archaeological gem.

8.The Broader Neolithic Field System

The Ceide Fields system of integrated stone walls, houses, enclosures, etc extends into the Lacken area and, as a result, the proposed wind farm site forms part of the Ceide Fields complex. Some of the proposed wind turbines are earmarked to be erected on top of the Ceide Fields complex. Others are in very close proximity to it and risk disturbing unmapped prehistoric field systems. There are 85 recording national monuments in the immediate area. The proposed development is, therefore, contrary to the Built Environment Objectives 1,2,3,4,5and 6 of the Mayo County Development Plan 2022-2028 as follows:

BEO1. "To protect the archaeological heritage and sites identified in the record of Monuments and Places, National Monuments in the ownership or guardianship of the state in addition to National Monuments that are the subject of Preservation Orders and to safeguard the integrity of the archaeological sites in their setting".

The field network mapped under parts of the proposed development has survived undisturbed for six thousand years. The construction of a windfarm here would irreparably damage the prehistoric field -wall system.

BEO 2 of the County Development plan reads "

"To protect the tentative World Heritage Site in Mayo on the UNESCO Tentative List , the Ceide Fields, from inappropriate development and support its nomination to World Heritage Status"

BEO 4 states: "To ensure that development in the vicinity of a Recorded Monument or Zone of Archaeological Protection is sited and designed in a sensitive manner, avoiding adverse effects on landscape setting and context of monument. "

BEO 5 "To protect all sites and features of archaeological interest discovered subsequent to the

publication of the Record of Monuments and Places.

BEO 6 " To protect archaeological sites, monuments, and archaeological objects in their setting, which are listed on the Record of Monuments and Places of County Mayo."

There can be no compatibility whatsoever in protecting these monuments in close proximity to the windfarm site and the construction and operation of several large wind turbines. Large wind turbines will not be capable of being installed in a sensitive manner, the landscape setting will be utterly transformed, and the ongoing function and operation will adversely impact on the landscape setting and context.

Archaeologists particularly Professor Seamus Caulfield of UCD and Martin Downes Professor of Biology at Maynooth who carried out environmental research were involved from the outset. Gretta Byrne, archaeologist surveyed and found the field walls from Ballycastle to Lacken. Byrne, M.J.B. (G.) 1986, "The Pre-Bog Archaeology of the Ballycastle-Palmerstown Area of North Mayo", Volumes 1 & 2. Unpublished MA Thesis, UCD.

She discovered that the same type of buried stone wall patterns continues far beyond the Ceide plateau. According to Seamus Caulfield. "The Ceide Fields system is not an isolated phenomenon but part of a much more extensive farming landscape stretching from Belderrig to the west to beyond Ballycastle and into the lowlands towards Rathlacken and Killala. (-Archaeology Ireland, Vol 6, No 1, 19922).

Later surveys by the National Monuments Service and the OPW for the UNESCO Tentative List include "the Ballycastle – Rathlacken sector "as part of the Buffer Zone for the Ceide Fields and North Mayo Boglands nomination.

Gretta Byrne also discovered significant traces of the Ceide integrated system of neolithic stone walls in Rathlacken near the Rathlacken Court Tomb which is just metres from the proposed windfarm site.

In a National Geographic article in September 2022, Gabriel Cooney (Professor Emeritus of Celtic Archaeology states: "in terms of early farm landscapes, Ceide Fields is an outstanding example at a global level. It provides us with evidence of the interaction of people with their environment. It's critical to our understanding of farming and how it happened and the context in which it happened across the globe "

The applicant describes the Ceide Fields as being 9km distant from the windfarm site. This is untrue. The Ceide Fields complex is not confined to a single site but spans tens of kilometres across north Mayo – a vast Neolithic farming landscape preserved almost intact beneath peat. It's the largest and most complete Stone Age field system yet discovered anywhere, stretching

at least 25 km along the coast and covering over 100 km^2 of upland terrain – an extraordinary window into early agriculture. In archaeological terms it's a veritable treasure trove, a jewel in the crown of neolithic finds. The proposed windfarm at Lacken which will involve huge amounts of excavation of peat and soil which, in all likelihood, will destroy irreversibly and in perpetuity, the underlying archaeology.

It is totally unrealistic to think that with the size and scale of the earth moving machinery that is used by wind farm developers that any archaeological remnants of the Ceide Fields system could be preserved. With the continual evolution of archaeological techniques, it is probable that soon there will be methodologies available to explore underground without excavation. Any such techniques could potentially open up a new exploratory vista for areas like Lacken.

We contend that the proposed wind farm development at Lacken has the potential to cause serious detriment to the precious, ancient archaeology of this area.

In its report, the applicant confirms that the Ceide Fields surveyed field walls measure merely 1km to the east of the nearest proposed turbine. The applicant confirms that the Ceide Fields is such that further walls could potentially be uncovered during construction activities associated with the proposed development. There is a clear acknowledgement that previous, unrecorded archaeological finds/ features are located within the site and that these could be impacted by construction phase activity.

9.UNESCO World Heritage Site

It is acknowledged worldwide that beneath the boglands of this area of North Mayo lies a system of fields, dwelling areas and megalithic tombs which together make up the most extensive stone age monument in the world. The stone walled fields, extending over hundreds of hectares, are the oldest known globally, older than the Pyramids and Stonehenge. The site has been described as the most extensive Neolithic site in Ireland. For good reason the site was placed on the UNESCO's Worlds Heritage Tentative List. The intricate remains of our ancestors prehistoric farming lives, fields, cattle byres and burial tombs lie perfectly cossetted in peat around thousands of acres (not just the existing Ceide Fields Visitor Centre site) from Rathlacken in the east to Glenamoy in the west. This area also incorporates Ballinglen Hills including Suifinn/ Annaghmore, Ballykinlettragh and Gunnane adjacent to Glenora and extend south to Blanemore Forest in Moygownagh. This clearly demonstrates the extent of this unique archaeology which is recognised by expert archaeologists as part of the Ceide Fields complex. The buried landscapes of North Mayo are iconic for Irish and European archaeology and an obvious candidate for World Heritage Site Status.

The Ceide Fields has earned massive international respect as an area of great cultural and archaeological significance; described by the New York Times as "A Pompeii in Slow Motion " by Seamus Heaney as a "landscape fossilized "by Professor Richard Bradley of the University of Reading as" deserving the widest national and international acclaim "expressing his astonishment at the unparallel sheer scale of the Ceide Fields".

The highly acclaimed English architect, Francis Pryor, best known for his discovery of the famous Flag Fen archaeological site near Peterborough and author of several books on archaeology summed up the Ceide Fields as follows, "it has always struck me as both odd and ironic that one of the earliest field systems in northern Europe was found at the extreme edge of the continent at the point where the last feeble ripples of the Neolithic wave of advance

merged with the rolling swell of the Atlantic Ocean. The fields in question were discovered in Co. Mayo… What makes these fields so remarkable is their great antiquity; they have their origins in the fourth millennium BC and were used throughout the third. Can we match that in England? I only wish we could." *(Francis Pryor, Farmers in prehistoric Britain, (Stroud, Gloucestershire, 2006), p.73)*

Given the above outstanding recognition by esteemed archaeologists, it is our strong contention that it would be unconscionable and constitute cultural and archaeological sacrilege to grant planning permission for a large windfarm in the Ceide Fields which could destroy its incalculable and priceless heritage. The proposed development will clearly have a detrimental impact on the archaeological and cultural heritage of the area and therefore would not be in accordance with proper planning and sustainable development of the area.

The North Mayo Boglands constitute an open-air laboratory with a unique, natural human history archive contained within them. This ancient, pristine, unadulterated treasure trove of monuments in an area of great cultural heritage significance is well worthy of World Heritage Status and demands to be protected by the appropriate organs of the state.

It is our belief that in any other jurisdiction other than Ireland absolutely no large wind farm would be countenanced in such close proximity to such a culturally significant heritage site.

The archaeological monuments of North Mayo in this location represent a living manuscript of changes over a period in excess of six thousand years of human habitation covering all periods from the Mesolithic Age to the current times. Past generations of its inhabitants have bequeathed a rich and rare heritage, and this and future generations can pass on no greater legacy to posterity than to leave untouched the many fine archaeological treasures including those still lying dormant under our precious boglands that adorn the areas landscape.

It is our contention that the applicant had a duty of care to have arranged proper archaeological excavations to have been carried out before making this strategic infrastructure application especially in circumstances wherein they concede that it is probable that the site location could contain significant archaeology. Construction activity on such an industrial scale would not be tolerated in other jurisdictions on sites of this importance and the wording used by the developer is a matter of concern to this group. Furthermore, we believe it contravenes all European regulations and directives regarding the identification and protection of our national monuments and the responsibilities placed on member states to ensure the safeguarding of our national heritage. The unique archaeology of the Ceide Fields complex must be explored and surveyed by expert archaeologists only and is deserving of a similar status to Pompeii; thus, ensuring all works are carried out by the subject experts as a work in progress for generations to come. This group contends that the sites identification and their surrounds should be preserved in their current state so as to ensure no further damage occurs to our rich and unique heritage.

10. Rathlacken Court Tomb

The applicants report on cultural history is significantly flawed in that it fails to highlight the importance of the archaeological find of the Rathlacken Court tomb, which adjoins the wind farm site and in fact downplays it substantially.

- Between 1990 and the late 1990's, the archaeologist Gretta Byrne was centrally involved in this discovery. The work was undertaken as an independent research

project. And with permission from Coillte (the landowner), the team excavated a site at Rathlacken that includes a well-preserved megalithic court tomb and an attached stone-walled enclosure in addition to a small house site.

- The tomb consists of a "three compartment chamber" formed of massive upright stones, plus a court in front, and is dated to around 5,300 years ago (i.e. Neolithic).
- The excavation revealed the junction between the cairn (tomb) and the D-shaped enclosure wall, and detailed features such as a drystone kerb around the cairn and the enclosure's wall construction.
- Artefacts and indications of use: although no full skeletal remains survived, there were probable burnt/cremation deposits found in one of the chambers, together with pottery of different styles and stone tools.
- The site also forms part of a wider prehistoric landscape: Byrne's work documented that the tomb and house/enclosure lie within a field-wall system of stone walls preserved beneath blanket bog - similar in nature to the better known Ceide Fields site nearby bot an integral part of the same integrated system
- The combined tomb, dwelling/enclosure and field-wall system demonstrate a complex, integrated Neolithic landscape, not just an isolated tomb. The excavation work helped show how ritual/burial zones, domestic occupation, and agricultural field systems were spatially inter-linked.
- The preservation under blanket bog means many of the stone-wall systems (normally lost) survive in good condition – Rathlacken contributes to understanding how early farming communities organised land, enclosed it, and tied it to ritual/communal monuments.
- This gives additional insight into the scale and organisation of Neolithic farming in north Mayo, underscoring that these communities were operating with significant social/engineering capacity: building large stone chambers, enclosures, and walls that required labour and planning.

This discovery of the Rathlacken court tomb was of major significance in the archaeological world. The applicant fails to recognize its importance and seeks to construct a wind turbine metres away. There are four other monuments discovered close to the court tomb including the galleries of other court tombs together with a collection of huge limestone flags. (www.carrowkeel.com). This further emphasizes the importance of this area.

At a number of areas, the applicant's archaeology report states that no UNESCO World Heritage Site or those on the Tentative List are located in or in close proximity to the proposed development and that the nearest such site is 55km away at Carrowkeel in Sligo. Astonishingly, the report fails to highlight the great significance of the fact that the very site in question, the Lacken and Rathlacken area as part of the Boglands of North and West Mayo/Ceide Fields was on the UNESCO Tentative List between 2010 and 2022.

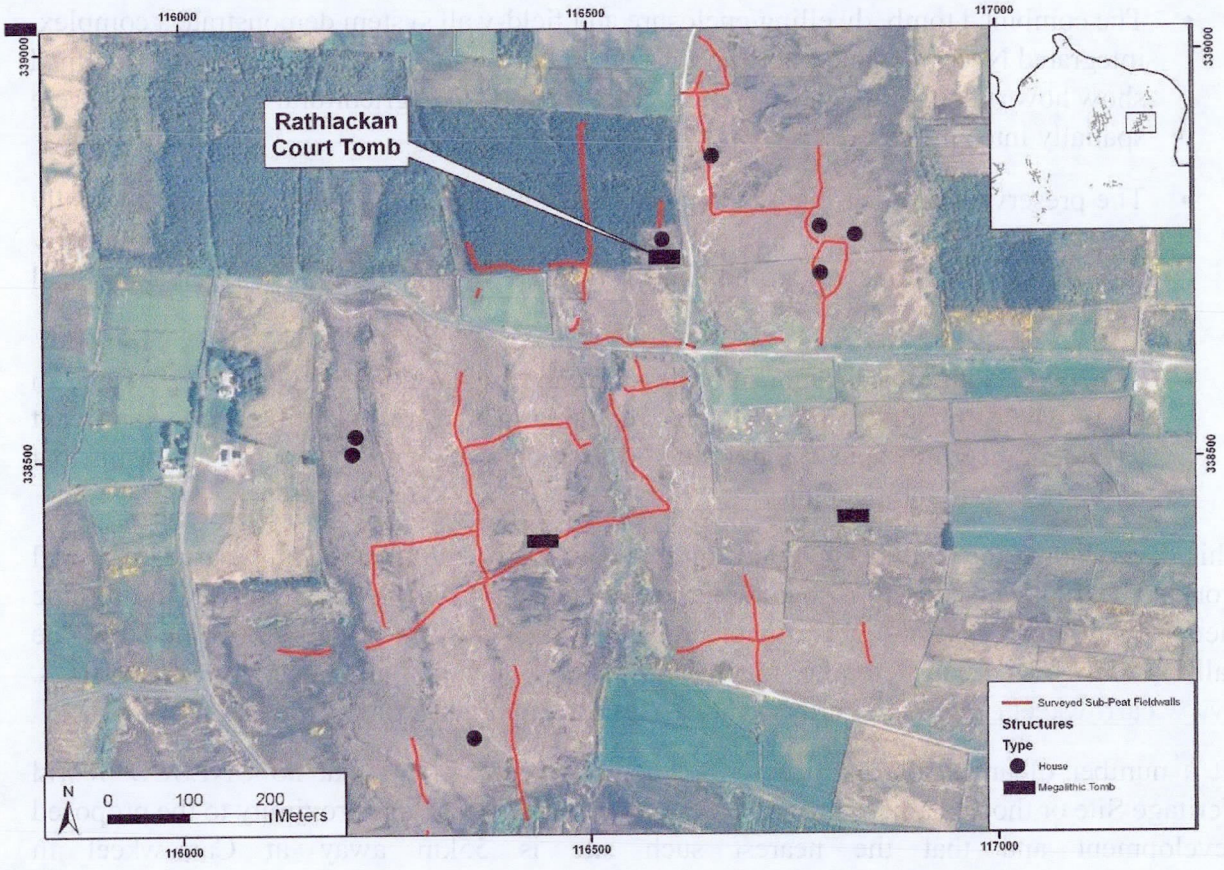
In its County Development Plans 2014 to 2020 and 2022 to 2028 and, Mayo County Council sets out as one of its core objectives to:

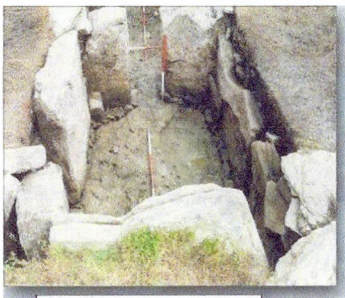
"Built Environment Objective 2: Protect the tentative World Heritage Site in Mayo on the UNESCO Tentative List – Ireland 2010, The Ceide Fields and Boglands of North and West Mayo from inappropriate development and support its nomination to World Heritage Status."

This proposed development does not support the nomination of this site to the UNESCO list and is an affront to Build Environment Objective 2 of Mayo's County Development Plan.

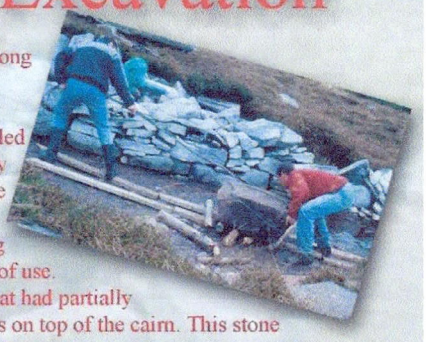
We have clearly set out in this submission the areas inestimable and incalculable cultural and heritage value. In that capacity and in the context of the Wild Atlantic Way tourism promotion, it features regularly in local, national and international tourism promotion. With its proximity to Downpatrick Head and at a pivotal position on the Wild Atlantic Way, it is nothing short of sacrilegious and cynical to consider that the status of the Ceide Fields and the surrounding areas could be so flippantly ignored and ceded, in order to facilitate the development of an industrial scale wind farm in an unsuitable area.

Please see map below showing detail of the walls, associated house sites and three court tombs including the main Rathlacken Court Tomb. The redlines throughout shows the areas of archaeological studies by Gretta Byrne in the Lacken area indicating where the Ceide Fields system of stones walls exists.





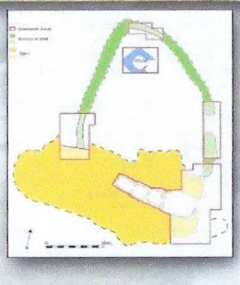
Rathlackan Excavation



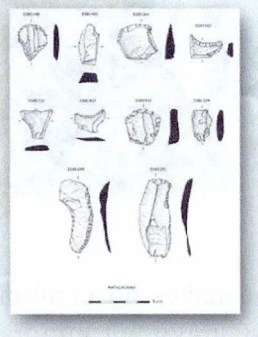
BEFORE excavation all that was visible was a long cairn, aligned east – west with a very large flat stone slab protruding from the eastern end. Excavations in the 1990s by Gretta Byrne revealed the circular court and three chambers completely filled with stones.The blocks of stone around the perimeter of the field are those that were removed. These may have been a deliberate filling and sealing of the tomb after it finally went out of use. The protruding slab was a displaced capstone that had partially collapsed into the front chamber and it now rests on top of the cairn. This stone was removed using Neolithic techniques with only ropes and wooden poles and the muscle power of seven people.

Above: Shifting stones during excavation
Below: Lifting the capstone





Top: Back chamber after excavation
Above: Plan of escavation site
Below: Drawings of finds found on site



DATING

Evidence from radiocarbon dates and artefacts show that the tomb was constructed and being used sometime around five and a half thousand years ago. There is further evidence for a major phase of activity both in the chambers and court around seven hundred years later but whether the surrounding area was continually inhabited and farmed throughout the intervening time is not clear. The associated house structure and probably also the enclosure wall were built during this later phase. Later again around four thousand years ago in the earlier Bronze Age a pottery urn was placed in the front chamber and a second urn in the back chamber above the floor levels. These would undoubtedly have accompanied burials indicating that the monument was accessible and still held a sacred significance a millennium and a half after being built.

FINDS

Artefacts discovered during the excavation include 205 pottery sherds from nine vessels in total. A total of 837 stone pieces were found, of which 88 were artefacts including a broken shale stone axe, the remainder beingwaste products of tool making. Most numerous of the artefacts were chert scrapers with a shallow concave edge. Analysis of soil samples gave some hint of possible foods eaten by the Neolithic people, including crab apple, hazelnuts, bramble seeds and common sorrel.



Above: House enclosure wall and cairn after excavation

House & Enclosure



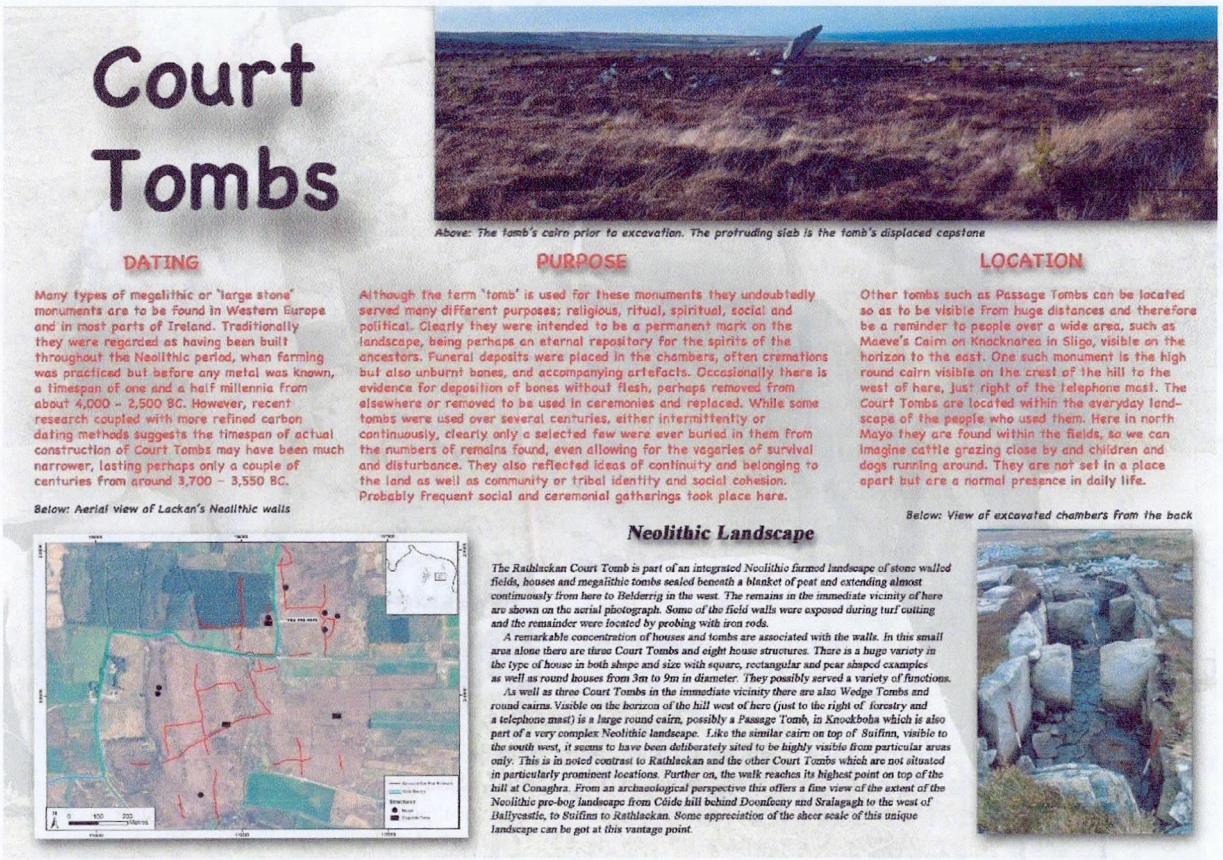
Above: Hearthstone found in the house
Below: The house during excavation



BUILT onto the northern side of the tomb was a semicircular shaped stonewalled enclosure. Portions of the wall were excavated and at the western end it was clearly built up against the retaining kerb of the tomb prior to any collapse from the cairn and prior to peat growth. Within the enclosure was a stone house structure - just inside the northern section of excavated wall, although not visible now as it was re-covered after excavation for protection. It was a roughly square-shaped structure, barely 3m across, with a clear entrance with an upright threshold stone, paving stones approaching the entrance and a cracked oval hearth stone in the centre which was completely covered by charcoal. The function of this structure was not clear. It was quite small to be a regular dwelling house, although hut sites of comparable size are known from Neolithic sites. No artefacts were found within it but it had very definite remains of a substantial fire on the hearthstone so perhaps it was used for cooking. It may have been used more in relation to activities associated with the tomb rather than domestic living.



Right: Enclosure wall and cairn before excavation



11.Ballinglen Arts Foundation.

It is incomprehensible that in the cultural heritage section, the applicant makes no mention whatsoever of the Ballinglen Arts Foundation. This is one of the most important cultural institutions in the West of Ireland. It was created to bring Irish and International artists to live and work in the village of Ballycastle and to savour the unique atmosphere of the place. Hundreds of artists from across the globe have completed residencies there. It is an internationally recognised centre for artistic creation while remaining deeply rooted in the local community. It has transformed what seem like an unlikely location into a thriving arts destination. Artists are attracted by the spectacular and dramatic cliffs, strands, boglands, hills, expansive skies, changing weather and the quality of the light in the Ballycastle, Lacken and Belderrig areas. Well-known artists who have resided include; Donald Teskey, Martin Gale Richard Gorman, Hughie O Donoghue, Mick O Dea, Diana Copperwhite and Elizabeth Magill. The actress Michelle Pfeiffer visited and described the area as "perhaps the most beautiful place on earth."

The failure to mention this centre of excellence by the applicant underscores its complete lack of knowledge and appreciation for the cultural heritage of the area. The proposed windfarm would lead to the degradation of the environment, the pastoral landscape, the skylines, and the aesthetics of the area. This would seriously impact on the work of artists at Ballinglen and violate Ireland's obligations under national heritage policy and international cultural protection frameworks. ACP has an obligation to seriously consider the applicant's abject failure to consider many highly pertinent and relevant issues relating to cultural heritage including the manifold omissions, exclusions, and negligence in the compilation of this section of the application.

AGRICLUTURAL IMPACT

Bovine Tuberculosis (bTB) Risk and Wildlife Disturbance

The proposed development raises significant concerns regarding the potential implications for bovine tuberculosis (bTB) management in the locality. The area surrounding the proposed turbine locations AT01 to AT06 has experienced a serious and unusual level of bTB activity in recent years, resulting in herd restrictions and prompting investigation by the Department of Agriculture, Food and the Marine (DAFM).

Local residents and farmers are aware that DAFM undertook badger trapping and testing operations in the Barnhill area during April and May 2026 as part of ongoing efforts to investigate and manage disease transmission pathways. This activity demonstrates that bTB is not merely a theoretical concern but a current and active issue within the immediate vicinity of the proposed development.

The project involves substantial ground disturbance, extensive excavation works, construction traffic, and the felling of approximately 31.86 hectares of forestry. Such activities have the potential to disturb wildlife populations and alter established movement patterns. Badgers are recognised as a wildlife reservoir of bTB in Ireland, while deer are also considered capable of contributing to disease transmission. The removal of significant areas of forestry cover may displace wildlife from existing habitats and force greater interaction with surrounding agricultural lands and livestock.

Despite the known sensitivity of the area from a bTB management perspective, the planning application, EIAR and Construction Environmental Management Plan do not appear to contain any meaningful assessment of the potential implications of construction-related habitat disturbance on bTB risk. Nor do they identify any mitigation measures designed to minimise disturbance to wildlife populations or prevent increased interaction between wildlife and neighbouring cattle herds.

Given the scale of the proposed works, the recent history of bTB restrictions within the locality, and the apparent involvement of DAFM in wildlife disease investigations in the immediate area, it is considered that this issue warrants specific assessment before any decision is made. The absence of any detailed consideration of bTB risk represents a notable omission from the environmental assessment of the project.

The only badgers mentioned in the survey are roadkill outside of the proposed windfarm area but there have been sightings of badgers in the Barnhill area in Spring 2026 on the L5179-23 in close proximity to a proposed new access road for AT07 onwards. It is unsurprising that the data is poor considering the developers admit in the CEMP that more than 36 months has passed since their surveys were completed and that a Pre-Construction Badger Survey will be required. However, under the Pre-Construction Badger Survey heading in the CEMP badgers aren't mentioned because the whole section has been copied and pasted from the otter section. This lack of attention to detail gives the impression that the developer isn't concerned about the correct assessment of the local wildlife and habitats.

Deer are given even less attention in the reports: *"Construction activity would be expected to cause larger mammals such as deer to remain in cover whilst the works are on-going."* It is highly unlikely that deer will "remain in cover" when large areas of their forestry cover would

be removed for this project, including for turbines AT02, AT03, AT04, AT06 and the met mast in the area of the bTB outbreaks.

In *"Is there an association between road building and bovine tuberculosis herd risk? A three time-point study in Ireland, 2011–2019"* by Barroso et. al., 2021, a study of the construction of the M17/M18 in Galway, shows a clear link between the construction of the road and bTB breakdowns in the surrounding herds. bTB cases increased during construction, remained high post construction and were more serious within 1km of the construction works. "*Badgers and Bovine Tuberculosis in Ireland"* by Robert O'Connor and Eoin O'Malley, 1989, includes a case study from Ballymooney Co. Offaly where a single badger with TB caused an unexpected outbreak in three previously clear herds.

Should this project go ahead it will interfere with DAFM efforts to control and eliminate the bTB outbreak in this area. If the developers had engaged with the community, including local farmers, they would show greater caution before recklessly endangering peoples' livestock and livelihoods. Considering an extra €85 million was allocated to the control of bTB in the last budget, unnecessary construction projects like this that will more than likely contribute to the spread of bTB are also wasting taxpayers' money.

From applicants documents

Pre-Construction Badger Survey

As several years will have lapsed from the time of the planning-stage surveys (carried out in 2023-24) and the commencement of construction works at water crossings, it will be necessary to carry out a survey for otter in areas of potential suitable habitat which will be disturbed by the works as the local distribution of otter may have changed in that period. This will be carried out by an ecologist with experience of otter survey.

It is noted that should the pre-construction survey indicate a requirement for protection of the relevant species (in this case otter), appropriate measures will be taken to comply with all relevant legislation and best practice guidance in force at the time.

Hedgerow Replanting

In Chapter 6: Biodiversity, the developer calculates that the removal of 1,604m of hedgerow will be required for this development but there are no maps or additional information to show how this figure is arrived at or where these hedgerows are. 1.6km is a very low figure considering the many miles of road widening that is required. They do acknowledge the importance of these hedges to the local area*: "The significance of the loss of hedgerows due to the Proposed Development is rated as an Adverse Significant Effect of Permanent Duration at a Local level of importance."* However they think they can mitigate against this by replanting a new hedge.

If a farmer wished to remove over 500m of hedgerow on their land an Environmental Impact Assessment would be required and even then permission would only be granted in limited circumstances. These are for road or farm safety issues, widening entrances for large machinery or farmyard expansion. If permission is granted the removal cannot be done during nesting

season (1st March – 31st August) and twice the length of hedge removed must be replanted. This hedge must be a like-for-like match of the previous hedge. Hedgerow removal permission would not be granted to a farmer just to allow him to turn a profit as the developer is requesting.

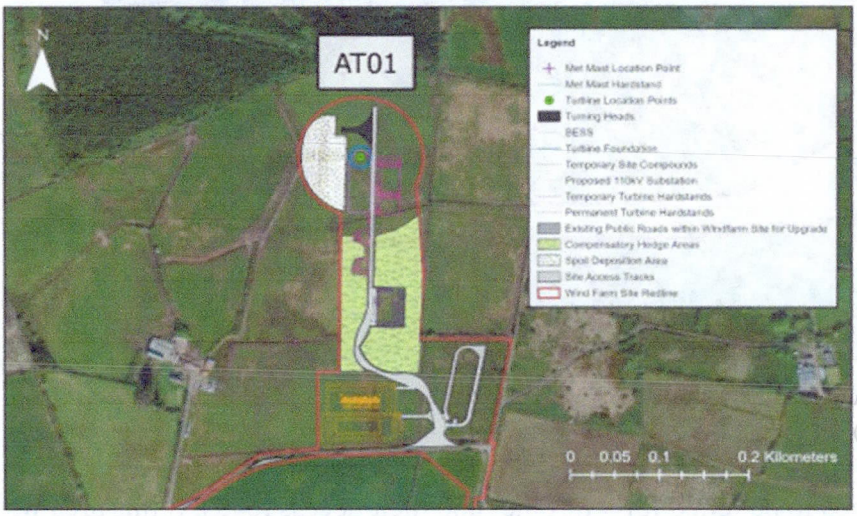
Also, the manner of replanting the developer is proposing is puzzling. It is proposed to replant 1.39ha of hedging in just three locations around AT01 and the substation, AT06 and AT14. Planting hedges in three small areas is not a like-for-like replanting of the original hedges which are mainly naturally growing, linear, road-side hedges. These three areas would be of no benefit to wildlife because they are three isolated locations and not connecting wildlife corridors like the existing hedgerows. Wildlife will not form a habitat under noisy, industrial structures that are so unlike the species-rich biodiverse habitats they have currently. Additionally, the local community will not benefit from these hedges when they are on windfarm property and not along the public roads where most of the hedgerows will be removed from. It is also questionable whether a replanted hedge would grow on this ground, especially around AT14 which is classified on page 54 of chapter 6, the biodiversity report, as wet grassland/scrub. If species were chosen that would survive on this type of ground they would not be a like-for-like replacement of the original hedgerows.

In summary, the total area of hedging, trees and scrub required to be planted to offset th losses is as follows:

	Length (m)	Area (ha)
Permanent hedgerow loss	2,406 m	0.72 ha
Temporary hedgerow loss	1,252 m	0.376 ha
Scrub at bat buffers	-	0.29 ha
Total	**3,658 m**	**1.39 ha**

To reflect the losses across the Wind Farm Site, the total area to be replanted will b distributed at three locations (see **Plates 6.23-6.25**), as follows:

AT01 / substation:	1.11 ha available
AT06 location:	0.67 ha available
AT14 location:	1.01 ha available
Total land available for planting	2.79 ha



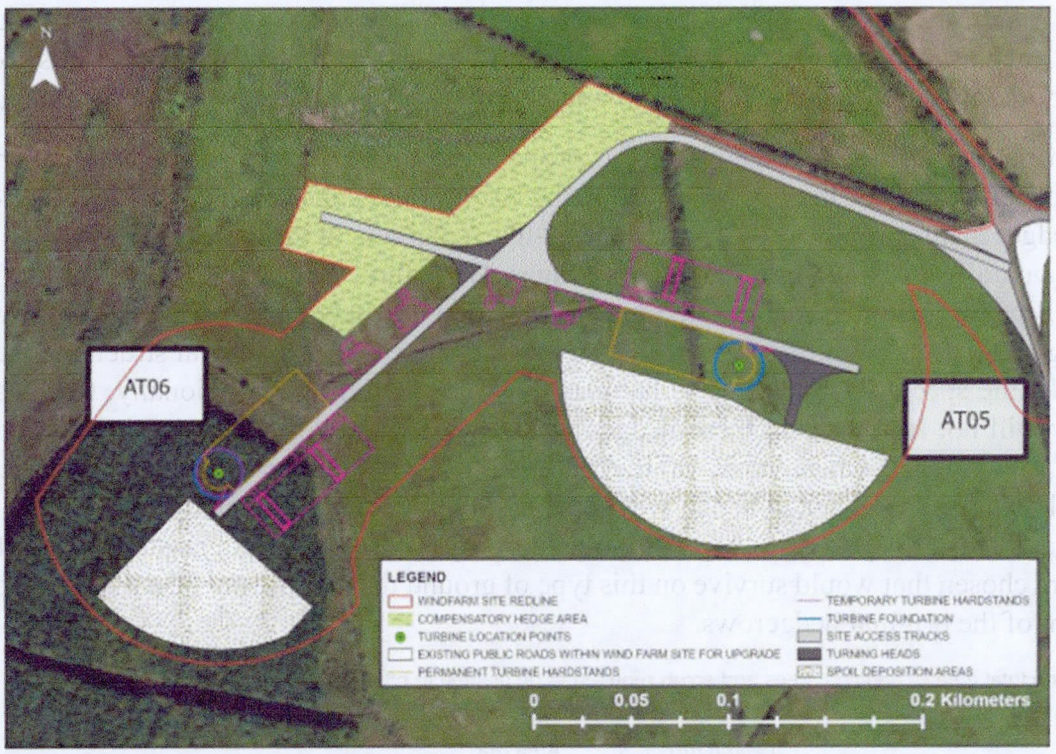


Plate 6.24: Detail of native woodland planting at AT06 location.



Plate 6.25: Detail of native woodland planting at AT14 location.

Forestry

31.86ha of forestry is planned to be felled for 9 turbines and their access roads. If this area was treated the same as ordinary forestry when it was felled it would have to be replanted as forestry. A farmer wouldn't even be allowed to return a felled forest to grassland so why are wind turbines a law unto themselves? When licences were granted for planting these forests originally and neighbours had the opportunity to object they never would have imagined wind

turbines being constructed in them. This change of use is misleading to communities where forestry is growing.

The intention to use urea to treat stumps is another double standard when compared to the regulations farmers have to adhere to. All forestry has numerous drainage channels between rows of trees and the forests in this area are on very wet land that does not have the capacity to soak up excess urea. These drainage channels flow into streams that all finish in the Saltmarsh which is in an NHA and SAC. This will severely pollute the local waterways and the Saltmarsh. However, when a farmer spreads chemical fertiliser on their land they must keep 2m away from all watercourses, including drains. Having different rules for the same substance just because it is used by different industries raises concerns with regards fair and proper planning.

This level of forestry felling will also disturb wildlife and leave them little alternative shelter because several nearby forests will be felled, either partially or entirely, in the same short time frame. This will also add hundreds, if not thousands, of extra journeys to narrow country roads, inconveniencing the local people and destroying the roads. None of this has been considered by the developers in the EIAR.

By law this 31.86ha has to be replanted somewhere. This was neither addressed or referenced in the Forestry Report but it was briefly mentioned in the Hydrology Report, which is at best poor referencing and at worst misleading. This stated that the replacement forestry will be at least 10km from the windfarm site and outside the catchments of the Cloonalaghan and Cloonaghmore Rivers. There are numerous problems with this. Firstly, this windfarm does not have one site. It is interspersed within our community. How can 10km be measured when there is no clear site boundary to measure from? Secondly, both the Cloonalaghan and Cloonaghmore rivers are close together and flow in approximately the same direction. As a result, the area that the developers have to avoid is quite small. The communities that this forestry could be planted in will have to deal with the loss of 31.86ha from agricultural production, and in the future, the likely loss of it to forestry companies. This makes it clear that our community is not the only one that will be negatively impacted by this windfarm.

Traffic

Farmers or agricultural contractors have not been considered at all in any of the traffic documents. In Chapter 17 Traffic and Transport the sensitivity of receptors are graded. Businesses on the main roads out of Ballina and Crossmolina are included but not local farmers, even though they are facing greater disruption because they are closer to this project. Construction hours are said to be between 07:00 and 19:00 Monday to Friday and 08:00 and 13:00 on Saturday and between these hours and the amount of construction vehicles that will be on the local roads the disruption will be enormous. Deliveries, road widening, diversions and road closures will prevent farmers from accessing their land and yards. This will be even more serious in spring time if farmers or their vets aren't able to get to animals in difficulty on time. It will prevent farmers with fragmented land from walking their animals on the road to fresh grazing as they have done for generations. It will make it extremely difficult for contractors to draw in silage and to spread slurry. Road widening that needs electricity poles to be moved will cut off power to yards. This will especially effect dairy farmers who need electricity to keep milk cooled before it is collected. Traffic and Transport page 46: *"On these concrete pour days, some 14-18 deliveries per hour will be required."* With this level of industrial traffic on our narrow local roads no one else will be able to use them. This traffic

level will not be short term. It will be ongoing for 21 months according to the developers and likely longer allowing for delays. Seriously disrupting at least 2 years of farmers' businesses by denying them the basic right to access their land has so many knock-on effects on the day-today functioning of the farm that it could put farmers out of business. You can't run a farm from a traffic jam 2 miles away and there's no option of remote working. The fact that the developers didn't consider farmers in any way throughout the planning documents despite the whole area being a rural, agricultural community shows the lack of regard they have for our community. This also affects contractors who rely on farmers staying in business so that they continue to have customers.

Peat

Under Good Agricultural and Environmental Condition (GAEC) 2, which came into effect on 1st May 2025, agricultural peat soils have to be farmed under four restrictions to protect them as a valuable carbon sink. These restrictions are: grassland cannot be ploughed for reseeding more than once in four years, no ploughing deeper than 30cm, existing drains cannot be lengthened or deepened, and any new drainage is subject to planning permission. 14 of the 16 turbines are intended to be constructed on peat soil. 13 of these 14 sites are currently in agricultural use, either as farmland or forestry and so are subject to GAEC 2. Should planning be granted this same soil that is protected under GAEC 2 now will be allowed to be dug out for access roads and turbine foundations. This is contradictory in the extreme. The four actions restricted under GAEC 2 are less invasive than wind turbine construction. The Department of Agriculture's press release from 2nd May 2025 on the introduction of GAEC 2 states that these carbon rich soils are *"are akin to Ireland's rainforests and thus must be protected."* Should this not apply to peat soil across the board instead of applying different standards to the same soil depending on what industry uses it?

The site of AT13 is particularly concerning. According to the developers own Biodiversity Report in the EIAR this site is 7.65ha of blanket bog and the Sphagnum Moss cover ranges from 30% to 60%. It also states that *"the vegetation present is dominated by peat-forming species indicative of active blanket bog growth"*. This information should single this site out in particular to be protected as a valuable habitat and carbon sink but instead it is described as of *"not more than local importance"*. Peat will be dug out not alone for the foundation of AT13, but also for the access road and cables linking to AT14. Machinery carrying out this work will have to drive over the rest of the blanket bog to be able to manoeuvre round the site, damaging more of this valuable habitat. According to the Irish Peatland Conservation Council (IPCC) website, it is estimated that Irish peatland stores 1,085 mega tonnes of carbon which is 53% of the soil carbon stored on the island of Ireland while only accounting for 16% of the land area. Peatland sites like this are helping our environment naturally, and extremely efficiently, with no side effects to us, in comparison to windfarms which emit tonnes of carbon in manufacturing and construction before they generate any electricity.

The Biodiversity Enhancement and Management Plan (BEMP) states that its primary objective is to *"to compensate for the loss of blanket bog at AT13"* by creating a man made habitat in the abandoned quarry, which is the proposed location of AT16. It is either wishful thinking or complete indifference to the quality of our local habitats that could lead the developers to think that a man made habitat, in an abandoned quarry no less, could be the equivalent of an actively growing blanket bog that they wish to destroy. Planting trees on the peat soil repositories and grass and wildflower seed on the mineral soil repositories will not have the same carbon

sequestering and storing capabilities as an actively growing blanket bog with sphagnum moss. In fact, planting a wildflower seed mix could bring in invasive species. In Autumn 2020 Teagasc Oak Park in Carlow planted a field margin with grass and wildflowers. It was found to have blackgrass, an invasive weed resistant to herbicides that produces thousands of seeds per plant and is capable of spreading very fast. If an invasive species like blackgrass is brought into the BEMP area it could spread far beyond it and destroy local habitats.

In order to encourage the revegetation of the damaged blanket bog around AT13 it is planned to save the turves of peat, water them while they are in storage and then place them back around the area of AT13 after construction. According to the IPCC website this will not preserve peat. It says *"Once peat is exposed to air by drainage, it begins to break down. Oxygen in the air makes it possible for bacteria to digest the peat. Carbon is released during decomposition. Drying of the peat and decomposition changes it structurally, making it difficult to re-wet and therefore unsuitable for re colonisation with Sphagnum mosses."* Once the sphagnum moss is gone the bog can no longer form peat and as a result stops growing. No amount of mitigation can undo the damage that wind turbines will do to this actively growing bog if this development is allowed to go ahead. The Status of EU Protected Habitats and Species in Ireland Report 2025 graded the overall blanket bog status in Ireland as bad. It was unfavourable-inadequate in 2007 and for the last three reports in 2013, 2019 and 2025 it has been unfavourable-bad. This report also noted that the trend is for blanket bogs to deteriorate.

It is estimated that of the 157,785 m^3 of soil to be excavated for this project 97,369m^3, almost 62%, will be peat soil. All of this soil is to be stored in spoil repository areas but it is confusing how many of these will be needed. Some documents say 17 and some say 19. The heights of these spoil repository areas are also confusing. In the Peat and Spoil Management Plan they are supposed to be mainly 1.5m high with SD01, 02 and 03 2.5m high. In the CEMP it says these three will be 3m high. Also, the total volumes in the summary of the Peat and Spoil Management Plan do not correspond with the figures given earlier in the report. As well as these mistakes, in section 3 the remaining quantity of soil, less what is to be used as a ballast, does not add up with the figures from earlier in the report. Figure 3.1, the map supposed to show the Permanent Spoil Repository Areas in this report, is extremely unclear and it doesn't even have a key to allow you to understand the symbols. In the CEMP it states: *"The precise design of the spoil repositories will be developed further at construction stage"*. The construction stage is not the time to be finalising a design. That is what the planning stage is for. This, and the number of mistakes throughout the Peat and Spoil Management Plan, especially in the calculations, shows a lack of care for an important part of the planning application and also for our community who will suffer the effects of poor planning.

Equine Health

Impact on horse owner, breeder and horse riders: The applicant did not address the local horse riding community which uses daily the Lacken loop walks, western way and other local roads in the proposed area. The British horse society has published an advice guide on wind turbines and Horses: a guidance for planners and developers and can be found referenced in other Irish windfarms e.g. https://www.derryaddwindfarm.ie/, Seskin Wind Farm Co. Carlow - EIAR EIAR Appendices - F - 2024.05.03 – 220246, https://www.pleanala.ie/publicaccess/EIAR-NIS/322225/EIAR/322225%20-%20eiar%20chapter%205%20appendix%205-3%20advice%20on%20wind%20turbines%20and%20horses.pdf

Wind turbines can negatively impact horse riders by triggering a flight response in horses due to sudden movements, casting shadows, and low-frequency noises. These hazards increase the risk of the horse bolting or bucking, endangering the rider's safety.

The key ways wind turbines impact equestrians include (www.yardownerhub.co.uk),: Visual Distractions: The sudden movement of rotating blades and moving shadows (flickering or strobe-like effects) can startle horses, particularly if they appear suddenly behind hedges or on sunny days. Audible Noise: Wind turbines generate varying levels of aerodynamic noise and low-frequency humming or rumbling. Because horses have more sensitive hearing than humans, distant noises that seem quiet to us can be quite loud and alarming to them. Safety and Route Displacement: Riders may be forced to avoid off-road trails near wind farms, which pushes them onto busier roads or requires traveling elsewhere, negatively affecting the equestrian community (e.g. AIRE approved riding school Iceford stables Ballina with their clients as well as AIRC horse riding members use the lacken loop walks on horseback which pass by the gazebo as well as parts of the western way regularly) and local rural businesses. (www.pleanala.ie). Unusual Testing Noises: The British Horse Society notes that annual mechanical testing of turbines can sometimes produce abrupt, unusually loud sounds that are particularly frightening to horses. https://www.bhs.org.uk/media/lgwdbphr/wind-turbines-0525.pdf

GEOLOGY

Geology & Soils

We are making the following observations in relation to the prospective planning permission of the 16 number wind turbines as part of the Tirawley wind farm application sent to An Coimisiún Pleanála.

On page 16 of the geology chapter it states the application is for 31 turbines this is a contradiction of the proposed 16 turbines and is an objection in of itself.

There has been no survey of watercourse diversions carried out in this report. There is no place where it says where all the water will be diverted once the turbine construction has started.

The groundwater data report shows that the bedrock in the region is a poor Aquifer so this will affect drainage and could lead to contamination flowing into the Lacken Saltmarsh which is a protected area.

The report also states that landslides are common in areas of peat soils near the surface and in fine coarse range materials such as glacial till which is all found in the proposed boundary of the windfarm.

It states in the report that all geological investigations were carried out by a desk study. No actual field studies were carried out for the Environment Protection report. This is wholly inadequate, proper field studies and tests should have been carried out as part of this planning process. The developer is clearly trying to cut corners by saving money.

The following is the makeup of the bedrock geology in the locality of the proposed windfarm:

Downpatrick Formation:
Sedimentary rock types including shore marine mudstones and siltstones, alluvial and deltaic sandstones and siltstones along with fully marine bioclastic limestones interbedded with calcerous shales.

The Moyny Point Limestone:
Tabular-bedded limestone and shale.

The Mullaghmore Sandstones:
Series of cyclical units of siltstones and shales which coarsen upwards into coarse grained sandstones.

It is a scientific fact that limestone rocks are highly erosive in water and they will be exposed to a lot of water once construction begins. When limestone is eroded it can lead to sinkholes and caves in the bedrock, think the Burren in Co. Clare. As the Lacken area is in close proximity to the Céide Fields and there is ample evidence that there is neolithic farms in the area, this is of grave concern. National heritage could and would be destroyed should this windfarm go ahead as planned.

There is a strong possibility of landslides occurring should the proposed windfarm go ahead, the turbines are to be constructed at elevated heights of over 130 metres. There is a series of houses situated below the prospective turbines should landslides occur houses and families will be destroyed.

Soils:

The following observations can be observed from the soil section in the report. There will be 3 peat and soil storage areas within an abandoned quarry at Lacken Hill, together with 14 other discrete sites within the redline boundary. It does not state where the 14 discrete sites are but I believe the soil and peat will be dumped near the turbines, this could lead to severe overloading of the land which will lead to potential landslides.

It states in the report that potential effects for the building of the turbines on the land as moderate significance, permanent and negative. This indicates a lasting irreversible degradation to the ecosystem which they state cannot be fully mitigated. Negative means it reduces the overall quality of the environment, lowers species diversity or diminishes ecological resistance.

It states in the report that soil sealing will occur when floating roads are constructed which will put agricultural land and biodiversity at increased risk of flooding. A detailed bedrock report has not been carried out to confirm otherwise. Stockpiling of peat can give rise to increased pore pressures and the possibility of a bog burst or peat slide. When peat is excavated it leads to the release of carbon dioxide (CO2) and nitrous oxide (NO2) which are both greenhouse gases. Peat being excavated will also give release to methane (CH4) which is another greenhouse gas.

Hydrology and chemical pollution:

Inland fisheries state no turbines should be constructed high above groundwater as it could lead to contamination. The proposed windfarm is in a highly elevated area. No mapping of the wells that people use for their drinking water has been carried out. An extensive amount of homeowners in the Lacken/Ballycastle areas still use wells for their water as they are not connected to public water supplies.

Wells cannot be drilled in the local area due to red water. There is no mention of this in the report. There is mention of a siltbuster mineral being used to help unclog the build up of water once turbines have been constructed. There is no mention of this being tested in the local area and what affects this could have on the saltmarsh or local ecosystems. Is the chemistry of the siltbuster harmful to animals or the ecosystem? This has not been investigated.

The turbines are to be constructed over geological faults which could affect the flow paths of water. Geological faults were caused by mini earthquakes at the time that the Atlantic Ocean was forming 200 million years ago. Lava would have came up through crevasses so the geological ingredients in the rock below the turbines will be different to the surrounding bedrock samples of these faults have not been taken. There could be minerals that could be potentially harmful if excavation is started. Increased pollution will raise the pH of the soil which will lead to a more acidic environment.

It is stated that microplastics will come off the turbines. The microplastics are called Bisphinol-A which the World Health Organization has stated that more than a picogram can be harmful to humans. The turbines will certainly give off more than a picogram of plastic which is going to cause untold damage to humans and the environment.

AIR QUALITY, POLYMER AS WELL AS HEAVY METAL BIOACCUMULATION

Most things wear, which leads to the question do wind turbines wear and where does these particles accumulate. Note a peer review journal supports and maintains integrity and authenticity in the advancement of science.

We Object as follows: Pollution of Local SAC our air and The Lacken Salt Marsh a Specific Area of Conservation. The introduction of 16 no turbines in this location will introduce the potential of microplastics to an extremely sensitive area. A peer review Journal published by the Department of Wind and Energy Systems, Technical University, Denmark Microplastic Emission from Eroding Wind Turbine Blades: Preliminary Estimation of Volume By L Mishnaevsky Jr Et al., This Journal clearly states that wind and rain erosion is one of the most frequent observed mechanisms of turbine blade, deterioration and damage.

Estimates show 540 grams per blade per year; may be lost to the adjoining countryside this would be 1.62 KG per Turbine and because of the local beaches salt marsh and sandstone quarries this estimates the erosion would be considerably higher. To be clear the units in this study are smaller than the Tirawley proposal and were operated at a considerably lower wind speed than the potential wind speed at the coastal elevated location at the community in Lacken.

	Per Blade	Per 3 blade Turbine	16 No Turbines	Yearly	Over a 30 Year life span
L. Mishnaevsky Jr Et al., Accepted and Published Dec 2024	540Grams	1.64KG	26.24 KG	26240 Grams	787 KG or 787000 grams
Company Deutsche Windtechnik Bremen Germany		2.1kg	33.6 KG	33600	1008 Kg 1008000 Grams

We object to the development because all the above has not been considered in the documentation in the CEMP or anywhere in their documentation

The Developer Mentions Air Quality How can they say no effect when the body of research and peer review journals state that 1000KG will be added to the unspoilt locality over the lifetime of the WF. Particular attention is drawn to Schedule 1,2 and 4 from the HSA Code of practice on chemical agent regulations 2026. These Polymers and metals from the BESS bio accumulates and will enter the food chain through bovine and fish sources as well as individual inhalation. With reference again to peer review journals Alkali Metal oxide exists on the

surface of glass fibres and may react with water to form strong alkalis, leading to corrosion of the glass fibres and decay in mechanical strength (Sokoli et al., 2017).

Different Polymers are used in different parts of the blades with degradation of protective coatings by erosion. Everyone has viewed this preventative maintenance on turbine blades tips, and all manufacturers confirm that this wear takes place. The protective coatings are polyurethane bases and epoxies and include thermoplastic and hybrid thermoplastics. The data above was collected with annual rainfall of 1000mm while Lacken rainfall averages 1355 mm thus potentially increasing the KG added to the local environment by an additional 35%

With reference again to yet another Peer review Journals the. Typical Turbine blades require repair after 2-5 years according to Leon Mishnaevsky Jr in his Science direct article on "Repair of wind turbine blades: Review of methods and related computational mechanics Problem Sept 2019.

Bioaccumulation by definition is the gradual build-up of substances, such as pollutants or Toxins in living organisms and entering the food chain in our case in Lacken this probably will occur from local fishing of the waters flowing from the SAC, Bovine and inhalation.

BPA is one of the potential contaminants from windfarm wear and 1 Kg of BPA is enough to Pollute10 Billion litres of water Since 2017 the WHO has advised drinking water should have a minimum of 0.1 Micrograms of BPA per litre that is the same as 0.0000001grams per litre of water. Asbjorn Solberg, Bard-Einar Rimereit and Jan ErikWeinbach, 08/07/ 2021 "leading edge erosion and pollution from wind turbines P15.

Micro Plastic Harmful to Public local residents Reference 2026 Code of practice Occupational Exposure Limits (OELV).

Polyurethane coated with typical risk Phrases

We Object on the following grounds the developer has not considered the existing ground water, and all wells for the potential contamination with microplastics and these must be all sampled to give a base line for any future potential contamination, this has not been undertaken by the developer and there is no mention in any of their documentation so how can this form part of a complete planning document.

The Swedish Environmental Protection Agency Have said that "Bisphenol A is the most toxic substance we know" BPA is a chemical produced in large quantities for use primarily in the production of polycarbonate plastics and epoxy paints. The Irish regulatory bodies particularly the EPA may not be aware of this most recent research

Sample risk phrases for repair epoxies for WT blades.

H350 may cause cancer

H411 Toxic to aquatic life with long lasting effects

H 372 Causes damage to organs through prolonged or repeated exposure.

Glass fibre reinforced Polymer are used in the manufacture of WT. On Review of typical Material Safety data sheets for the above products, with BPA epoxy resin being used for structural integrity of the Wind Turbine Blades.

I would urge the board to request all the safety data sheets for the production and repair procedures for these WT Blades and carefully review the impact these chemicals will have on future generations. We all have a duty to protect future generations. when we hold a position of privilege, we must endeavour to ensure we do the right thing.

The scale of this proposed BESS approx. 1.6 acres not to mention all the other additional HV electrical infrastructure and operations building. There are Processes that will be required for maintenance and operation of the systems over its life time, the developer has omitted the requirement for an EPA discharge licence for the site The list of chemicals tested for are comprehensive but on detailed consideration does not include what would be expected from a battery storage facility, so how can you find what you are not testing for or looking for. If you do not test for lead, then your sample will not give any result for lead.

In An emergency situation where a fire takes place all this leachate and ash will find its way into the local streams if not adequately policed (By Way of an EPA licence) and these substances from such a BESS bioaccumulate, again which leads into a SAC and the local food chain. The Scale of this BESS will have high quantities of Dielectric Fluids and Coolants which requires stringent procedures to prevent contamination of the entire area again no evidence of this in their documentation.

Just to explain further on the above point. When you test for a particular substance you may find the level in that sample, but when the test record does not test for a representative potential toxin then how can the effluent be deemed safe to discharge into the local streams from the BESS when you are not testing for that chemical.

"Endocrine Disruptors are chemicals that can interfere with the endocrine system, which is responsible for regulating hormones in the body. This disruption can lead to a wide range of disorders and even cancer" -EC Regulation 2023/707

Far from saving future generations, wind turbines and the BESS could prevent them!..

P. Kearney MSc. EHS Management Chartered Member of the Institute of Safety and Health.

Leon Mishnaevsky Jr in his Science direct article on "Repair of wind turbine blades: Review of methods and related computational mechanics Problem Sept 2019

L. Mishnaevsky Jr Et al., Accepted and Published Dec 2024

Asbjorn Solberg, Bard-Einar Rimereit and Jan ErikWeinbach, 08/07/ 2021 "leading edge erosion and pollution from wind turbines P15.

Swedish Environmental Protection Agency

Sokoli et al., 2017

NOISE & SHADOW FLICKER

Noise

Incorrect application of NG4

We object to the development, in particular because the EIAR incorrectly misclassifies the area as not a quiet area under EPA Noise Guidance NG4 (11.4.6.1). This is based on an inaccurate figure for the population of Ballycastle. This error causes the noise assessment to misapply the EPA noise guidance to all receptors in the report.

The below is extracted from the EIAR:

"11.4.6.1 NG4

There are a number of steps involved in confirming the assessment under the NG4 guidance:

- *Step 1: Quiet Area Screening of the Development Location The location of the Proposed Development should be screened in order to determine if it is to be located in or near an area that could be considered a 'Quiet Area' in open country according to the Agency publication Environmental Quality Objectives - Noise in Quiet Areas. This will involve determining if the following criteria are satisfied:*
  - *At least 3 km from urban areas with a population >1,000 people;*
  - *At least 10 km from any urban areas with a population >5,000 people;*
  - *At least 15 km from any urban areas with a population >10,000 people;*
  - *At least 3 km from any local industry;*
  - *At least 10 km from any major industry centre;*
  - *At least 5 km from any National Primary Route, and;*
  - *At least 7.5 km from any Motorway or Dual Carriageway*

The proposed site is located within 3 km of Ballycastle. Therefore, the site is not considered a quiet area."

The applicant's finding in red above is fundamentally incorrect. The most recent census April 3, 2022, found the population of Ballycastle is 199 people and not >1,000 people. Therefore the EIAR is mistaken in applying a limit of 45-55db to receptors in the area (Table 11.19). This mistake upends the findings of the report at all receptor locations.

Table 11.19 confirms the appropriate noise limits for a Quiet area, but these limits are misapplied because of this mistake:

Table 11.19: Proposed Impact of Directivity Assessment at receptors in exceedance (12 m/s)

Scenario	Daytime Noise Criterion, dB $L_{Ar,T}$ (07:00 to 19:00hrs)	Evening Noise Criterion, dB $L_{Ar,T}$ (19:00 to 23:00hrs)	Night-time Noise Criterion, dB $L_{Ar,T}$ (23:00 to 7:00hrs)
Quiet Area	Noise from the licensed site to be at least 10dB below the average daytime background noise level measured during the baseline noise survey	Noise from the licensed site to be at least 10dB below the average evening background noise level measured during the baseline noise survey	Noise from the licensed site to be at least 10dB below the average night-time background noise level measured during the baseline noise survey
Areas of Low Background Noise	45dB	40dB	35dB
All other Areas	55dB	50dB	45dB

If we look up NG4 guidance from the EPA, the following describes the appropriate treatment of an anthropogenic noise source in a quiet area:

> If the site does not meet these criteria it is not considered to be a quiet area as per the Agency definition; proceed to Step 2.
>
> In the event that these criteria are satisfied then a very stringent noise criterion may be considered appropriate. The *Environmental Quality Objectives – Noise in Quiet Areas* document proposes that the following criterion be applied to anthropogenic[iv] noise sources in quiet areas:
>
> > *'The noise from anthropogenic sources should not be clearly audible at any point within Quiet Areas'.*
>
> In order to comply with this criterion it is necessary to conduct an extensive background noise survey, at a number of locations, over an extended period, under a range of weather conditions, in order to establish existing noise levels. The results of the survey should be analysed to establish the average background noise levels (in terms of L_{AF90}) during daytime, evening and night-time periods. The resultant noise criterion applicable to the licensed facility (in terms of either $L_{Ar,T}$ or $L_{Aeq,T}$) is then derived by subtracting 10dB from the average background noise level during each period.
>
> It should be noted that, in a Quiet Area, it does not necessarily follow that levels of noise within the area will be low. The noise levels in a quiet area will typically have little, if any, contribution from manmade (i.e. anthropogenic) noise sources such as road or rail. However, the noise levels may be elevated due to the natural noises that form the soundscape[v] of the area in question. Also, a quiet area should not be confused with an area of low background noise as these are two distinct and different areas of concern in the context of this document.

An Bord Pleanala has gone further than these limits in a previous decision:

11.2.3.2 An Bord Pleanála

2022 An Bord Pleanála Decision

A recent decision by ABP for a wind farm (ABP-309306-21, dated 26th : noise limits in accordance with the 2006 Guidelines and were as follow

(a) between 7am and 11pm:

(i) the greater of 5 dB(A) L90,10min above background noise l 10min, at wind speeds of 5m/s or greater,

(ii) 40 dB(A) L90, 10min, at all other wind speeds.

(b) 43 dB(A) L90,10min at all other times

Reference belowfrom page 30 Wind energy guidelines 2006

> In general, a lower fixed limit of 45 dB(A)[10] or a maximum increase of 5dB(A) above background noise at nearby noise sensitive locations is considered appropriate to provide protection to wind energy development neighbours. However, in very quiet areas, the use of a margin of 5dB(A) above background noise at nearby noise sensitive properties is not necessary to offer a reasonable degree of protection and may unduly restrict wind energy developments which should be recognised as having wider national and global benefits. Instead, in low noise environments where background noise is less than 30 dB(A), it is recommended that the daytime level of the LA90, 10min of the wind energy development noise be limited to an absolute level within the range of 35-40 dB(A).

As the area must be designated as a very quiet area the above LA90 10 Min limit of 35-40 dB(A) must apply

I would urge ABP to ensure an independent survey is completed under the rules of natural justice for such a Quiet area.

The EPA guidance (NG4) should be applied to both turbines and BESS, and given the Quiet area directs a much more conservative approach to noise nuisance than applied in the EIAR.

The importance of protecting quiet areas is further supported by the applicant's own definitions in the EIAR:

- *11.1.2 Acoustic terminology "A change in noise level of 3 dB (A) is 'barely perceptible', while an increase in noise level of 10 dB (A) is perceived as a twofold increase in loudness."*
- *11.2.3.1 "Noise impact should be assessed by reference to the nature and character of noise sensitive locations. Separate noise limits should apply for daytime and for night-time Noise limits should be applied to external locations and should reflect the variation in both turbine source noise and background noise with wind speed."*

"However, in very quiet areas, the use of the margin of 5 dB(A) above the background noise at nearby noise sensitive properties is not necessary to offer a reasonable degree of protection and may unduly restrict wind energy developments. Instead in low noise environments where background noise is less than 30 dB(A), it is recommended that the daytime level of LA90,10min of the wind energy development noise should be limited to an absolute level within the range 35-40 dB(A)".

Noise exceedance at receptors

Even following the applicant's own mistaken assessment, the following 6 receptors have predicted noise levels higher than the night-time noise limit of 43 dB, at various wind speeds – H3, H4, H6, H10, H11 and H13.

Table 11.17: Margin between Predicted Noise Levels and 45 dBA Noise Limit

	ITM	ITM	4 m/s	5 m/s	6 m/s	7 m/s	8 m/s	9+ m/s
House ID	Easting	Northing	dBA	dBA	dBA	dBA	dBA	dBA
H1*	515110	837466	-4.8	-0.7	3.1	5.4	5.7	5.7
H2*	515526	833767	-7.7	-3.6	0.2	2.5	2.8	2.8
H3	516227	836339	-8.6	-4.5	-0.7	1.6	1.9	1.9
H4	514628	834072	-9.7	-5.6	-1.8	0.5	0.8	0.8
H5	516241	833804	-12.6	-8.5	-4.7	-2.4	-2.1	-2.1
H6	515489	833504	-10.4	-6.3	-2.5	-0.2	0.1	0.1
H7	517503	837983	-11.8	-7.7	-3.9	-1.6	-1.3	-1.3
H8*	515450	832962	-9.7	-5.6	-1.8	0.5	0.8	0.8
H9	515080	831996	-12.7	-8.6	-4.8	-2.5	-2.2	-2.2
H10	515456	833467	-10.4	-6.3	-2.5	-0.2	0.1	0.1
H11	516561	837118	-9.6	-5.5	-1.7	0.6	0.9	0.9
H12	515575	835060	-11.2	-7.1	-3.3	-1	-0.7	-0.7
H13	515019	834112	-10.4	-6.3	-2.5	-0.2	0.1	0.1

BESS noise

The following predicts noise impact from the BESS on a small sample of receptors ranging from 0dB to 33.9dB. Again it exceeds the NG4 guidance for quiet areas.

House ID	ITM	ITM	Predicted Noise Impacts LAeq, 1hr, dB
	Easting	Northing	
H43	517767	837579	5
H44	517742	837383	5.7
H45	515873	833236	33.9
H46	516625	836322	12.5
H47	517758	837737	4.4
H48	516764	835557	16.7
H49	517632	838261	0
H50	517628	837100	7

Aerodynamic modulation indeterminate

We object that in section 11.2.7 (page 12) "current scientific knowledge is such that AM cannot be predicted at the planning stage, but can only be measured once the windfarm becomes operational". This is important information necessary for an EIA decision. How are we expected to live and sleep when the developer confirm they cannot predict at the planning stage what AM we are to be subjected to? They confirm that once the turbines are built they will have to measure the AM. Is it not practicable for us to expect an accurate representation of what to expect rather than just saying they will measure it after the WF is in Place?

The most recent information in relation assessing AM comes in the IEC TS 61400-11. The scope of this document includes an assessment of the sound characteristics of the noise and relies on the Institute of Acoustics Reference Method (IoA RM) to quantify the AM level along with the WSP Phase 2 Report which identified a penalty scheme as shown **Plate 11.1** below.

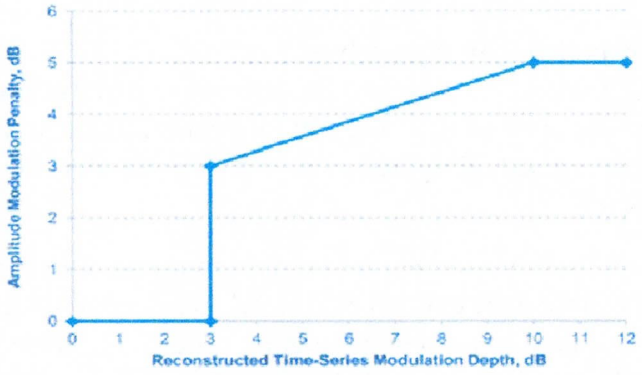


Plate 11.1: Proposed Penalty Scheme

Current scientific knowledge is such that AM cannot be predicted at the planning stage, but can only be measured once the wind farm becomes operational.

The above is extracted from the Noise Section of the report and specifically states that the AM cannot be predicted at the planning stage so how can the developer say it is safe for a community to live around the foot of such a development when it cannot be measured. With Respect ABP must investigate such a coastal location with recorded high wind speeds, especially towards the Gasebo Side of the development.

Noise limits in school

The WHO recommend Maximum background noise of 35 decibels(dBA) in classrooms for effective learning.

The WHO Shows how noise affects sleep and cardiovascular and metabolic function and reducing noise is covered by the EuZero Pollution Action Plan.

Table 11.16 shows that a wind speed of 7m/s will exceed this permissible noise level for Lacken Cross School (H102). As you can appreciate wind speed can frequently be higher than this in this area, causing a greater noise level for the students in the school.

The WHO has stated that background noise in classrooms should not exceed 35 dBA for optimal learning conditions research evidence shows that noise does have an effect on children's performance at school, with older children appearing to be the most affected by noise The Effects of Noise on Children at School a Review, Bridjet M Shield et al., J. Building Acoustics 10(2)-106 2003.

Applicant ignores advice of experts they cite themselves

The applicant refers to peer review journal "A procedure for deriving wind turbine noise limits by taking into account annoyance; Science of the total Environment; 2019" A wind turbine limit of 43.1 dBA is derived and this is also highlighted in the report by the developer, but they continue to use the 45dBA noise level

The WHO recommend that the population should not be exposed to levels of external noise at night above 40 db. Once the board examine the data given it clearly shows many receptors over this noise level. And the developer talks about a complaints procedure that seems extremely unlikely to work when people are deprived of essential sleeping time

Table 11.16 only predicts noise up to 9m/s windspeed

From the Vestas V117 Data sheet below. V117 is designed for high wind speed locations and operation.

The turbines Kick in at 3 M/S but can operate at wind speed up to 25M/S and if this wind turbine speed is exceeded it cuts out, and the turbine can cut back in at 23m/s. Then why does the developer not include this information in the above tables. The data above shows a steady rise DBA when graphed against wind speed between 4M/S and 8 M/S but there is no data for high wind speeds that we will encounter at our home locations.

The Proposed WF is located in a coastal area in north mayo with the proposed WF on a hill beside a salt marsh. When you look at met Eireann data wind speeds force 5 fresh breeze (9 M/S is exceeded between 30 to 35% of the time

Table 11.16: Predicted Noise Levels as LA90 at Varying Wind Speeds from the Proposed Development

	ING	ING	4 m/s	5 m/s	6 m/s	7 m/s	8 m/s	9+ m/s
House ID	Easting	Northing	dBA	dBA	dBA	dBA	dBA	dBA
H1*	515110	837466	38.2	42.3	46.1	48.4	48.7	48.7
H2*	515526	833767	35.3	39.4	43.2	45.5	45.8	45.8
H3	516227	836339	34.4	38.5	42.3	44.6	44.9	44.9
H4	514628	834072	33.3	37.4	41.2	43.5	43.8	43.8
H5	516241	833804	30.4	34.5	38.3	40.6	40.9	40.9
H6	515489	833504	32.6	36.7	40.5	42.8	43.1	43.1
H7	517503	837983	31.2	35.3	39.1	41.4	41.7	41.7
H8*	515450	832962	33.3	37.4	41.2	43.5	43.8	43.8
H9	515080	831996	30.3	34.4	38.2	40.5	40.8	40.8
H10	515456	833467	32.6	36.7	40.5	42.8	43.1	43.1
H11	516561	837118	33.4	37.5	41.3	43.6	43.9	43.9

When you interpret the data above the DBA level increases steadily but there is no data available for operating in higher wind speeds at up to 2.5 times the data given for operating such a Wind turbine.

If these units are designed for high wind speed locations then the number of rotations will increase in the same order of magnitude and the shadow flicker must be investigated further for such an elevated location for in particular

POWER REGULATION OPERATIONAL DATA	Pitch regulated with variable speed
Rated power	4,000/4,200kW
Cut-in wind speed	3m/s
Cut-out wind speed	25m/s
Re cut-in wind speed	23m/s

Baseline Noise – Inadequate and Misleading Representation

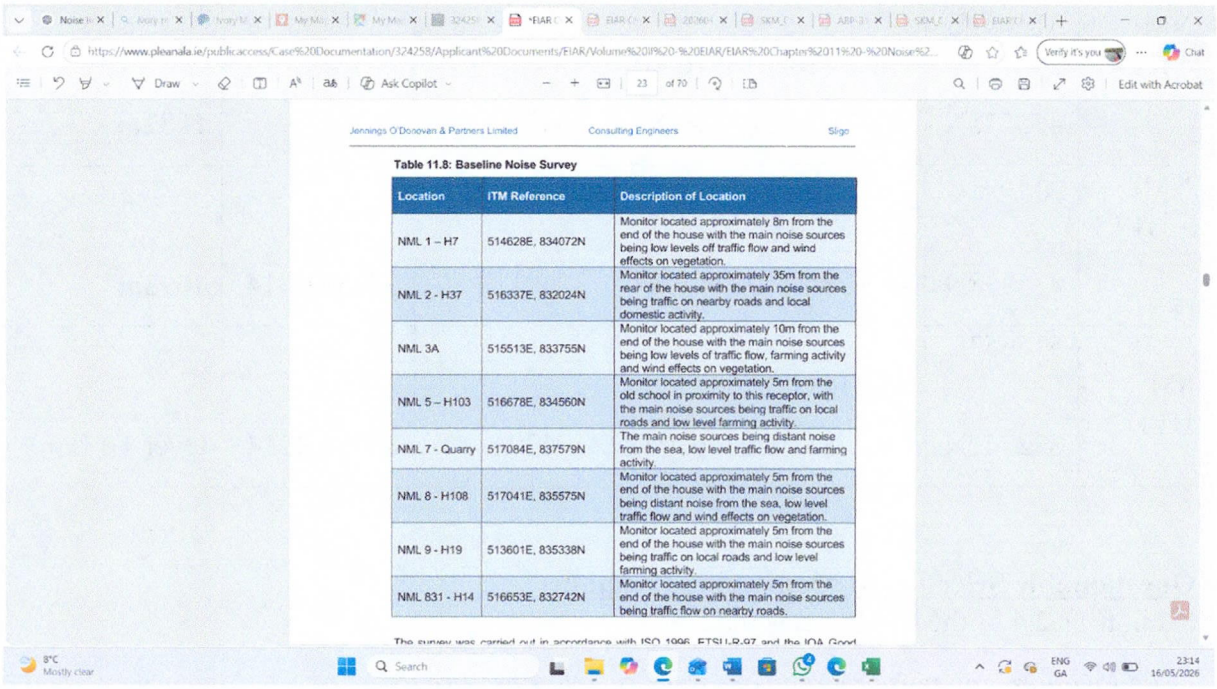
The **EIAR Noise Chapter (Vol. II, Ch. 11)** and associated appendices (11.1–11.6) identify a number of Noise Sensitive Receptors (NSRs) and Noise Monitoring Locations (NMLs), namely H7, H37, H103, H108, H19, and H14, plus a quarry site. See table 11.8 from chapter 11 inserted below. There also appears to be a material inconsistency between the receptor labels used in Table 11.8 and the ITM coordinates for those monitoring locations. The coordinates appear to correspond to different receptor IDs than those stated in the table. This requires independent verification by the planning authority before the noise assessment can be relied upon.

When the ITM coordinates contained within Table 11.8 are converted using the Irish Grid Reference Finder, the coordinates correspond instead to different receptor IDs: **H4, H178, H2, H92, the Quarry, H89, H91, and H204** (see Figure 2.3). The ITM Ref coordinates from table 11.8 Baseline Noise Survey also correspond to H4, H178, H92, H89, H91 and H204 within the developers own EIAR Table 11.16 not the H numbers we are led to believe in Table 11.8

This apparent discrepancy raises concerns regarding:

- the accuracy and consistency of the baseline noise assessment
- the identification and mapping of Noise Sensitive Receptors
- whether the correct dwellings were assessed
- whether the survey locations represent those closest to the clusters of turbines in the Northern area of the development
- and the overall reliability of the baseline noise dataset relied upon in the EIAR.

These apparent discrepancies undermine confidence in the receptor selection process and the representativeness of the baseline noise survey, particularly given that the nearest inhabited dwelling identified throughout the EIAR, does not appear to have been assessed as part of the baseline monitoring survey.



Jennings O'Donovan & Partners Limited Consulting Engineers Sligo

Table 11.8: Baseline Noise Survey

Location	iTM Reference	Description of Location
NML 1 – H7	514628E, 834072N	Monitor located approximately 8m from the end of the house with the main noise sources being low levels off traffic flow and wind effects on vegetation.
NML 2 - H37	516337E, 832024N	Monitor located approximately 35m from the rear of the house with the main noise sources being traffic on nearby roads and local domestic activity.
NML 3A	515513E, 833755N	Monitor located approximately 10m from the end of the house with the main noise sources being low levels of traffic flow, farming activity and wind effects on vegetation.
NML 5 – H103	516678E, 834560N	Monitor located approximately 5m from the old school in proximity to this receptor, with the main noise sources being traffic on local roads and low level farming activity.
NML 7 - Quarry	517084E, 837579N	The main noise sources being distant noise from the sea, low level traffic flow and farming activity.
NML 8 - H108	517041E, 835575N	Monitor located approximately 5m from the end of the house with the main noise sources being distant noise from the sea, low level traffic flow and wind effects on vegetation.
NML 9 - H19	513601E, 835338N	Monitor located approximately 5m from the end of the house with the main noise sources being traffic on local roads and low level farming activity.
NML 831 - H14	516653E, 832742N	Monitor located approximately 5m from the end of the house with the main noise sources being traffic flow on nearby roads.

The survey was carried out in accordance with ISO 1996, ETSU-R-97 and the IOA Good

	ITM REF Table 11.8	**Converted using Irish grid ref finder**	**Actual H ID**	**Approx Distance to R314**	**Distance to nearest Turbine Table 15.1**
NML 1 – H7	514628E, 834072N	54.24836406876109 -9.309963414706216	H4	384M - R314	**555m**
NML 2 – H37	516337E, 832024N	54.23024828038031 -9.283176530256615	H178	250M - R314	Over 1.17km
NML 3A	515513E, 833755N	54.24566314790785 -9.296298380255672	H2	610m -R314	**322m**
NML 7 – H103	516678E, 834560N	54.25308558696446 -9.27865222053572	H92		**1095m**
NML - Quarry	517084E, 837579N	54.28027214018676 -9.27325913056019	QUARRY		

NML 9 – H19	517041E, 835575N	54.262262613776365 -9.273364117724983	H89		**1082m**
NML 9 – H19	513601E, 835338N	54.25956449621492 -9.32608210624988	H91	330M R314	**1093m**
NML 831 – H14	516653E, 832742N	54.23674982043359 -9.278530603663047	H204	830M R314	Over 1.17km

Questionable Selection of Monitoring Locations

Section 11.2.4 of the EIAR states that:

"The locations for noise monitoring were selected by inspection of Site layout maps and by identifying the nearest receptors surrounding the wind turbines."

Section 11.3.1 further states that:

"Based on the initial layout, potential noise sensitive receptors, including occupied and unoccupied dwellings, were identified from maps."

The available evidence does not appear to support these statements.

- **4 of the 8 monitoring locations** are financially connected to the developer, either through landowner involvement or family connection.
- A fifth was but has since changed ownership. This house was sold by a family relative, just prior to this application.
- **5 of the 8 monitoring locations** are located close to the R314, at distances of approximately **250m–830m**, and therefore do not accurately represent the quieter rural environment in the northern half of the site.
- **Only 3 of the 8 monitoring locations** are within 1km of a proposed turbine. Of these, one appears to have been excluded from operational noise predictions due to being under the control of the developer, and one is the quarry.
- The quarry has been selected as a noise monitoring location yet it fails to appear in either the noise or shadow flicker predictions as a sensitive receptor for either study. If the quarry is not treated as a noise-sensitive receptor for operational assessment, it is unclear why it was suitable as a representative baseline monitoring location.

These factors raise significant concern whether the baseline monitoring survey adequately characterises the existing noise environment at the nearest occupied and potentially worst affected receptors.

In particular, the selected monitoring locations may be disproportionately influenced by existing road traffic noise, this combination of factors indicates that the baseline monitoring data do not provide an accurate or representative assessment of the quiet rural residential properties located in close proximity to the proposed turbine clusters on the Northern area if the development.

ETSU-R-97 and the Institute of Acoustics guidance indicate that baseline noise surveys should be carried out as representative Noise Sensitive Receptors and at locations representative of the likely worst affected occupied dwellings.

IOA guide states

"2.2.3 many cases there will be significant variation in general background noise levels within the study area, because of topography and the varying influence of existing noise sources such as roads. In rural or semi-rural areas, noise generated by wind in trees is generally a dominant noise source at higher wind speeds and therefore the proximity of the monitoring location to trees and vegetation, and the type of such vegetation, may be significant. Noise from streams and other watercourses can also be a local factor."

As shown in the table above some locations are close in location to the R314 and some were carried out beside a forestry therefore as shown in 2.2.3 from IOU Guidance this could be significant to the baseline.

The concerns that these standards have not been adequately satisfied within the current assessment and do not adequality represent the most affected by turbine noise.

1.2 Baseline Monitoring Not Representative of the Northern Rural Environment

A significant proportion of the selected baseline monitoring locations appear to be situated in proximity to the R314 regional road. Of the eight identified baseline locations, five are specifically noted as being located between approximately 250m and 830m from the R314.

However, the majority of the proposed turbines are located within the northern section of the site, away from the R314 corridor and within a quieter rural environment.

Accordingly, it is unclear why a greater proportion of baseline monitoring was not undertaken at receptors located within the northern half of the site where turbine concentration is greatest and where the receiving noise environment is materially different from roadside locations adjacent to the R314.

The monitoring locations selected near the R314 do not appear to provide an accurate representation of the quieter rural sound environment experienced at receptors in the northern section of the development area.

This raise concerns regarding whether the baseline survey accurately reflects the existing acoustic environment at the locations most likely to experience operational turbine noise impacts.

1.3 Contradiction Regarding H2

The EIAR (Section 11.4.3) states:

"There is one dwelling, H2, located approximately 321 m southwest of AT01. This property is under the control of the developer, and the owner is a financial beneficiary of the proposed development. The owner has confirmed that this property will remain unoccupied for the operational lifespan of the proposed development. These dwellings have not been included in this assessment."

However, as outlined above H2 corresponds to Monitoring Location 3A identified within Table 11.8 and the associated baseline noise monitoring appendices.

If H2 has been excluded from the operational noise assessment on the basis that it is not considered a Noise Sensitive Receptor due to its unoccupied status, it is unclear why this location was considered appropriate for baseline noise monitoring purposes.

This appears inconsistent with the stated methodology that baseline noise data was obtained at "representative locations close to the Wind Farm Site" for the purpose of characterising the existing noise environment at nearby inhabited dwellings.

This directly contradicts the stated methodology that baseline data were gathered at "potential noise-sensitive receptors." Section 11.4.3 of the EIAR states:

Excluding "financially involved" or developer-owned houses is not robust or future-proof

The EIAR proposes to:

- Exclude H1 and H2 from the assessment altogether because they are currently under the control of the developer and claimed to be vacant / to be used as an operations building.
- Apply a higher 45 dB night-time limit at H8 on the basis that these are "financially involved" receptors

This approach raises a number of concerns

1. Planning permission attaches to the land, not to the current owner. There is no guarantee that H1, H2, H8 will remain unoccupied or in the same ownership for the 30-year life of the project.
2. Recent ABP decisions increasingly apply noise limits to "any residential or noise sensitive properties" rather than excluding certain dwellings for ownership reasons.
3. Financial involvement does not alter the status of a dwelling as a residential receptor, nor remove the potential for operational effects on residential amenity, sleep, or health.
4. The approach is inconsistent with the precautionary principle and the EIA Directive requirement to consider likely significant effects over the full life of the project.

Summary of Baseline Noise Assessment issues

The baseline noise assessment presented within the EIAR appears to contain a number of material inconsistencies and methodological concerns, including:

- discrepancies between receptor IDs and mapped coordinates.
- reliance upon monitoring locations that are financially connected to the development.
- use of unoccupied dwellings as representative receptors.
- concentration of monitoring locations near the R314 rather than within the quieter northern rural environment where turbine density is greatest.
- and exclusion of certain nearby receptors from operational assessment despite their inclusion within the baseline survey.

Taken together, these issues undermine confidence in the representativeness and reliability of the baseline dataset underpinning the operational noise predictions.

In the absence of representative baseline monitoring at the nearest occupied rural dwellings, including H3, it cannot be concluded with sufficient certainty that the operational noise assessment accurately reflects the likely impacts on residential amenity.

Accordingly, it is difficult to conclude with confidence that the operational noise assessment is sufficiently robust or representative.

EPA EIAR Guidance and NG4

The EIAR states that the significance of effects has been assessed by reference to the EPA *Guidelines on the Information to be Contained in Environmental Impact Assessment Reports* 2022, and also identifies EPA NG4 as relevant noise guidance.

However, the conclusion that residual operational noise effects will be "not significant" is weakened by the applicant's own assessment. The EIAR acknowledges that baseline monitoring was undertaken only at selected "representative locations", rather than at every affected receptor, and that operational assessment is then based on predicted turbine noise compared with derived limits. Where the selected monitoring locations are not demonstrably representative of the quietest and most affected dwellings, the reliability of the derived background limits is uncertain.

This concern is particularly important because the applicant's own modelling identifies exceedances before mitigation and relies on directivity adjustments and curtailment to achieve compliance, with some receptors predicted at or extremely close to the relevant thresholds. A conclusion of "not significant" is therefore not robust where compliance depends on mitigation, modelling assumptions and very small margins.

NG4 is not a wind-farm-specific standard, but it is relevant because it reflects the EPA's approach to protecting Noise Sensitive Locations and minimising noise impact on the local environment. The EIAR itself notes that NG4 requires all reasonably practicable measures and BAT to minimise noise impact, and identifies typical limits at Noise Sensitive Locations. The EPA also recognises that excessive noise can seriously harm human health, disturb sleep, cause stress and provoke annoyance responses.

Accordingly, the planning authority should not accept a "not significant" conclusion unless the applicant demonstrates, with sufficient certainty, that the baseline monitoring is representative of the most affected dwellings, that the mitigation strategy is enforceable, and that operational noise will remain compliant under real-world conditions throughout the lifetime of the development.

Implications for Affected Residential Receptors

The EIAR does not demonstrate that baseline noise monitoring was undertaken at, or in the immediate vicinity of, several of the residential receptors identified as potentially affected by the proposed development. While a number of baseline monitoring locations were selected by the applicant, the assessment does not provide sufficient evidence that these locations are representative of the acoustic environment experienced at all affected dwellings.

Many of the residential properties surrounding the proposed development are situated within a quiet rural environment characterised by low residual background noise levels, particularly during night-time periods. In such environments, relatively modest increases in turbine noise can become highly perceptible and may result in significant effects on residential amenity, sleep quality and overall quality of life.

As identified in Table 2.3, the assessment understates the extent to which residents will be affected by the proposed development. A number of residential receptors are impacted by multiple turbines, including H3 (AT08, AT09 and AT10), H8 (AT02, AT03 and AT04), H22 (AT11, AT12 and AT13), H4 (AT05 and AT06), and H11 (AT14 and AT16). The cumulative effect of several turbines in close proximity to the same dwelling is likely to be significantly greater than the impact of any individual turbine considered in isolation.

Despite this, the EIAR does not demonstrate that the selected baseline monitoring locations accurately reflect the existing acoustic conditions experienced at all affected receptors. In the absence of representative baseline measurements, the reliability of the derived background noise limits and subsequent operational noise predictions remains uncertain.

As a consequence:

- the adopted noise limits (Background +5 dB(A) or fixed limits of 43–45 dB(A) LA90) may not adequately protect all affected receptors situated within quiet rural environments;
- the operational noise predictions may be based upon baseline assumptions that are not demonstrably representative of every affected dwelling; and
- the actual operational effects experienced by residents may therefore be underestimated.

This approach appears inconsistent with the principles set out in:

- the Wind Energy Development Guidelines (2006), which require protection of nearby noise-sensitive receptors;
- EPA Guidance Note NG4 (2016), which emphasises protection of residential amenity and avoidance of adverse noise effects; and

- ETSU-R-97 and the Institute of Acoustics Good Practice Guide, both of which require representative baseline assessment.

Accordingly, concerns remain regarding whether the baseline assessment methodology provides a sufficiently robust basis for the operational noise assessment presented within the EIAR.

Predicted Operational Noise – Risk of Exceedance

The applicant's own modelling demonstrates that a number of residential receptors are predicted to experience operational noise levels at, or extremely close to, the applicable guideline thresholds, leaving little or no meaningful compliance margin.

For example, Table 11.17 predicts operational noise levels at H3 of up to 44.9 dB(A) under certain wind speed conditions, only 0.1 dB below the applicable daytime limit of 45 dB(A).

Furthermore, the applicant acknowledges that predicted operational noise levels exceed the night-time limit of 43 dB(A) at six receptors prior to mitigation measures being applied, including H3, H4, H6, H10, H11 and H13. Section 11.5.2 states:

"*Therefore, mitigation measures are required for exceedances at these receptors.*"

The proposed mitigation strategy initially relies upon directivity adjustments. However, the applicant's own assessment demonstrates that, even following application of these adjustments, exceedances remain at several receptors.

The applicant subsequently introduces turbine curtailment measures in an attempt to achieve compliance. However, the resulting predicted noise levels remain only marginally below the applicable limits at several receptors.

At H3, the remaining compliance margins are reported as:

- 0.4 dB below the limit in one scenario;
- 0.1 dB below the limit in another scenario; and
- 0.3 dB below the limit in a further scenario.

Similarly limited margins are reported for other receptors, including:

- H4, predicted at only 0.1 dB below the limit; and
- H11, predicted **directly at the applicable threshold**.

The EIAR therefore demonstrates that:

- exceedances are predicted prior to mitigation;
- compliance is dependent upon multiple layers of mitigation;
- the final predicted outcomes rely upon extremely small compliance margins; and
- there remains a realistic risk of operational exceedance during the lifetime of the development.

The compliance margins presented are significantly smaller than the uncertainties typically associated with environmental noise prediction and modelling. The assessment relies upon multiple assumptions including directivity corrections, turbine operating modes and curtailment strategies in order to achieve nominal compliance.

However, little or no tolerance remains to account for:

- meteorological variability;
- turbine performance variation;
- cumulative turbine interaction;
- ground condition variability;
- amplitude modulation;
- tonal characteristics;
- low-frequency noise effects; and
- long-term operational changes over the lifespan of the project.

Given that a number of receptors are already predicted to operate at or extremely close to the applicable limits, the EIAR does not demonstrate robust compliance with sufficient certainty to ensure protection of residential amenity within this quiet rural environment.

Conclusion on Predicted Operational Noise Impacts

Environmental noise prediction is inherently subject to uncertainty arising from meteorological conditions, ground absorption assumptions, turbine operating behaviour, propagation modelling and future operational conditions. Where compliance margins are reported to be as little as 0.1Db(A) or exactly at the 43Db(A), these margins are significantly smaller than the uncertainties typically associated with environmental noise prediction. The applicant has therefore not demonstrated compliance with a sufficient degree of confidence.

The EIAR demonstrates that several non-participating residential receptors are predicted to experience operational noise levels at, or extremely close to, applicable guideline thresholds.

The assessment further demonstrates that compliance at a number of receptors can only be achieved through the application of layered mitigation measures including directivity adjustments and turbine curtailment.

Despite this reliance on mitigation, the remaining compliance margins are negligible and fall within normal acoustic modelling uncertainty.

Furthermore, baseline monitoring was not undertaken at all potentially affected receptors and the EIAR does not demonstrate that the selected monitoring locations are fully representative of the acoustic environment experienced at every affected dwelling.

Accordingly, significant uncertainty remains regarding whether operational turbine noise can consistently remain within acceptable limits throughout the operational life of the development while adequately protecting residential amenity, residential health and quality of life for affected residents.

Cumulative Noise Exposure from Multiple Turbines

The EIAR frequently assesses receptors by reference to their distance from the nearest turbine. However, this approach does not adequately reflect the cumulative acoustic environment arising from the simultaneous operation of multiple turbines surrounding individual dwellings.

A number of receptors, are situated within areas where several turbines are located in relatively close proximity. Examples

H3 is influenced by AT08, AT09 and AT10.

H8 is influenced by AT02, AT03 and AT04.

H22 is influenced by AT11, AT12 and AT13.

H11 is influenced by AT14 and AT16.

The assessment largely discusses compliance by reference to receptor limits but does not clearly explain the experiential effect of multiple turbines operating simultaneously around individual dwellings.

Consequently, the acoustic environment experienced by residents will arise from the combined and overlapping operation of multiple turbines rather than from any individual turbine considered in isolation.

This cumulative operational scenario has the potential to increase:

- overall noise exposure;
- audibility and perceptibility of turbine noise;
- amplitude modulation effects;
- frequency and persistence of blade interaction noise;
- low-frequency noise exposure; and
- night-time disturbance within an otherwise quiet rural environment.

The spatial arrangement of turbines surrounding certain receptors may also result in noise being experienced from multiple directions simultaneously, reducing opportunities for natural acoustic screening and periods of relative acoustic relief.

The EIAR does not appear to provide a sufficiently detailed assessment of:

- cumulative directional impacts from multiple turbines operating concurrently;
- overlapping amplitude modulation effects;
- potential turbine synchronisation effects;
- worst-case meteorological and atmospheric stability conditions; or
- the interaction between low background noise levels and turbine audibility.

Given the low baseline rural noise environment identified within the assessment, even moderate increases in turbine-related noise may become highly perceptible and intrusive, particularly during night-time periods.

Accordingly, the EIAR has not demonstrated with sufficient certainty that the cumulative operational effects arising from the simultaneous operation of multiple turbines will not result in significant adverse impacts on residential amenity, sleep quality and overall quality of life for nearby residents throughout the operational lifespan of the development.

Legal precendents on noise

The principles applied in recent wind turbine nuisance cases are rooted in the long-established Irish law of nuisance, as recognised by the Supreme Court in *Hanrahan v Merck Sharp & Dohme (Ireland) Ltd* [1988] IESC 1, which recognised that the law protects the ordinary and reasonable enjoyment of property from substantial environmental interference.

The significance of uncertainty in relation to wind turbine noise impacts is reinforced by recent Irish High Court jurisprudence concerning operational wind farms. In *Webster & Anor v Meenacloghspar (Wind) Ltd* [2024] IEHC 136, the High Court found that wind turbine noise constituted an actionable nuisance, with particular regard to its characteristics, including amplitude modulation, low-frequency components and the resulting impacts on sleep and residential amenity. The judgment illustrates that compliance with conventional noise assessment metrics may not, of itself, guarantee the protection of nearby residents where the specific character of turbine noise gives rise to significant adverse effects.

Similarly, in *Byrne & Moorhead v ABO Energy Ireland Ltd* [2025] IEHC 330, the High Court found that noise from an operational wind farm constituted a substantial interference with the residents' enjoyment of their home and ordered the permanent shutdown of three turbines. While both cases concerned private nuisance claims relating to operational wind farms rather than the assessment of a proposed development under the planning code, they provide important cautionary examples of the consequences that can arise where turbine noise gives rise to unacceptable impacts on nearby residents.

In the present case, the EIAR itself identifies a level of uncertainty that requires careful consideration. It predicts operational noise levels at receptors that are close to the applicable limits, with some receptors exceeding the relevant thresholds prior to mitigation and final compliance being dependent upon directivity adjustments and turbine curtailment measures. The remaining compliance margins in certain scenarios are as little as 0.1 dB, a margin that is smaller than the ordinary uncertainties associated with environmental noise prediction and modelling. Furthermore, concerns have been identified regarding whether the baseline noise monitoring locations are truly representative of the quietest and potentially most affected dwellings, particularly in the northern area of the site where turbine density is greatest. The assessment also acknowledges that amplitude modulation cannot be reliably predicted at the planning stage. These uncertainties are particularly significant in light of the findings in *Webster* and *Byrne & Moorhead*, which demonstrate that the actual impact of wind turbine noise may depend not only on predicted sound levels but also on its specific characteristics, cumulative effects, persistence and the resulting impact on sleep, health and residential amenity.

Accordingly, the Board should adopt a cautious and precautionary approach in determining whether the EIAR has provided sufficient certainty that operational turbine noise will remain acceptable throughout the lifetime of the development. Where compliance depends upon modelling assumptions, multiple mitigation measures and minimal margins of tolerance, and where important characteristics of turbine noise cannot be reliably predicted in advance, the possibility of significant adverse effects on nearby residents cannot be excluded with the degree of confidence required by the EIA process. The precautionary principle requires that such uncertainties be satisfactorily addressed before consent is granted rather than only after residents have experienced unacceptable impacts.

Protection of Residents in Relation to Health and Amenity

The assessment of noise impacts does not adequately protect the health and amenity of nearby residents and relies upon national guidance that is now almost two decades old and no longer fully reflects current international public health recommendations.

In *The People Over Wind CLG v An Bord Pleanála & Others* [2024] IEHC 136, Justice Egan observed that:

"*there is not a binary choice to be made here between the generation of clean energy by a wind farm, and a good night's sleep for its neighbours. It should be possible to achieve both.*"

This statement recognises that the promotion of renewable energy development must be balanced with the protection of the health, wellbeing and residential amenity of those living in close proximity to such developments.

The proposed development relies on the Wind Energy Development Guidelines for Planning Authorities (2006), which permit night-time wind turbine noise levels of up to 43 dB LA90 at neighbouring dwellings. These guidelines do not reflect the current understanding of environmental noise impacts on human health and sleep.

The World Health Organization (WHO) Environmental Noise Guidelines for the European Region (2018) recommend that wind turbine noise should not exceed 45 dB Lden, broadly equivalent to approximately 37 dB LA90. The WHO states that these recommendations are intended to protect human health and are based upon evidence linking wind turbine noise exposure with adverse effects including annoyance and sleep disturbance.

The Environmental Protection Agency's *State of the Environment Report 2024*, in summarising the WHO guideline values, notes that their purpose is to provide recommendations for the protection of human health and identifies increasing risks of adverse health effects as noise exposure increases.

International examples demonstrate that more protective approaches are achievable. For example, New South Wales, Australia, applies a base night-time limit of 33 dB LA90 together with penalties for special audible characteristics such as amplitude modulation and tonal noise. By contrast, the Irish 2006 Guidelines permit substantially higher limits and contain no equivalent adjustment for particularly intrusive characteristics of turbine noise.

The significance of this issue is particularly acute in the present case. The EIAR demonstrates that a number of nearby non-participating dwellings are predicted to experience operational noise levels at or extremely close to the maximum levels permitted under the 2006 Guidelines.

At H3, for example, predicted compliance margins are reported to be as little as 0.1 dB following the application of directivity corrections and turbine curtailment measures. The assessment therefore relies on multiple layers of mitigation and leaves little allowance for ordinary uncertainty associated with environmental noise modelling. Furthermore, the EIAR acknowledges that characteristics known to contribute significantly to annoyance and sleep disturbance, including amplitude modulation, cannot be reliably predicted at the planning stage. The cumulative influence of multiple turbines surrounding receptors such as H3, H8, H11 and H22 further increases the potential for persistent and intrusive noise effects, particularly during night-time periods in a quiet rural environment.

The planning authority is required under the EIA process to consider the likely significant effects of the development on human beings, including health, quality of life and residential amenity. Compliance with the numerical limits contained within the 2006 Guidelines should not, in itself, be regarded as conclusive evidence that significant adverse effects will not occur, particularly where compliance is dependent upon operational mitigation and achieved only by negligible margins.

Noise predictions assume perfect operation of turbines

The noise predictions in the EIAR are based on brand new turbines in perfect order. However, experience from windfarms elsewhere in Mayo suggest that noise increases as turbines age. In particular, gear boxes and brakes on older turbines can introduce a noise element that exceeds the noise of the blades themselves. Given the lack of any margin for noise nuisance to neighbours, it seems certain the noise limits will be breached in future years as turbines age and gearboxes start to add to the noise nuisance.

Effect of infrasound on heart failure rates in local populations

The study "Significantly increased incidence of heart failure and arrhythmia in municipalities with significant expansion of wind energy; Christian-Friedrich Vahl + Olivier Dietz; Deutschen Gesellschaft fur Innere Medizin; 2026" compared similar populations in 4 german regions. Two with little wind energy penetration, and the other two with a large and expanding wind energy infrastructure. The study was conducted on public health records from 2015-2024, and the populations were similar in size, age and general health terms.

The 2 regions with elevated wind energy recorded increased and increasing rates of both heart failure and arrhythmia. The study found increases in heart failure of at least 21% per year between 2021 and 2024 in one region, and at least 20% per year (and as much as 68% in a single year) in the second. The 2 control regions (with similar population profile) did not record a meaningful increase.

The study lays the blame for this very significant difference with infrasound from turbine motion. While, that specific mechanism can be challenged, what cannot be challenged is the very high, and statistically significant ($P<0.0001$) finding that wind energy developments are associated with increased heart failure, and arrhythmia. Whatever the mechanism, the result is damage to human health.

Recent reporting on investigations undertaken at Delft University of Technology (TU Delft) has highlighted growing concerns regarding the health impacts of prolonged exposure to low-frequency noise and vibration. The article reports that an internal investigation at TU Delft identified low-frequency sound generated by a building ventilation system as a contributing

factor to a range of reported health complaints among building occupants, including sleep disturbance, headaches, dizziness, stress-related symptoms and cardiovascular effects. While the circumstances differ from those associated with wind turbine developments, the findings reinforce the importance of carefully assessing low-frequency noise impacts and ensuring that conventional noise assessment methodologies do not overlook frequencies that may cause disturbance or adverse health effects for nearby residents. The reported findings further support calls for a precautionary approach where uncertainty remains regarding long-term exposure to low-frequency sound. See appendices for link to article

SHADOW FLICKER

Shadow Flicker Assessment and Reliance on Operational Mitigation

The applicant's shadow flicker assessment identifies the potential for widespread shadow flicker effects across the study area. According to the EIAR (Table 15.3), 89 out of 100 receptors are predicted to experience some degree of shadow flicker, while 56 receptors have the potential to exceed the recommended maximum daily threshold of 30 minutes prior to mitigation. The assessment therefore demonstrates that shadow flicker is not a localised issue affecting only a small number of properties but is a matter with the potential to affect a substantial number of nearby residents.

The Wind Energy Development Guidelines for Planning Authorities (2006) recommend that shadow flicker at neighbouring dwellings should not exceed 30 minutes per day or 30 hours per year. While the applicant concludes that the proposed development can comply with these guidelines, the EIAR clearly demonstrates that such compliance is dependent upon the operation of automated turbine shut-down systems rather than being achieved through the siting or design of the development itself.

The Draft Revised Wind Energy Development Guidelines (2019) adopt a more precautionary approach and recognise that where shadow flicker is predicted at residential properties, site design should first be reviewed to seek elimination of the effect. Where elimination is not possible, automated mitigation measures should be employed. In this case, the EIAR acknowledges that numerous receptors would experience shadow flicker in excess of the adopted daily threshold prior to mitigation, indicating that the proposed turbine layout does not avoid shadow flicker impacts through design alone.

We are concerned that the assessment relies heavily on operational mitigation measures for the lifetime of the wind farm without providing sufficient information regarding their long-term effectiveness, monitoring or enforcement. The EIAR does not provide adequate detail regarding:

- The specific turbines that will require curtailment to protect individual receptors;
- The frequency and duration of turbine shut-down events required to achieve compliance;
- Independent monitoring or auditing of shadow flicker control systems;
- Reporting requirements to the Planning Authority; or
- Publicly accessible records demonstrating ongoing compliance.

Instead, the EIAR proposes a process whereby complaints may be investigated after impacts have been experienced. This approach places significant reliance on future operational management rather than demonstrating that impacts have been avoided through project design.

We are also concerned by inconsistencies within Chapter 15 regarding the number of receptors assessed. Various sections refer to 100 receptors, 108 receptors and 119 receptors within the study area. Clarification should be provided regarding the correct number of receptors assessed and whether these discrepancies have any implications for the conclusions of the assessment.

The applicant concludes that residual shadow flicker effects will be neutral and imperceptible following mitigation. However, this conclusion appears to rely upon assumptions regarding the effectiveness of operational turbine curtailment rather than on demonstrated and enforceable mitigation measures. In the absence of detailed information regarding monitoring, verification, enforcement and long-term operation of the proposed shadow flicker control system, it has not been demonstrated that residential amenity will be adequately protected throughout the operational life of the development.

We therefore request that the Planning Authority carefully examine the adequacy, enforceability and long-term effectiveness of the proposed mitigation measures and seek clarification regarding the inconsistencies identified within the assessment before determining the application.

A further concern relates to the operation of the proposed shadow flicker mitigation system. The EIAR states that automated turbine shut-down controls will be implemented to ensure compliance with the recommendations of the Wind Energy Development Guidelines for Planning Authorities (2006), namely a maximum of 30 minutes per day or 30 hours per year of shadow flicker exposure.

However, it is unclear from the EIAR whether the proposed system is intended to eliminate shadow flicker effects at affected dwellings, consistent with the precautionary approach reflected in the Draft Revised Wind Energy Development Guidelines (2019), or whether turbine curtailment will only occur once predicted exposures approach the 2006 guideline thresholds.

The EIAR does not clearly explain the operational parameters of the proposed control system, the trigger points for turbine shut-down, how compliance will be monitored, or how residents and the Planning Authority can be satisfied that exceedances will not occur. The assessment therefore lacks clarity regarding whether the mitigation measures will prevent shadow flicker from occurring or merely seek to limit it to levels considered acceptable under the 2006 Guidelines.

Given that 56 receptors are predicted to exceed the 30-minute daily guideline threshold prior to mitigation, greater detail should be provided regarding how the control system will operate in practice, the extent to which shadow flicker will be eliminated, and the arrangements for independent monitoring and verification of compliance throughout the operational lifetime of the development.

Omission of Sensitive Receptors from the Shadow Flicker Assessment

We submit that the current shadow flicker assessment appears incomplete. The applicant defines the shadow flicker study area as 10 times the rotor diameter, i.e. 10 × 117 m = 1,170 m, and states that receptors within this study area are to be assessed.

The previous Tirawley Wind Farm EIAR, ABP Case Ref. PAX16.323778 , Table 15.1, identified properties within that study area and listed their coordinates and distance to the nearest turbine. In the previous assessment, the following receptors were identified within the 1,170 m study area:

Previous ID	Coordinates	Nearest Turbine	Distance
H119	517007E, 836317N	AT10	1,124 m
H122	515945E, 831977N	AT02	1,144 m
H123	516052E, 832172N	AT02	1,152 m

These receptors are all within the applicant's stated 1,170 m threshold and therefore fall within the defined shadow flicker study area.

As demonstrated by the extracts provided from Table 11.16 of the current EIAR and Table 15.1 of the previous application (ABP Case Ref. PAX16.323778), the coordinates for these receptors remain unchanged. While turbine AT10 has been renumbered as AT08 in the current application, the turbine location itself does not appear to have materially changed. The omission therefore cannot be explained by either relocation of the receptors or changes to turbine positioning outside the study area.

On that basis, any receptor previously confirmed to be within 1,170 m of a turbine should have been included within the current shadow flicker assessment unless the applicant clearly demonstrates that:

- the receptor no longer exists,
- the receptor now lies outside the 1,170 m study area.

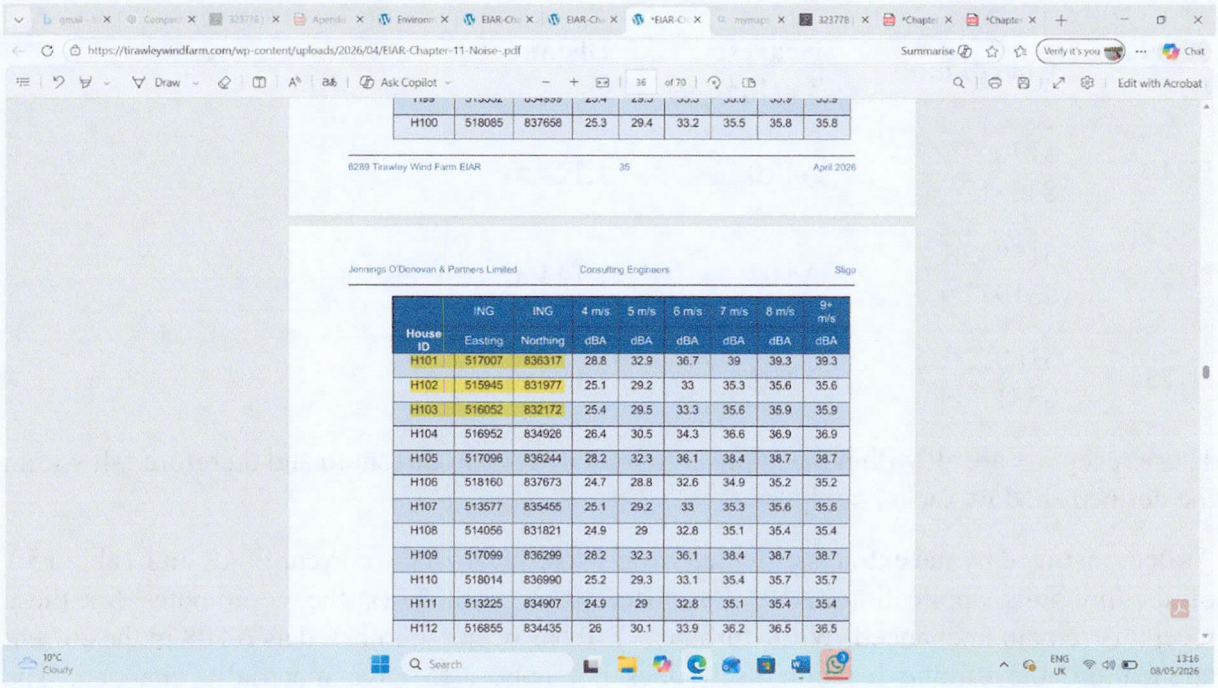
No such explanation appears to have been provided.

It should also be noted that previous receptor H122, now identified as H102 in the current documentation, is St Patrick's College, a secondary school and therefore a highly sensitive receptor. The receptor location and distance to turbine AT02 remain within the applicant's stated shadow flicker study area of 1,170 m. Despite this, the receptor does not appear to have been included within the current shadow flicker assessment.

The omission of a school receptor from the assessment is particularly concerning given the potential for shadow flicker effects during school operating hours and the expectation that educational facilities would be fully assessed where they fall within the applicant's own study area criteria.

Accordingly, the failure to assess receptors that demonstrably fall within the applicant's stated 1,170 m study area calls into question the robustness, reliability and overall completeness of the shadow flicker assessment presented in the EIAR. This is particularly significant given that one of the omitted receptors is St Patrick's College, a highly sensitive educational receptor.

The below extract is taken from chapter 11 and table 11.16, we have highlighted 3 House ID's and there easting and northing coordinates



H100	518085	837658	25.3	29.4	33.2	35.5	35.8	35.8

8289 Tirawley Wind Farm EIAR 35 April 2026

Jennings O'Donovan & Partners Limited Consulting Engineers Sligo

House ID	ING Easting	ING Northing	4 m/s dBA	5 m/s dBA	6 m/s dBA	7 m/s dBA	8 m/s dBA	9+ m/s dBA
H101	517007	836317	28.8	32.9	36.7	39	39.3	39.3
H102	515945	831977	25.1	29.2	33	35.3	35.6	35.6
H103	516052	832172	25.4	29.5	33.3	35.6	35.9	35.9
H104	516952	834928	26.4	30.5	34.3	36.6	36.9	36.9
H105	517096	836244	28.2	32.3	36.1	38.4	38.7	38.7
H106	518160	837673	24.7	28.8	32.6	34.9	35.2	35.2
H107	513577	835455	25.1	29.2	33	35.3	35.6	35.6
H108	514056	831821	24.9	29	32.8	35.1	35.4	35.4
H109	517099	836299	28.2	32.3	36.1	38.4	38.7	38.7
H110	518014	836990	25.2	29.3	33.1	35.4	35.7	35.7
H111	513225	834907	24.9	29	32.8	35.1	35.4	35.4
H112	516855	834435	26	30.1	33.9	36.2	36.5	36.5

The below is taken from Table 15.1 in the applicant's previous application in relation to Tirawley Windfarm case number PAX16.323778

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Hours per day not supplied

Table 15.3 displays three measures of shadow flicker at relevant receptors. The hours per year, the expected hours per year, and the expected hours per day. The word "expected" is doing a great deal of lifting here, as the EIAR reduces shadow flicker per year by 85-90% for receptors, based on statistical probabilities of cloud cover and wind (15.2.3, p.8).

This 85-90% "expected" reduction, based on statistical probabilities, seems generous for the hours per year test. And no margin of safety appears to have been added to account for particularly sunny years.

However, its application is much worse in the case of the hours per day test, where statistical sunshine and wind records are inappropriate factors in calculating shadow flicker. It is a common and normal thing for a day to have weather that varies from the statistical norm, and

any receptor can expect to have sunny-windy days. Despite this, no unaltered "hours per day" calculation has been supplied for receptors in the study area. This needs to be calculated for a proper assessment of the hours per day test.

Even using this weather adjustment, many receptors are shown to be exposed to more than 30 mins per day on certain dates of the year (Appendix 15.1, pages 17-173).

If the hours per day limit is breached at many houses, even after reducing the measure by 90%, then clearly, this site wildly exceeds the limit on sunny-windy days. No amount of sophistry can escape this.

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Complaints process

The applicant outlines a complaints process, where residents can apply to beg for consideration of their shadow flicker problems (15.2.9.3). The applicant has avoided all consultation with the local community, sworn the contracted landowners to secrecy, and avoided any type of engagement with local residents. How then can we have any faith that they will deal fairly with any complaints after planning is granted?

Paragraph 15.2.9.3 of the EIAR outlines a complaints process, which explicitly states that complaints will be assessed inter alia on the basis of how persistent and dogged the complainant is:

"In the event that complaints of shadow flicker are received by the Developer / site operator or by Mayo County Council, an investigation will take place and the complaints frequency, duration and time of complaints will be considered and specialist modelling software will be used to confirm the occurrence(s). Should the complaint persist, a shadow flicker survey involving the collection of light data will also be carried out at the property in which the complaint was made." (EIAR 15.2.9.3)

That is really no way to run anything. If this is their level of commitment before planning, what will it be afterwards?

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Extent of study area

The study area for Shadow flicker is 1.17km (15.2.4). Presumably, this area was chosen because of the 2006 Guidelines comment that "*at distances greater than 10 rotor diameters from a turbine, the potential for shadow flicker is very low*" (15.2.2). At first glance that seems reasonable, however, those guidelines are outdated, and for several reasons, the study area is too small:

1. In table 15.3, many houses exceed the 30 mins per day limit, even when the absolute figure is reduced (inappropriately) by 90% to allow for weather.
2. The 2006 Guidelines may suggest that 10 times the rotor is sufficient, but that same guidance limits flicker to 30 hours per year or 30 mins per day. Table 15.3 shows even houses near the edge of the study area are experiencing significant flicker and even breaching these limits. The fact that even the remoter houses in the study area are breaching the guidelines, (even using applicant's reduced numbers), demonstrates the

study area is insufficient. If unaltered daily shadow flicker figures are provided, this situation will be much worse. The 30 minutes per day guideline is clearly to be exceeded at many receptors, including many not even in the study area.

3. This is a populated area! 89 out of the studies 100 receptors will experience shadow flicker. This figure will rise if the study area expands.
4. The elevation of this site above surrounding terrain, and above all receptors in the area requires a greater study area to capture the true extent of flicker.
5. H102 is the local secondary school. i.e. in figure 2.3 ranking of homes according to distance from the turbines, H102 is the 102nd closest to a wind turbine. However, the shadow flicker study area only embraces the 1st 100 houses and just excludes the secondary school. As the school is a place of work and study for a large quantity of people, some of whom have sensory issues, it seems appropriate that it receive special consideration.

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Shadow control system – who is protected?

The EIAR relies very heavily on a single mitigation measure (Shadow Control System) to address shadow flicker concerns. Mitigation by avoidance is not considered in the EIAR.

The record of these control systems elsewhere in Mayo is abysmal, and while it may be useful in situations where shadow flicker is of marginal concern, it is not equal to the shadow flicker challenge in this residential area.

Even if we take it at face value, it is not absolutely clear which houses are to be protected by this system:

- Is it houses within 500m of a turbine (per 2006 guidelines). If so, the shadow control system is irrelevant, as the nearest home is 555m (H3).
- Is it the 100 houses within the study area (10 times the rotor)? If so, we would ask that Lacken Cross School be added to the protected receptors.
- Is it the 108 receptors referred to in 15.2.9.5, and if so, which houses are these?
- Is it all houses everywhere, which would reflect the as yet unimplemented 2019 guidelines? It should be noted that the 2019 guidelines would require a much wider study area than undertaken here, as it covers all effected houses, which, given the altitude and size of these turbines, will cover a very wide area. Arguably including parts of Sligo also.

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Shadow control system – how will it operate?

There is little detail in the application about how this system will operate in practice. Important questions include:

- Is it proposed to reduce shadow flicker to zero, or to 30 mins per day? If the capability exists to eliminate shadow flicker, why wouldn't we?

- Will the system be plugged in to the Met mast, and only operate when conditions are sunny/windy? This will give rise to failure if broken clouds passing over the Met mast cause the system to permit shadow flicker across the rest of the windfarm.
- How long does the system stop the turbines? Will it kick in before alignment with one side of the house, and cut out after the sun has cleared the other side? Or will it be just a fleeting stoppage?

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There is an inconsistency between the modelled shadow flicker at H50 and H64. These 2 houses are neighbouring, yet H64 is modelled to have shadow flicker for a period each Summer, while H50 is not.

Appendix 15.1, page 118 shows the dates and times that shadow flicker might be expected to arise at H64. On the 14th of June each year, the Analysis predicts shadow flicker from 20.56 to 21.16.
On 14 June 2026, at 8.57pm, the following picture was taken from H64, towards the sun and with H50 in the midground. This picture begs the question, if H64 (where the photograph was taken) is modelled to receive shadow flicker at this time, and the sun is still nicely above the horizon, why does H50 (pictured) not receive shadow flicker at the same time?



This inconsistency points to the trust that has to be placed in the modelling of shadow flicker, and therefore the trust to be placed in the shadow control system.

The baseline noise assessment conducted by the applicant does not appear to have measured infrasound. The rapid motion of turbine blades will give rise to oscillations in pressure at very low frequencies, that can impact receptors nearby. Yet, the baseline noise assessment does not measure infrasound, and therefore the report cannot meaningfully model the change in infrasound from the development. It is hard for us to engage with infrasound as an issue without any measurement of the current baseline, or a model for the change, and therefore the decision is currently blind to this issue, and needs some substance.

The Noise study area was set at a 2km radius from the turbines. We would ask, how was this 2km limit selected? The noise of turbines can travel great distances. Some locals report being able to hear the turbines in Sligo when conditions are right. Therefore, it seems important that the size of the noise study area be adequate and logically arrived at. We ask ACP to consider the scale of the noise study area, it adequacy, and whether nearby quiet areas like Kilcummin need to be wrapped into it.

Low-Frequency Noise and Infrasound

The assessment of wind turbine noise should not be limited solely to conventional A-weighted audible noise measurements. A-weighting significantly reduces the contribution of very low-frequency sound and infrasound and may therefore not provide a complete assessment of the low-frequency pressure fluctuations associated with modern large-scale wind turbines.

Recent peer-reviewed research has highlighted that modern wind turbines differ substantially from earlier generations due to their greater rotor diameters, increased hub heights, and lower blade-passing frequencies. A 2026 study published in *Applied Acoustics* by Mattsson et al. investigated infrasound propagation from modern wind farms using validated three-dimensional acoustic modelling together with field measurements using specialised, calibrated infrasound microphones. The study reported that modern large-scale wind turbines generated significantly higher infrasound levels than those previously reported for older turbine designs.

The applicant's acoustic assessment appears to be based on conventional environmental noise assessment methods. However, recent peer-reviewed research has demonstrated that specialised infrasound measurements using calibrated low-frequency instrumentation can identify low-frequency pressure fluctuations from modern wind turbines that are not specifically assessed through conventional A-weighted noise assessments. It is therefore reasonable to question whether the submitted assessment adequately characterises the low-frequency acoustic environment associated with modern large-scale turbines, particularly given the increasing size and changing acoustic characteristics of modern turbine designs.

Importantly, the authors state that the long-term effects of exposure to the characteristic pulsating infrasound produced by modern wind turbines remain unresolved and that further studies reproducing realistic long-duration exposure conditions are required. In circumstances where scientific uncertainty remains, the applicant should demonstrate through a comprehensive and independently reviewed assessment that the proposed development will not result in unacceptable impacts on residential amenity.

Accordingly, it is requested that the planning authority require a detailed, site-specific assessment of low-frequency noise and infrasound, including consideration of the proposed

turbine model, blade-passing frequencies, local topography, atmospheric conditions, and cumulative effects with existing or permitted wind energy developments.

Mattsson, K., Eriksson, G., Persson, L., Chilo, J. and Tatar, K. (2026) *Efficient finite difference modeling of infrasound propagation in realistic 3D domains: Validation with wind turbine measurements*. **Applied Acoustics**, 243, Article 111156.

HYDROLOGY

We object to this development because of the impacts it will have on the local groundwater, surface water, pollution levels, and also for its inadequate geological investigations.

Groundwater

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Groundwater vulnerability

Geological Survey of Ireland has mapped the entire area of the wind farm as being "high" groundwater vulnerability. Meaning the groundwater here readily accepts pollutants which rapidly discharge into springs and surface waters. They can go on to transmit high amounts of pollutants to a single receptor in a short period of time.

Receptors in the area include the SAC into which all of the surface waters from the windfarm drains, and also (something not considered in the EIAR) many natural springs in use for water supplies by local homes – including some homes that are especially vulnerable (see below).

Inland Fisheries Ireland, in their scoping reply advised that no turbine or associated building be built on areas of high groundwater vulnerability. By contrast to this, every single turbine in this proposal is planned to be built on an area of high groundwater vulnerability.

The EIAR really dodges groundwater vulnerability as a problem, and dismisses it as a serious concern. This is a serious mistake, as not only is this an area of high vulnerability, but it also has some particular local conditions that make groundwater a really vital part of any assessment of this proposal, as the next few paragraphs will try to explain.

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Turbines sited on faults

The danger of groundwater contamination is exacerbated by the location of mapped faults in the bedrock (EIAR figure 9.8) that lie directly beneath turbines AT01, AT05 and AT09 (Other turbines, though not directly on top of these faults, are also quite close, including AT06, AT10). "Groundwater flow in this area will be concentrated in the vicinity of faults" (9.3.8.1) and allow rapid and long distance flows of pollution from these sites, far in excess of the short distance flow paths envisaged in the EIAR (9.3.8.1).

This is consistent with local experience of groundwater flows being easily disturbed and rerouting over long distances (see "Flow paths" below).

==========

Groundwater quantity

The turbine foundation excavations, and the increased hard surface areas on the hilltops will inevitably reduce the quantity of groundwater in the area. Already quite a poor aquifer, the recharge is slow, and much of the deep water is unusable red water, tainted with arsenic.

There is every reason to believe that these excavations will impact groundwater levels and flow paths, not just during construction, but during the operational life of the wind farm, and even after decommissioning.

The applicants main defence against this problem is to say that foundations will be shallow – though the precise depth is left uncertain (see below), and to say that flow paths here are short and will be unaffected, which contradicts local experience, and is based on general study over a much larger area (see below).

As many houses here depend on natural groundwater springs for their domestic water supply, the quantity and quality of groundwater must be an important part of this decision. Certain villages are especially vulnerable to groundwater disruption (see below), and there is the possibility of an unexpected and very negative outcome for these houses if groundwater supplies are reduced or diverted.

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Lengths of flow paths

The EIAR quotes a previous study (GSI 2004) of the Belmullet GWB to say that groundwater flow paths will be short and will not easily be disturbed. This is just not consistent with the experience and knowledge of the people on the ground, and draws upon a study of a much larger area extending across the whole of North Mayo -not the specific hill on which our springs and the proposed windfarm are proposed to coexist.

Unexpected holes (Sousmerras) can appear and swallow up streams unpredictably, and springs dry up and reemerge hundreds of meters away. A well known example, is St Brigid's well in Kilbride, which moved 940m Southwest to its present location at an indeterminate point in the past. Other, less dramatic, but still unpredictable movements of springs and groundwater (and surface water) have happened in living memory also.

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Scale of aquifer

The EIAR refers to the scale of the development and its impact as being quite small in comparison to the Belmullet aquifer. This is true from a regulatory point of view, in that the Belmullet aquifer is the WFD unit to be assessed for groundwater impacts. But that does not in any way speak to the needs of residents to maintain residential water supplies from groundwater springs and wells coming out of an aquifer that in reality is much, much smaller, encompassing 2 small hills in Lacken. In the scale of these 2 hills, the windfarm is of a far greater impact. Thus, the EIAR ticks the box of aquifer impact on a WFD scale, while completely ignoring the real-world aquifer and the domestic water needs of local residents they propose to co-exist with.

In fact, when talking about surface water risks, the EIAR is extremely clear that the groundwater is hydrologically isolated by several surface water streams that isolate the aquifer. Yet, when it comes to groundwater, and human drinking water supplies, it is a different and inconsistent description of a vast territory in which the turbines will have no impact.

==========

Mapping of local springs and wells woefully inadequate. Zero consultation

The applicant's map of local springs and wells in use for residential supply is inadequate to the task.

Relying on GSI mapped wells, and assuming all houses in the area have a bored well outside the house itself (incorrect), they assume that a setback distance around these houses is enough to remain distant from all residential watersources (figure 5.4).

This is the type of information that can only be gathered in consultation with homeowners, which the applicant has been careful to avoid. They have been gathering information on us for 15 years, but (aside from a single consultation event, held in another part of the county, with minimal advertising) they have avoided releasing any information about their project to the local population until this application was lodged. Therefore, they were unable to gather data on local water abstraction points.

In particular, there are villages here in an extremely precarious position with drinking water (see below) that have not been considered in the EIAR or mapped.

A preliminary map of some wells/springs in the area is included with this submission. It has been produced with much less time than the applicant had, and with zero resources, and only shows some of the most impacted springs in the area, as well as the groundwater vulnerability status mapped by GSI. It is too bad that the applicant did not include anything like this in the EIAR.

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Domestic water being abstracted from wells downslope of turbines, and spoil area

Some residential houses are abstracting drinking water from wells that are downslope of turbines (see map provided), as well as some private wells that are downslope from the quarry into which it is proposed to tip a large quantity of spoil. There is every reason to think that dirty water arising from the construction phase, and lasting several years after it, will seep into the groundwater these houses are using.

==========

Especially vulnerable villages to groundwater supply disruption

Some households in the vicinity of the turbines (Kilbride and Carrowmore) are in an especially vulnerable position because:

They have no public water supply, despite years of trying to get one.

They cannot bore for a well, because the water that comes up from deep underground is tainted from sandstone, contains arsenic, is coloured bright red and is unusable even for washing. Therefore, the applicant's assumption that every house in the area has a bored well (9.4.2.9) is inaccurate and undermines their overall position that groundwater is a non-issue.

The only semi-reliable water source for these homes is shallow groundwater springs that they pipe to their homes. Many of these natural springs are high up on the hill, at a similar elevation as the turbine foundations, and susceptible to changes in either groundwater levels or flow paths arising from the development. They already run dry in protracted droughts, and any deterioration from large excavations and/or piling beneath turbine stands could worsen this.

Some of them are located in a karstified aquifer and ABP should be extremely careful that these vital and vulnerable natural springs are fully protected, otherwise what future might there be for the villages depending on them as the only available water supply?

The EIAR does not appear to have considered the fact that many of the houses in the area are supplied with their drinking water from these shallow springs, even though it acknowledges that most groundwater here emerges in this way (9.5.1.9).

Most of these shallow springs are also in the extreme groundwater vulnerability area mapped by GSI, and pollution is also a major concern. Pollution needs to be considered not just as a surface water and environmental issue, but in relation to drinking water supplies too. Pollution is a concern from the development itself, but also from any action (e.g. pile driving) that mixes red water from inside the hill with clean surface water feeding domestic supplies.

EIAR figure 9.8 shows a fault leading directly from AT09 and AT10 to this area, which adds to the concern.

The characterization of the hill gently sloping eastward is technically true (9.3.1.1), however, it is a very gentle slope (this is also noted in 9.5.1.6), and really, it is a plateau, which absorbs rainfall and discharges it in all directions, including the extreme groundwater vulnerability areas to the North and West.

Given this extremely precarious position, these villages already live under the constant threat of having no water for long periods, and a worsening of the aquifer, could literally make some villages uninhabitable. Sandwiched between no available public supply and no usable deep water, natural groundwater springs must be taken as a very serious issue. Yet the EIAR does not truly engage with this as an issue at all.

==========

Foundation depth maximum needed

The turbine foundations are intended to be shallow. The issue of groundwater is repeatedly dismissed in the EIAR on this basis.

Even if this logic is taken at face value, the application leaves wiggle room for deeper foundations to be dug, where bedrock is inadequate (see 2.6.3), and there is also mention of pile driving (see Appendix 9.3, WFD assessment, section 4.1, page 20). Therefore, there is no guarantee that foundations will be as shallow as outlined, or that groundwater will not be subjected to much deeper excavations. There appears to be no maximum depth contemplated.

If the proposal does receive permission, in the interest of local drinking water supplies, and groundwater sources that feed surface waters, ABP should set a maximum depth permissible to excavate, and/or pile drive and someone reliable and independent should be required to certify that this maximum is actually observed in construction.

==========

County Development Plan Climate Action Policy 9

The applicant's Planning Statement document rightly notes that the county plan is supportive of renewable energy developments (Planning Statement, 4.8, page 61). But this support is not unqualified, and given the unique groundwater quality issues here, it seems misguided for the applicant to claim to have the support of CAP 9 of the MCDP for this specific development:

CAP 9: To support Ireland's renewable energy commitments outlined in national policy by facilitating the development and exploitation of all appropriate renewable energy sources at suitable locations within the county, where such development does not have a negative impact on the surrounding environment (including water quality), landscape, biodiversity or local amenities, so as to provide for further residential and enterprise development within the county.

Given the precarious water situation of local residents, this proposal does not appear to be supported by Climate Action Policy 9 of the County plan.

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EIAR deliberately avoids groundwater as an issue

Section 9.5.1.9 of the EIAR uses peculiarly emphatic language ("Conclusive ...robustly") to express the applicant's position that groundwater is not an issue in this project. This verbal emphasis is not accidental, and really reflects an insecurity around the issue of groundwater, private wells and springs. Careful reading of this chapter reveal further hints at this insecurity:

Dismissal of Inland Fisheries straightforward requirement that the project "must avoid high groundwater vulnerability areas" (9.2.7). The applicant's terse reply is that they have avoided "extreme" vulnerability areas. Ouch! Take that IFI!

In a 100 page report on hydrology, one page only (9.3.9) is dedicated to groundwater vulnerability, even though the entire windfarm is built on a high groundwater vulnerability area. Is this credible?

No map of groundwater vulnerability accompanies the application, as one might expect in a report of this size. Similar, recent wind farm developments in this area have included a map of groundwater vulnerability – yet it mysteriously was forgotten in this application. Where it matters greatly, but inconveniently.

No attempt is made to map wells and/or springs in the vicinity of the turbines, even though the vulnerability of several important local springs is in the extreme zone and the houses are well known to be already in a precarious water situation. We cannot believe the applicant is unaware of this after 15 years of obsidiously gathering data about this area.

Knowing groundwater to be a serious, and unanswerable issue, the EIAR deliberately attempts to curtail discussion of it and not engage with it as an issue. This is a quite unworthy decision.

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Drinking Water Directive not considered in EIAR

The EIAR refers to a large number of statutes, more than it has been possible to research in the time allowed for submissions. One important statute is not named: The Drinking Water Directive 2020, which includes the following:

"*Article 16*

Access to water intended for human consumption

Without prejudice to Article 9 of Directive 2000/60/EC and to the principles of subsidiarity and proportionality, whilst taking into account the local, regional and cultural perspectives and circumstances for water distribution, Member States shall take the necessary measures to improve or maintain access to water intended for human consumption for all, in particular for vulnerable and marginalised groups, as defined by the Member States. For that purpose, Member States shall:

identify people without access, or with limited access, to water intended for human consumption, including vulnerable and marginalised groups, and reasons for such lack of access;

assess possibilities for improving access for such people;

inform such people about possibilities for connecting to the distribution network or about alternative means of having access to water intended for human consumption; and

take measures that they consider necessary and appropriate to ensure that there is access to water intended for human consumption for vulnerable and marginalised groups."

Source: Official Journal of the European Union L 435/28 23.12.2020

This is a European Directive, which is clear, precise and unconditional when it states that it is necessary to "improve or maintain" the water supplies of "all", without reservation. It does not have direct legal effect on the applicant, but it does have direct effect on An Bord Pleanala and the State. It can be relied upon by anyone whose water supply is diminished or polluted by this development. Particularly, those houses in the vulnerable position outlined above. And we ask that ACP consider their obligations to the directive (as well as the State generally) in this regard.

Further, we invite ACP staff to visit these villages where we can exhibit the precarious water situation they live in, and the concerns about turbines disrupting underground water flows.

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SURFACE WATER

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Concentration of risks at single critical location

All the streams and surface water leaving the development eventually merge at a single location, creating a concentration of risks here. Unfortunately, this concentration of risks, also happens to be an SAC, with a salt marsh, including a delta of many islands that is a refuge for birdlife, and rich with crabs and other prey.

Given the extent of this development, and the concentration of all surface flows at this sensitive spot, even with all of the mitigation measures envisaged in the EIAR implemented in full, a decline in water quality at this location is to be expected. The amount of peat and spoil to be excavated, transported, heaped etc seems virtually impossible to keep out of surface waters, even if the project is constructed exclusively by saints.

Bathing waters not considered

The EIAR assesses the nearest bathing waters to be at Ross beach (WFD assessment 2.7.2). We are not sure what criteria were used to assess what is a bathing water or not. However, there is a large number of daily swimmers at Lacken Pier, Kilcummin beach, and Kilcummin backstrand. All of which have had investment from Mayo County Council as bathing spots, and all are fed directly by surface waters flowing off of the site. Kilcummin pier is also a popular bathing water nearby that should be assessed also.

Surface water testing

It has been noted by one local resident that water sampling was done in recent years by someone that entered private land without permission, and that refused to identify themselves. We believe that may have been part of the preparation of this report, and would like it noted that trespassing is not the right way to go about preparing a report like this. Private contractors have no right to access lands for water testing without permission. We assume it was not an authorized public official, as they would more readily identify themselves upon challenge.

Souterrain drains

There are miles and miles of unmapped souterrain drains beneath the fields here, that make predicting surface water flows quite difficult. A significant margin for error is needed to manage water arriving unexpectedly quickly at some points or draining away unexpectedly quickly, as a result of exposing these unmapped drains.

Salmon and trout stocks

The Cloonaghmore River is under environmental pressure and salmon stocks have declined below their conservation limit and the company has not stated any ways or solutions to retain the salmon and trout fish stocks.

POLLUTION

Ph changes to an acidic environment

The local ecology, including the SAC into which all the surface waters drain, is quite acidic, and peat is the dominant soiltype. By introducing a great deal of lime and cement, one would expect the turbine foundations to raise the ph of local surface waters, disturbing the local wildlife balance.

Siltbuster

The EIAR envisages use of "siltbuster" chemical as a last line of defence against heavy particle flows into surface waters (9.5.1.10). Ingredients include Poly Aluminium Chloride, Aluminium Sulphate, Ferric Iron, Ferrous Iron (9.4.2.10).

It is not clear that this chemical been tested in this area before, or a similar area. Nor is it confirmed whether it is approved for use in an SAC. Or in an area of shellfish population. All of these questions need answers before approving the use of this chemical in the natural environment -albeit, its purpose is to protect waters from the flow of silt, which is a good thing in itself.

We would also like to ask, is it safe for drinking water supplies coming out of the local groundwater?

There's no discussion of any of these questions in the EIAR, which seems like an omission

Furthermore, EIAR 9.5.1.10 states that an alternative chemical agent may be used in sensitive locations. It does not name this alternative, its ingredients, or why it should be used in sensitive locations but not on a wider scale. It is impossible to tell if this unspecified alternative agent is really safer or less safe than siltbuster.

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Microplastics

Recent studies have shown that microplastics can be shed from in large quantities from wind turbine surfaces, which are composed of a mixture of glass fibre and epoxy. These microplastics can enter nearby air, soil and water, causing human and animal health impacts of a quite serious nature.

The proposed turbines have a nacelle and blades composed of a mixture of fiberglass, plastic and epoxy (EIAR 2.6.2.1). These are durable materials, but in the extreme conditions of turbine blades, it can still be anticipated that a portion of this material will wear from the blade surface each year. This may be as much as 62kg per turbine per year ("Leading edge erosion and pollution from wind turbine blades", 2021, Asbjorn Solberg et al).

Once in the environment, the microplastics in question, combining epoxy and fibred glass, release toxins such as phthalates and/or Bisphenol A ("Environmental occurrence and ecotoxicological risks of plastic leachates in aquatic and terrestrial environments", 2024, Science of the total environment, https://doi.org/10.1002/etc.3663), which are harmful to human and animal health, and could disrupt the "normal physiology of various species".

Bisphenol A is a particularly toxic leachate from these microplastics, with endocrine disrupting qualities at very low levels. The WHO guides that drinking water, such as the shallow springs and deep wells in this area, should have a maximum of 0.1 micrograms Bisphenol A per litre of water

(https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32020L2184&from=EN) . An extremely high standard, and one that is inconsistent with the wearing of microplastics high up on a hill from which drinking water is being sourced.

Against this strict standard, the rate of microplastic shedding from turbine blades is unhappily quite high. As much as 0.276% for every 10 hours of saltwater rain (https://doi.org/10.1007/s40735-021-00472-0 , Rain Erosion Maps for Wind Turbines Based on Geographical Locations: A Case Study in Ireland and Britain, K Pugh, 2020). This can be worse in areas of salt and sand erosion of turbine parts, such as the proposed location of this wind farm (see "Wind turbine blade behaviour in abrasive wear conditions", Cristian Muntenita et al, 2024, in *Polymers,* https://doi.org/10.3390/polym16243483).

Apart from the damage to drinking water, leachates from microplastics can disrupt the DNA of fish and other species ("Toxicity assessment of pollutants sorbed on environmental sample microplastics collected on beaches: Part I-adverse effects on fish cell line", Pannetier et al, 2019, https://doi.org/10.1016/j.envpol.2018.12.091)

This is a new and emerging area of study, showing that turbine emissions of microplastics are both large in quantity, and high in impact to both human and animal health. This particular location magnifies these problems by being located

on top of shallow springs, and wells used for human drinking water,

Above surface water flows flowing down into an SAC

In an area of aggressive salt and sand erosion.

The wind turbine industry has yet to respond to these new findings, but until they do, it seems prudent that a development, such as this one that is located at the convergence of multiple magnifying risks, should be refused.

1. This proposal will undermine the ambitions of the local community and Mayo County Council, to achieve UNESCO World Heritage status for the Ceide Fields.

   The application does not consider Goals 1 or 4 of the Strategy for World Heritage in Ireland 2025-2035:

   - "Goal 1: Increase the number of Irish sites inscribed on the World Heritage List and undertake a regular review of Ireland's Tentative List."
   - "Goal 4: Support the **protection, conservation, management, interpretation, and presentation** of Ireland's World Heritage Properties and Tentative List sites. - Strategic Objectives: 1. Seek to ensure, in partnership with key stakeholders, that the Outstanding Universal Value and **authenticity and integrity** of World Heritage Properties is protected and managed through the adoption of best practice management strategies;"

The application also does not consider BEO 2 of the County Development Plan, which specifically identifies this region for special protection, to realise our UNESCO ambitions.

"BEO 2: To protect the tentative World Heritage Site in Mayo on the UNESCO Tentative List - Ireland 2010, The Céide Fields - from inappropriate development and support its nomination to World Heritage Status."

It is a source of great disappointment locally that we missed out on the last iteration of the tentative list because of local political concerns that were not connected with the significance of the site. On the contrary, the archaeological significance of the site is beyond question. The Ceide Fields are more than just a national monument. They are an insight into neolithic civilisation that exists in just a handful of places on the earth. With proper commitment, this monument will not only get onto the tentative UNESCO list, but actually go all the way to achieve World Heritage status. Even more so, because the fields contain a potential candidate for World Natural Heritage status also (Downpatrick Head/Dun Briste).

The available guidance suggests that the Ceide Fields, with their insights into an era of human development which is largely untraceable globally, is a strong contender for World Heritage status:

"For a nominated property to be inscribed on the World Heritage List, it must:

a. demonstrate Outstanding Universal Value by meeting one or more of ten criteria required for inscription (described below),

b. meet the conditions of ***integrity and/or authenticity*** *(for cultural and mixed sites),*

c. demonstrate community and stakeholder support and engagement, and

d. must have an ***adequate protection*** *and management system in place.*

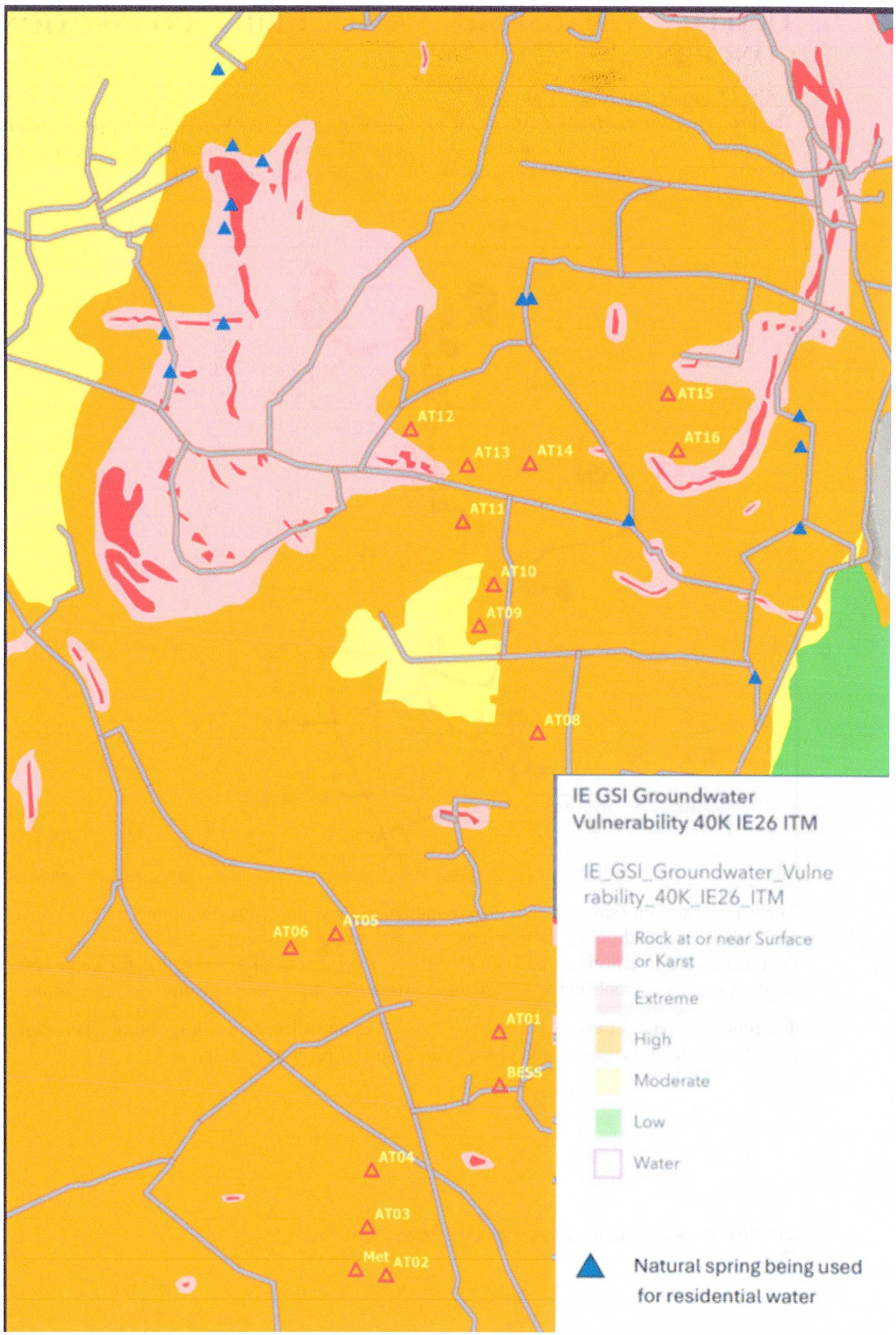
The ten criteria for inscription are:

1. *Represent a masterpiece of human creative genius;*
2. *Exhibit an important interchange of human values, over a span of time or within a cultural area of the world, on developments in architecture or technology, monumental arts, town-planning or landscape design;*
3. ***Bear a unique or at least exceptional testimony to a cultural tradition or to a civilisation which is living or which has disappeared****;*
4. *Be an outstanding example of a type of building, architectural or technological ensemble or landscape which* ***illustrates (a) significant stage(s) in human history****;*
5. *Be an outstanding* ***example of a traditional human settlement, land-use****, or sea-use which is representative of a culture (or cultures), or human interaction with the environment especially when it has become vulnerable under the impact of irreversible change;*
6. *Be directly or tangibly associated with events or living traditions, with ideas, or with beliefs, with artistic and literary works of outstanding universal significance. This criterion should preferably be used in conjunction with other criteria;*

7. *Contain superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance;*
8. *Be outstanding examples representing major stages of earth's history, including the record of life, significant ongoing geological processes in the development of landforms, or significant geomorphic or physiographic features;*
9. *Be outstanding examples representing significant ongoing ecological and biological processes in the evolution and development of terrestrial, fresh water, coastal and marine ecosystems and communities of plants and animals; and/or*
10. *Contain the most important and significant natural habitats for in-situ conservation of biological diversity, including those containing threatened species of Outstanding Universal Value from the point of view of science or conservation." (Strategy for World Heritage in Ireland 2025–2035)*

with the right support at local, county and national level, Ceide Fields is certainly capable of achieving UNESCO status and therefore a strong asset to achieving Goal 1 of the Strategy for World Heritage in Ireland 2025-2035.

Preserving the integrity of the site is literally the first step towards achieving this goal.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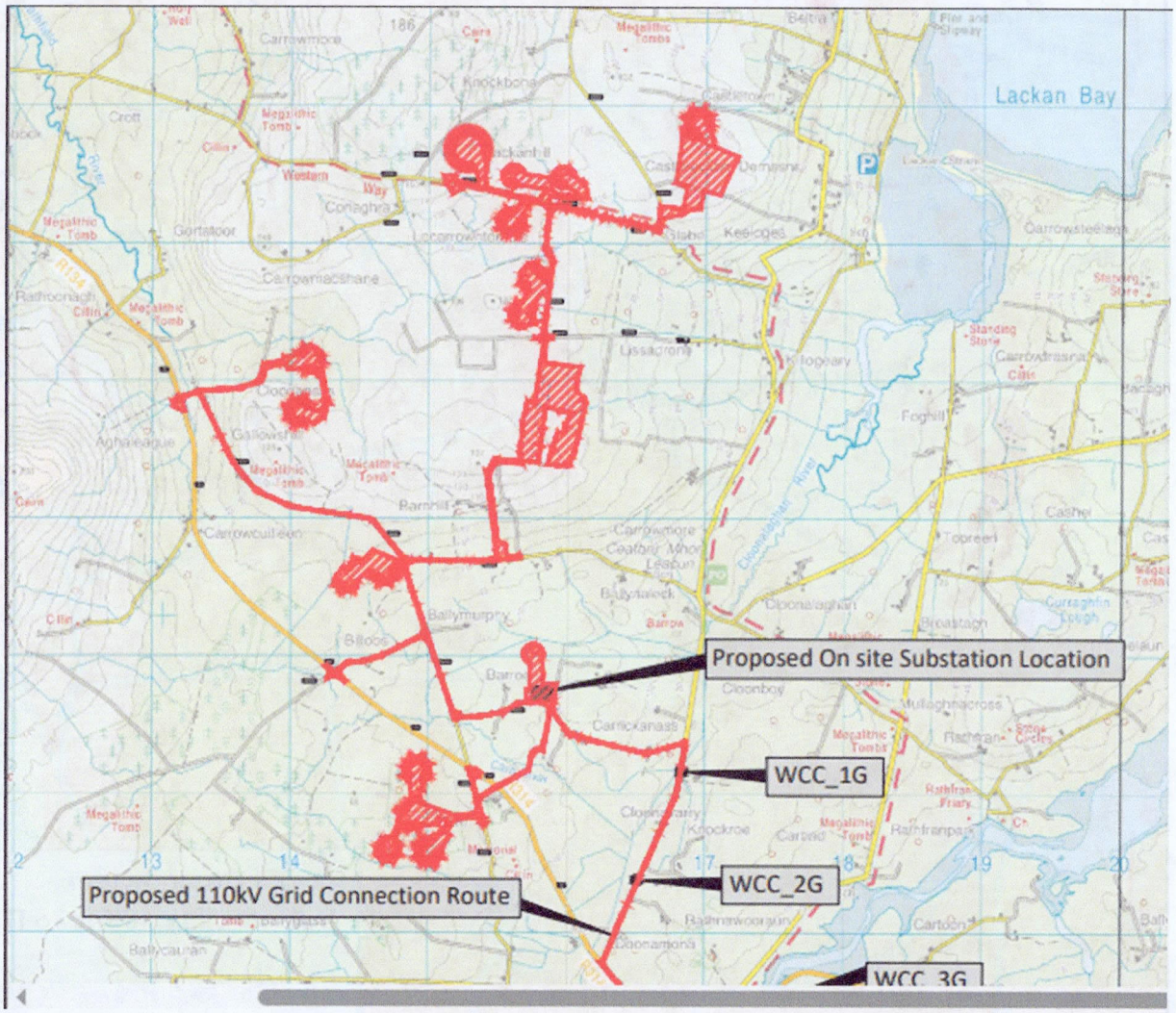
IE GSI Groundwater Vulnerability 40K IE26 ITM
IE_GSI_Groundwater_Vulnerability_40K_IE26_ITM
Rock at or near Surface or Karst
Extreme
High
Moderate
Low
Water
Natural spring being used for residential water

TRAFFIC, TRANSPORT AND GRID CONNECTION CONCERNS

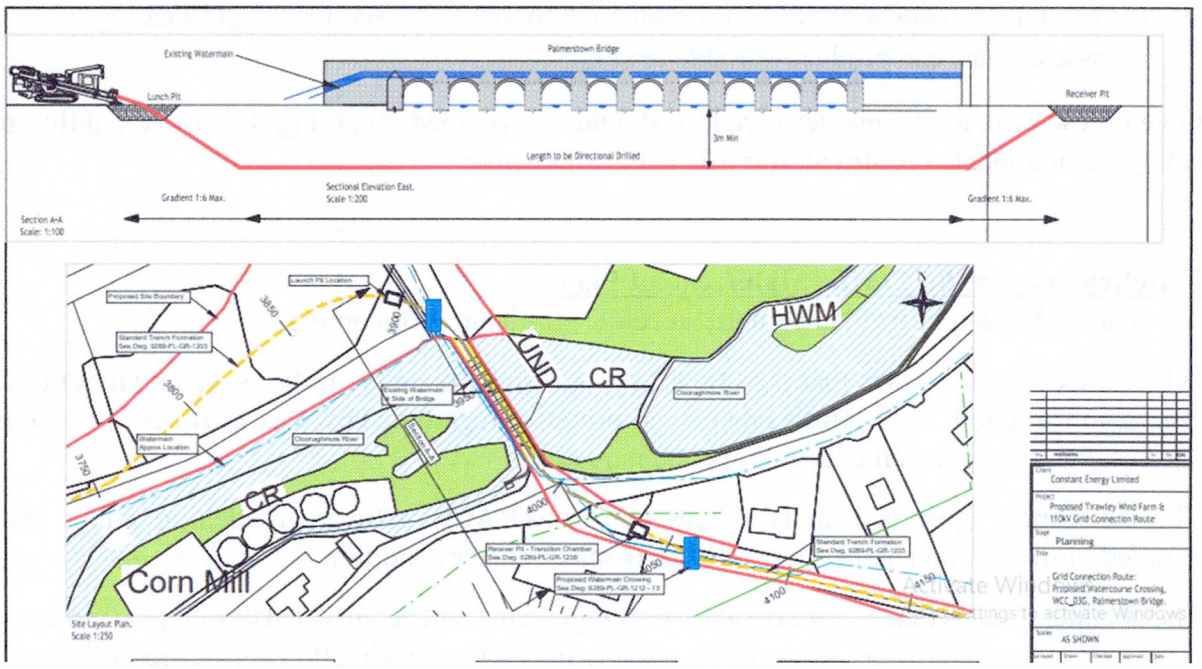
1. Grid Connection Route Concerns

The proposed grid connection route extends approximately 13.55 km, following public roads from the Asahi site through Castlerea and along the R314 to Carrickanass Road before entering the wind farm site. Several concerns arise from the information presented.



The watercourse crossing location maps continue to show the original turbine locations (AT07 and AT08 in Heathfield), raising concerns regarding the accuracy and updating of the documentation. In addition, the Carn River and several smaller streams that the cable route must cross are not identified as watercourse crossings within the application documentation.

The route also passes over two bridges on the Carrickanass Road, creating additional concerns regarding structural capacity and potential impacts during construction.



Particular attention should be given to the fact that Mayo County Council reportedly advised during a 2023 pre-planning meeting that it was not in favour of electricity cables being installed within the road carriageway. The application does not adequately explain how this concern has been addressed.

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2. Palmerstown Bridge and River Crossing

The proposed Horizontal Directional Drilling (HDD) operation at Palmerstown Bridge raises significant questions.

The bridge inspection report relied upon was completed on 10 January 2023 and has not been updated for the current application, despite the passage of time and the opportunity to undertake further investigations.

The report itself acknowledges that close inspection of the bridge arches and abutments was not possible due to fast-flowing water. Despite this limitation, the report concludes that the bridge is in good structural condition and capable of supporting wind farm traffic.

This conclusion appears questionable given that:

- Important elements of the bridge could not be properly inspected.
- Vegetation obscured parts of the structure.
- The report specifically recommends a further inspection during periods of lower water levels.
- No evidence is provided that such a follow-up inspection was ever undertaken.
- Appendices referred to in the report regarding inspection ratings appear to be blank.

- The report acknowledges that the calculation methods used for weight-bearing assessments can produce variable results.

Given these limitations, greater certainty should be provided regarding the bridge's ability to safely accommodate construction traffic and HDD works.

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3. Deficiencies in the Traffic Management Plan

The Traffic Management Plan contains several significant shortcomings.

While the document states that directional signage and a one-way traffic system will be used during construction, there is little practical information regarding how road closures, diversions and local access arrangements will operate in reality.

The assessment appears heavily reliant on AutoTRACK software modelling rather than detailed on-the-ground assessment of local roads and their condition.

The document states that alternative access arrangements will be provided during road closures. However, alternative routes may not be suitable in emergency situations or where businesses, farms and residents require immediate access. In areas such as Barnhill, where multiple roads are proposed for construction traffic, practical diversion options may be extremely limited.

The Traffic Management Plan further states that a detailed Traffic Management Plan will be prepared by the contractor. This raises a fundamental concern, as the application currently before An Coimisiún Pleanála does not contain the detailed information necessary for affected residents to fully understand the likely impacts.

Questions also remain regarding:

- How restrictions on construction vehicles using unsuitable local roads will be enforced.
- Whether local roads are capable of carrying the proposed vehicle weights.
- The absence of specific details regarding road closures and diversion routes.
- The lack of assessment of impacts on farming operations and agricultural contractors.

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4. Construction Traffic Impacts

The proposed construction phase will generate substantial traffic volumes.

The application indicates:

- Over 11,500 HGV movements during construction.
- Between 35 and 40 staff vehicles per day during peak periods.
- Between 50 and 70 workers on site during peak construction.
- Up to 75 vehicle movements per day during peak activity.

- Up to 14–18 concrete deliveries per hour on foundation pouring days.

Construction activities are expected to occur between 07:00 and 19:00 Monday to Friday and 08:00 to 13:00 on Saturdays. However, the documents also acknowledge that works may occur outside these hours for weather-dependent and specialist operations.

These traffic volumes will inevitably coincide with school transport, commuter traffic, agricultural activities and normal community movements.

The application assumes that avoiding conventional morning and evening rush hours is sufficient mitigation. This approach fails to recognise that farming operations do not follow standard office-hour patterns and often require unrestricted road access throughout the day.

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5. Errors and Inconsistencies within the EIAR

A number of apparent errors and inconsistencies were identified within Chapter 17 and associated documents, including:

- References to figures that do not exist.
- Incorrect appendix references.
- Incorrect traffic calculations.
- Traffic figures assigned to the wrong directions.
- Incorrect speed limit information for the R314.
- Conflicting construction hour information between different documents.
- Apparently incorrect route descriptions through Ballina.
- Lack of clarity regarding the source of certain traffic assumptions and percentages used in calculations.

The presence of multiple errors raises concerns regarding the overall reliability of the traffic assessment. Reference Page 2, Page 6, Table 17.3, Page 21, Page 22 Table 17.7 – 17.11 Page 28, Page 31

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6. Inadequate Consideration of Farmers and Rural Businesses

A recurring concern throughout the traffic assessment is the apparent failure to adequately consider farming operations.

While residences, schools and businesses are included as sensitive receptors, farmers and agricultural contractors appear largely absent from the assessment despite being among the most dependent users of the affected road network.

The assessment does not adequately address:

- Access to farmyards and agricultural lands.

- Delays during silage and harvesting periods.
- Impacts on agricultural contractors.
- The consequences of road closures for livestock management and farming operations.

Statements that contractors will merely "endeavour" to avoid periods of high agricultural activity provide little reassurance to those whose livelihoods depend on unrestricted road access.

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7. Road Condition and Maintenance Concerns

The assessment frequently relies upon national road capacity guidance rather than the actual condition of local roads.

Many of the roads affected are narrow rural roads that already require significant maintenance. There is little confidence that existing road conditions have been adequately considered when assessing the impact of thousands of heavy vehicle movements.

Although a road bond is proposed, concerns remain regarding:

- The condition of roads during the construction period.
- The length of time temporary road surfaces may remain in place.
- The adequacy of reinstatement works.
- The long-term condition of local roads following construction.

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8. Environmental Concerns

Several environmental issues remain inadequately addressed.

Wheel-cleaning facilities are proposed to prevent mud and debris reaching public roads, yet there is little information regarding how contaminated runoff water will be managed.

The assessment also concludes that increased traffic will have an imperceptible effect on air quality despite the significant volume of diesel-powered construction vehicles involved.

Concerns also arise regarding:

- Potential pollution from construction traffic.
- Increased mud and debris on public roads.
- The generation of plastic particles from cutting turbine blades during decommissioning.
- The destruction and attempted restoration of existing wet heath habitats.

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9. Archaeological and Access Issues

A further concern relates to a recorded monument (MA014-030).

The area surrounding this monument was reportedly excluded from forestry planting due to its archaeological significance. However, the current proposal appears to allow construction of an access road through the same area.

The application should clearly explain how impacts on this recorded monument have been assessed and avoided.

In addition, the proposed access road appears to cross an existing private access road at two separate locations. The plans do not provide sufficient information regarding how this interaction will be managed or how access rights will be protected.

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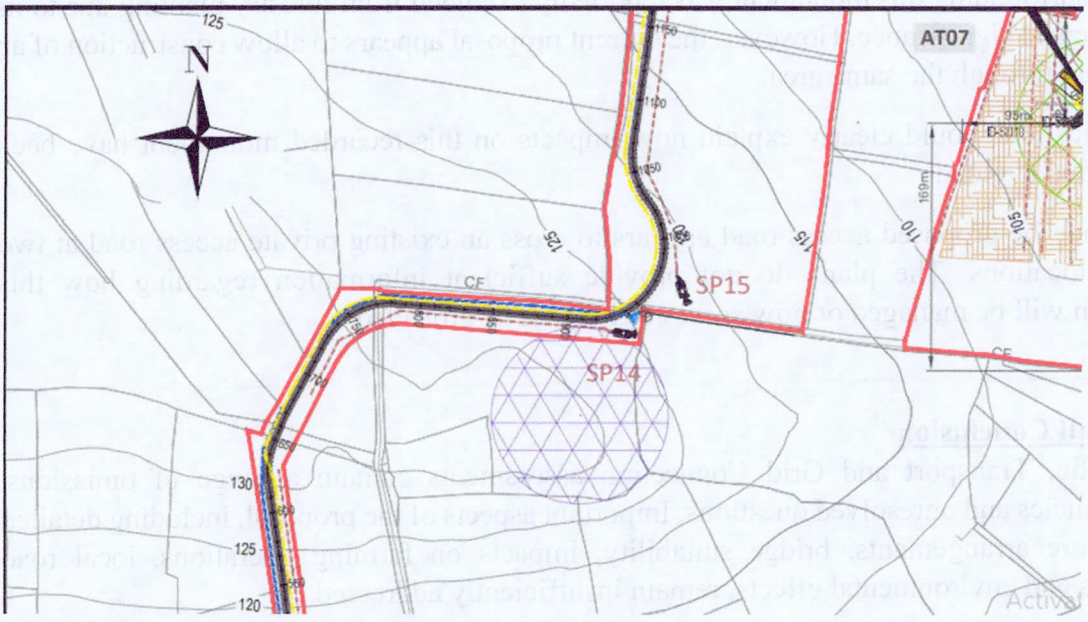
10. Overall Conclusion

The Traffic, Transport and Grid Connection assessments contain a range of omissions, inconsistencies and unresolved questions. Important aspects of the proposal, including detailed road closure arrangements, bridge suitability, impacts on farming operations, local road conditions and environmental effects, remain insufficiently addressed.

Given the scale of construction traffic, the dependence of the local community on the affected road network, and the apparent inaccuracies within the submitted assessments, it cannot be concluded that the likely effects on traffic, transport and local accessibility have been fully or adequately assessed.





The same section of new access road will also have to cross an existing private access road in two places but there is no detail of any description in the plans about this



- This piece of ground was supposed to be planted in the early 2000s(estimate) but was not allowed to be fully planted due to the recorded monument at the top of the field (MA014-030). Despite this the access road is planned to go through it now.

CONCERNS REGARDING TRAFFIC AND TRANSPORT CALCULATIONS

Introduction

A review of the Traffic and Transport calculations submitted as part of the Tirawley Wind Farm application identifies a number of apparent omissions, inconsistencies and calculation errors. These issues call into question the reliability of the applicant's assessment of construction traffic volumes and, consequently, the conclusions reached regarding the impacts on local roads, residents, businesses and farming operations.

Given that the scale of traffic generation forms a fundamental part of the environmental assessment, it is essential that the calculations used are accurate, transparent and based upon complete information.

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1. Apparent Omission of Turbine Hardstand Materials

One of the most significant concerns identified relates to the calculation of construction material deliveries.

The applicant's calculations appear to omit the quantity of crushed stone required for turbine hardstands. Based on the quantities provided elsewhere within the application documentation, approximately 37,843m³ of additional crushed stone would be required for these hardstands.

Using the applicant's own delivery assumptions, this would equate to approximately 3,154 additional HGV deliveries.

This omission is significant because turbine hardstands are a fundamental component of wind farm construction and cannot reasonably be excluded from traffic calculations. If these materials have been omitted, the resulting traffic estimates are substantially understated.

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2. Reliability of Monthly Traffic Estimates

The application provides estimated monthly delivery figures based on the overall HGV calculations.

However, if the underlying delivery totals are incorrect or incomplete, then the monthly traffic estimates derived from those figures are also unreliable.

As a result, the projected distribution of construction traffic throughout the construction programme cannot be considered robust until the overall delivery calculations have been independently verified.

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3. Discrepancies in Grid Connection Traffic Calculations

The calculations associated with the grid connection works also contain inconsistencies.

A review of the quantities and delivery numbers presented suggests that certain delivery totals have been incorrectly calculated. For example, some quantities appear to have been converted incorrectly when determining the number of required HGV movements.

These discrepancies raise concerns regarding the accuracy of the overall assessment and suggest that further independent verification is required.

4.Underestimation of Total HGV Movements

The applicant estimates that the total number of HGV movements associated with the development will amount to approximately 11,022 loads over the construction period.

However, when the omitted hardstand materials and identified calculation discrepancies are considered, the actual total appears to be closer to 11,565 HGV loads, assuming the quantities of materials stated elsewhere in the application are correct.

This represents a substantial increase over the figures presented in the Environmental Impact Assessment Report.

An underestimation of this magnitude has important implications for:

- Road safety assessments;
- Road capacity assessments;
- Traffic management planning;
- Noise and air quality assessments;
- Road maintenance requirements;
- Community disruption;
- Agricultural access and business impacts.

The reliability of all subsequent impact assessments is dependent upon the accuracy of the underlying traffic calculations.

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5. Uncertainty Regarding Road Widening Requirements

A further concern arises from the design drawings relating to road widening works.

The drawings state:

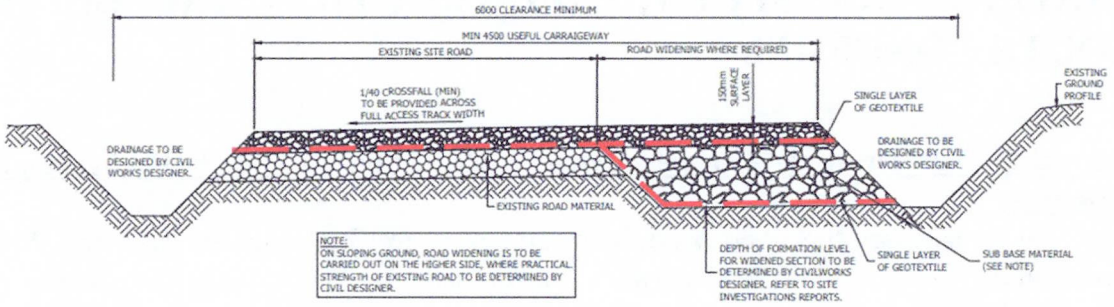
"Depth of formation level for widened section to be determined by Civil Works Designer."

This statement indicates that a key design parameter remains unresolved.

The depth of road formation directly influences the quantity of excavation, imported fill material, stone, geotextiles and associated construction traffic required to complete the works.

If this information has not yet been determined, it is difficult to understand how the applicant can accurately calculate the number of HGV deliveries associated with the road widening works.

The traffic calculations therefore appear to be based on assumptions that have not yet been finalised.



TYPICAL ACCESS TRACK WIDENING ON EXISTING SITE ACCESS TRACK WHERE REQUIRED CONSTRUCTION PHASE
SCALE 1:50

---

6. Implications for the Traffic Assessment

The identified omissions and inconsistencies suggest that the construction traffic impacts may have been underestimated throughout the application documentation.

The accuracy of the Traffic and Transport Chapter depends entirely upon the validity of the underlying assumptions regarding:

- Material quantities;
- HGV delivery numbers;
- Construction traffic volumes;
- Peak traffic movements;
- Road widening requirements;
- Grid connection works.

If the delivery figures are understated, then the conclusions regarding road capacity, road condition, traffic impacts, noise, air quality and community effects may also be understated.

Conclusion

The traffic calculations submitted in support of the proposed development contain a number of apparent omissions, unresolved assumptions and calculation discrepancies. In particular, the apparent exclusion of turbine hardstand materials, inconsistencies within grid connection delivery calculations, and unresolved road widening design requirements raise significant concerns regarding the reliability of the applicant's traffic assessment.

Until these matters are clarified and independently verified, it cannot be concluded that the full extent of construction traffic associated with the proposed development has been properly assessed. Consequently, the conclusions of the Traffic and Transport assessment regarding the significance of traffic impacts should be treated with caution and revisited before any determination is made on the application.

TRAFFIC, TRANSPORT, CONSTRUCTION AND DELIVER ROUTE CONCERNS

Appendix 17.1 Tirawley Turbine Delivery Report.pdf - 17.1.1 Background and Objectives

This chapter assesses the likely significant effects of traffic associated with the Proposed Development on the public road network and on sensitive receptors in the vicinity of the Proposed Development, describes the existing public road and junction network, identifies whether there is any potential for significant effects to arise (both in isolation and in combination with other developments) and outlines the mitigation measures that will be implemented to avoid, reduce, or offset any potential significant effects that might arise.

Observations: The above focuses on mitigating significant effects of the proposed development, however the development is so far reaching that at best there are potentially an enormous amount of effects when combined total a seismic change in air, water, lands, visual, noise, environment, infrastructure that this cannot be mitigated against.

Appendix 17.1 Tirawley Turbine Delivery Report.pdf 17.1.3 Site Location, Context, and the Development

The Proposed Development is located ~14.5 km northwest of Ballina Town, ~5.2 km northwest of the village of Killala and ~2.4 km east of Ballycastle village in north Co. Mayo. The Wind Farm Site is located ~10.5 km east of the county border between Mayo and Sligo. The redline boundary extends to 119.12 ha. The Wind Farm Site is accessed via local public roads which branch off the R314 which joins Killala in the southeast to Ballycastle in the northwest. These local public roads serve numerous dwellings and associated farm buildings scattered in lands surrounding the Wind Farm Site.

Observations: The proposed development fails to state the parish/townland of Lacken. This unique coastal area is home to over 1,200 people and exists in its own right. It has done so for centuries. This area is steeped in history and must be preserved. Lacken has connections back to St Patrick in the 5th Century. Our church, local land marks and wells are called after St Patrick. General Humbert landed in Lacken in 1798. Lacken has recognised court tombs,famine graveyards, Ceide fields complex is one of the oldest Neolithic sites in the world which predates the Egyptian Pyramids and extends into Lacken. There are numerous Clubs, societies and groups in Lacken all of which are making a submission so it very concerning why Lacken is not being recognised. These clubs are making a submission. Lacken GAA, Lacken Community Care, Lacken Sensory Garden, Lacken Biodiversity Group, Lacken Parish council, Humbert Development and other groups. Lacken is a vibrant community but it has not been mentioned in any documentation whatsoever. This is very concerning as the director of the proposed wind farm and his brother ran a quarry business in Lacken for over two decades. This tells us that the developer is trying to conceal Lacken as a location. It shows a complete lack of understanding and no regard to our community here in Lacken. This is outrageous and I question what else the developer has omitted. This naming of Lacken has been omitted in the whole application and gives the impression by reading the submission that Lacken does not exist which is completely misleading and false.

Is the reason for this glaring omission by Constant Energy because a wind farm was denied permission in Lacken. Application ACP 239901, Planning Authority P11/409 in 2012. This was a fraction of the size both in numbers and height but was deemed unsuitable for the area by An Bord Pleanála.

Appendix 17.1 Tirawley Turbine Delivery Report.pdf - 2 ASSESSMENT SCOPE

Observation: This section states that the TDR Option 1 previously proven for turbine component delivery to other wind farm projects in the area, notably Oweninny Wind Farm. This statement is misleading as Oweninny and Lacken area not in the same area or share a common road network. They are over 40KM away so this is factually incorrect. This again is a worrying rhetoric as a ready could be easily tricked into believing this.

2.2 SWEPT PATH ANALYSIS An AutoTrack model was developed for this assessment. A Vesta V117 turbine blade measuring 57.2 m in length, each with additional overhang on a trailer, was used to track the path from Ballina Town Co. Mayo to the Wind Farm Site. Refer to Figure 2 - Typical Turbine Delivery Vehicle (V117 Blade). Pinch points along the route were identified using aerial photography, available topographical survey data and site visits.

Observation: 2.2 SWEPT PATH ANALYSIS states the blade length is 57.2m. Appendix-2.1-CEMP-Management-Plan-7-Traffic-Management-Plan.pdf Point 2 states that the Turbines will be 76.5m. This is confusing and misleading. Which figure is correct: 76.5m or 57.2m? There is a massive difference and calls into question all 3 possible TDR routes. It null and voids any assessment that was made using AutoTrack model, desktop, visual or site visits. This catastrophic error has a cascading effect on the whole project. This again proves inconsistent information in the Developers submission and shows an unprofessional approach to a proposed project.

Appendix 17.1 - Tirawley Turbine Delivery Report.pdf

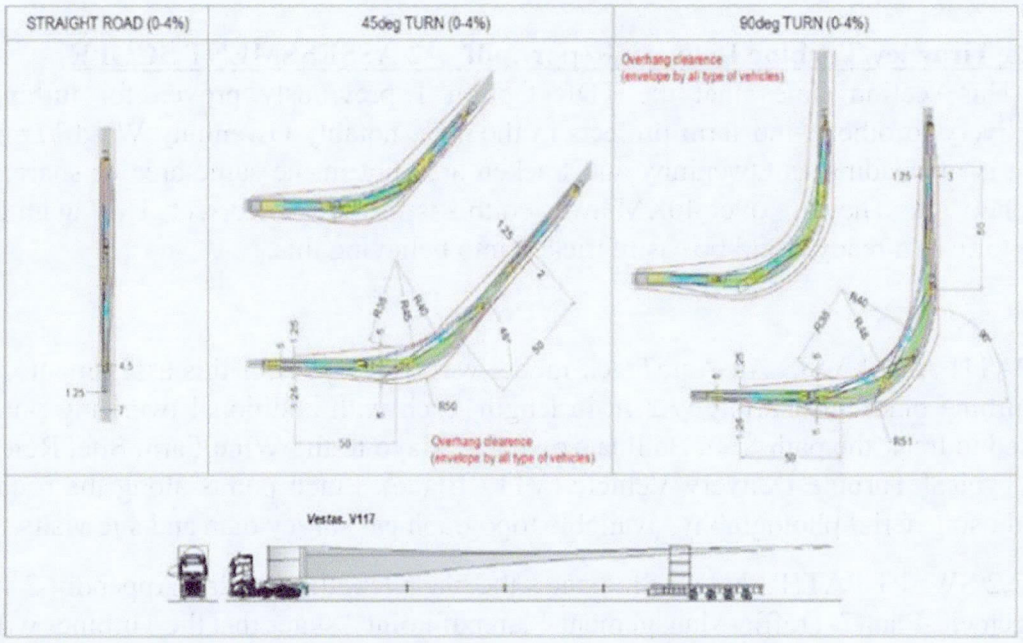
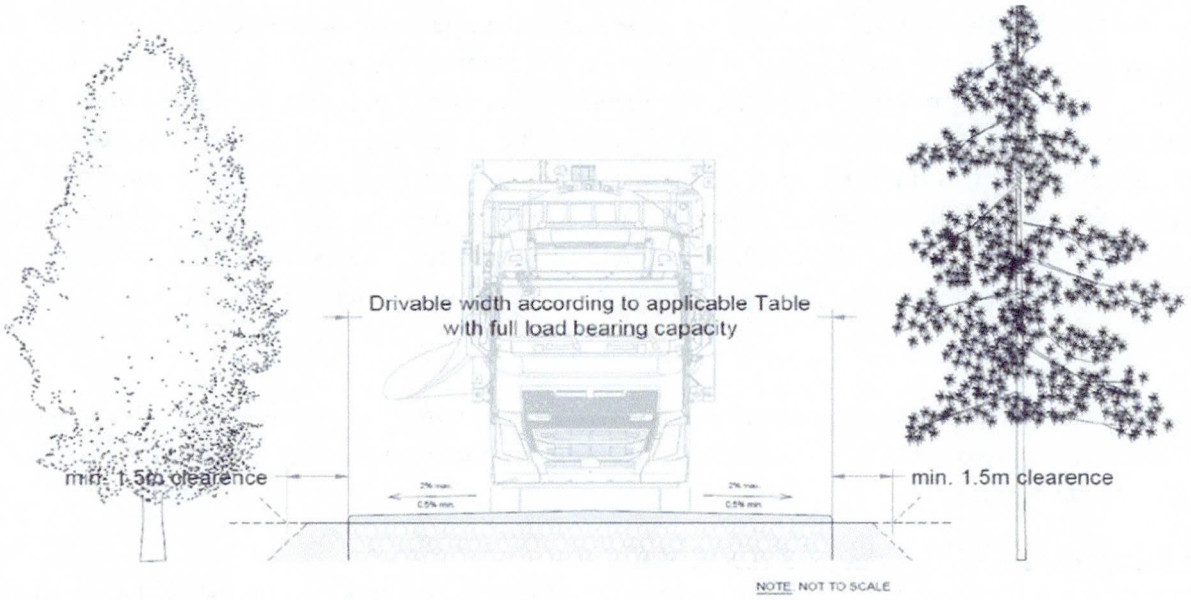


Figure 2: Typical Turbine Delivery Vehicle (Vestas V117 Blade)

Observation: The above diagram is not clear and is difficult to read so it cannot be assessed correctly.

2.3 ROUTE CONSTRAINTS

Figure 3 below highlights the typical road width and clearances that is required for the delivery of WTG towers. A total of 18 no. wind turbines delivered to the Wind Farm Site, consisting of 18 no. Vestas V117 (4.3 MW).



Observation: Figure 3 is not to scale and has no width measurements stated for the TDR width required, only a min 1.5M clearance each side. This is contradicting point 2.3. This is the only figure available which is misleading and does not allow me to assess the TDR in detail as the road infrastructure is not equipped to handle the large number of abnormal loads.

3.1.1 Killybegs TDR Option 1 - Route Break Down – Start to Finish

Turn left onto Bunree Rd. (850 m) • Turn right onto Healy Terrace/R294 (750 m) • Continue straight on Tone St onto Garden St • Continue straight on Garden St onto McDermot St • Continue onto Gurteens/L1119 (650 m) • At the roundabout, continue straight (75 m) • Continue onto N59 (4.2 km)

Observation: This TDR will be going through the heart of Ballina town along with going the incorrect way on a number of one way streets. This will be disruptive to road users and poses a health and safety issue even during the night as there are a number of large Factories in Ballina and on the outskirts.

3.1.2 Killybegs TDR Option 1 First Leg – Killybegs Port to Ballina The route from Killybegs Harbour to Ballina Town has been previously utilised for the transportation of turbine components for the following wind farms: Oweninny Wind Farm Phase I (55 m blades) and Phase II (57.5 m blades), Sheskin Wind Farm (57.3 m blades), and Killala Community Group Wind Farm (49 m blades). The initial segment (The First Leg) of TDR Option 1 was not assessed in this report, as it had been previously evaluated and employed by other operating wind farms in the region of the Wind Farm Site. This segment has already undergone modifications, including alterations to roundabouts, junctions, and roadside infrastructure, along with necessary upgrades, to facilitate the delivery of turbine components. The following is a brief description of TDR Option 1:

Observation: Similar to point 2 above on Assessment Scope. The developer is not aware of what work is required in the first leg as they omitted it from this report. This section states that the TDR Option 1 previously proven for turbine component delivery to other wind farm projects in the area, notably Oweninny Wind Farm. This statement is misleading as Oweninny and Lacken are not in the same area or share a common road network. They are over 40KM away so this is factually incorrect. This again is a worrying rhetoric as a ready could be easily tricked into believing this. The closing sentence of the point 3.1.2 is misleading as it states the *"following is a brief description of TDR Option 1" but then references point 2.*

Observation: All proposed routes are passing/close proximity to Ambulance dispatch at Ballina district hospital. No mitigation has been put in place for this service when abnormal loads are taking place

3.5 FINAL LEG TDR – WIND FARM SITE

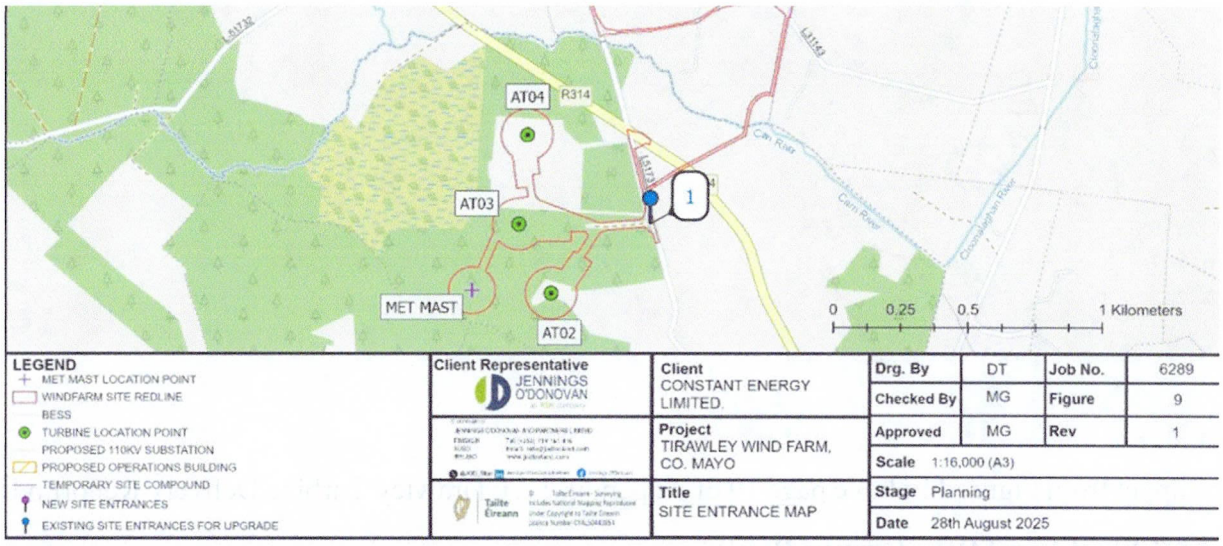
The start point for the Final Leg TDR options is at Annagh Beg junction on the R314 (i.e. the cessation point of the Second Leg TDR). For the purpose assessment and the EIAR, the Wind Farm Site TDR (Final Leg TDR) was split into two individual routes (Blue and Orange).

Observation: Annagh beg junction is not located on the R314. This is misleading and shows no attention to detail for the most important leg of the journey. This shows a poorly drafted submission for a glaring error like to exist.

3.5.1 Final Leg TDR - Blue Route The Blue Route (Figure 10) provides direction for the delivery of turbine components for wind turbines AT01 – AT04 from the cessation point of the Second Leg at TDR Annagh Beg junction to their final destination. Directions for the delivery of turbine components for wind turbine AT01: • Continue straight from the cessation point of the Second Leg TDR, through the Annagh Beg junction located on the R314 east onto the L51792

Observation: Annagh beg junction is not located on the R314. This is misleading and shows no attention to detail for the most important leg of the journey. This show a poorly drafted submission for a glaring error like to exist.

Figure 9 – Site Entrance's to Each Turbine Locations onsite



Observation: Map legend states that the Redline is the Windfarm site. The line includes a public road which Constant energy does not own. This is misleading and was stated in a pre-planning meeting by Mayo Co Co that this should not be included and should be removed but it has not. This indicates that the developer will not follow direction, engage with the planning process or adhere to any governing body. I have grave concerns regarding the ability of Constant Energy to undertake the proposed project.

3.5.2 Final Leg TDR - Orange Route

Directions for the delivery of turbine components for wind turbine AT05 and AT06:

• Turn left into the Wind Farm Site using Site Entrance 3 (Figure 2.1) to wind turbine AT05 and AT06's final destination.

Observation: No such Site entrance exists in Figure 11 nor can I locate a Site entrance 3 or (Figure 2.1) in this document.

3.5.2 Final Leg TDR - Orange Route

Directions for the delivery of turbine components for wind turbine AT07 and AT08: • Continue straight from the cessation point of the Second Leg TDR, through the Annagh Beg junction located on the R314 east onto the L51792 • Turn right onto the L51791, continue north for 530 m • Turn left into the Wind Farm Site using Site Entrance 4 (Figure 2.1)

Observation: The above directions are incorrect. It does not lead you to AT 07 or 08 as it misses direction at the below junction. No such Site entrance exists in Figure 11 nor can I locate a Site entrance (Figure 2.1) in this document.



Snippet from Figure 11 above page 19 of Appendix 17.1 Tirawley Turbine Delivery Report.pdf

3.5.2 Final Leg TDR - Orange Route

Directions for the delivery of turbine components for wind turbine AT09 and AT10: • Utilise the same route for wind turbines AT07 and AT08 as far as Site Entrance 5 (Figure 2.1)

Observation: The above directions are incorrect to AT07 and AT08 so by default effect AT09 and AT10. No reference to site Entrance 5 Figure 2.1 on Figure 11.

3.5.2 Final Leg TDR - Orange Route

Directions for the delivery of turbine components for wind turbine AT11 to AT12: • Turn left off local road L31142-0 onto local road L5187-47 • Turn left off local road L5187-47 onto AT11 Site Access Track using Site Entrance 8 (Figure 2.1) • Utilise the same route for wind turbine AT12 as far as Site Entrance 9 (Figure 2.1)

Observation: Cannot locate a reference to Site entrance 8/9 in Figure 11 or identify Figure 2.1 in - Appendix 17.1 Tirawley Turbine Delivery Report.pdf

3.5.2 Final Leg TDR - Orange Route

Directions for the delivery of turbine components for wind turbines AT13 & AT14: • Utilise the same route for wind turbines AT11 and AT12 as far as Site Entrance 7 (Figure 2.1) • At Site Entrance 8, continue west on the L31142 for 236 m

Observation: Cannot locate a reference to Site entrance 7 in Figure 11 or identify Figure 2.1 in - Appendix 17.1 Tirawley Turbine Delivery Report.pdf

3.5.2 Final Leg TDR - Orange Route

Directions for the delivery of turbine components for wind turbines AT15 and AT16: • Utilise the same route for wind turbines AT11 to AT14 traveling east from Site Entrance 7 on the L5187-47 as far as Site Entrance 12 (Figure 2.1) Continue north across the width of the L21148 to Site Entrance 14 (Figure 2.1) to wind turbines AT15 and AT16's final destination.

Observation: Cannot locate a reference to Site entrance 12,14 in Figure 11 or identify Figure 2.1 in - Appendix 17.1 Tirawley Turbine Delivery Report.pdf

4.3 TDR GENERAL ROAD WORK

These works may have a slight, negative, temporary effect on residents, businesses and road users due to the increased noise and vibration resulting from construction activities, and increased journey times and delays due to temporary traffic management. However, these effects will be short term during the construction phase, prior to the delivery of the turbine components and hence, are not predicted to have a significant effect.

Observation: The amount of road widening , road hardening , hedge removal, power cables to be moved, mains water, is far from slight. Vibration to near by monuments, houses, protected bridges/structure is very concerning. As mentioned above Lacken is a rich archaeological area and I see no mitigation factors for any works. No reference to any bridges on the TDR such as MO-R315-013, REF Google maps: 54°10'09.7"N 9°20'51.7"W which is a hump back bridge no assessment was carried out on this bridge to see if it can cope with abnormal loads. Even with additional axel's on the vehicle/trailer the weight will be on the highest point of the bridge therefore putting it under untold stress. Will it cope with this weight? The bridge at Garranard crossing the Carn river on the R315 has had remedial work carried out in the last number of years. REF Google maps: 54.176548, -9.353405



4.5 TRAFFIC MANGEMENT

A Traffic Management Plan (Management Plan No. 7) will be developed as part of this Construction Environmental Management Plan (CEMP) Appendix 2.1 of EIAR. Prior to the commencement of the construction phase, this Traffic Management Plan will be revised, and the route survey updated.

Observation: No traffic management plan in place so cannot assess the impact this will have on the area and residence.

4.6 OVERHEAD ELECTRICITY LINES

To determine the control measures required for a high load, ESB Networks will have to individually assess each overhead line crossing on the proposed route. In some cases, no specific control measures beyond this assessment may be required. In general, control measures may vary from having to arrange for ESB Networks to supervise load transport to switching out and earthing lines or, in more extreme cases, making arrangements for raising the height of

the lines before the load is transported. Works along the TDR will adhere to the ESB Networks Guide ESB Networks Code of Practice for Avoiding Danger from Overhead Electricity Lines.

Observation: No assessment in place by ESB so cannot assess the impact this will have on the area and residence. No risk assessment conducted for the community. TDR is via Regional and local roads used by residents, farmers and vulnerable road users so this is a major concern.

5 TURBINE DELIVERY ROUTE PINCH POINT ASSESSMENTS

The Second and Final legs of the TDR were assessed visually and using Swept Path Analysis. The local road survey and Sweep Path Analysis identified a total of 19 pinch points. These pinch points are summarised in this report and Planning Drawings 6289- TIR-AT-BA-00B to 6289-TIR-AT-BA-021 (Table 1).

Observation: No clear reference to this to Planning drawing or quick link in document, this is difficult to assess.

5 TURBINE DELIVERY ROUTE PINCH POINT ASSESSMENTS

TDR Pinch Point Assessment A desktop review and site visits were carried out for the second and final leg of the TDR. For the purposes of this assessment and report, site visits were conducted in the summer of 2023/24. This consisted of a visual inspection of each pinch point identified in the desk top study, travelling along the route and by reviewing video footage taken from the car of the associated roads. Pinch Points and their associated roads are outlined below: – Pinch Point 1, 2 and 3 – R314

Observation: Pinch Point 1,2,3 are not located on R314. This is confusing, misleading and indicates the Developer is thorough in their assessment. The company is very competent with years of experience but has a frightening number of errors in this submission.

5 TURBINE DELIVERY ROUTE PINCH POINT ASSESSMENTS

Prior to the delivery of turbine components at construction phase, a detailed Route Survey and Trial Run will be completed in accordance with Vestas Site Roads and Hardstand Specifications, V117 Access Requirements Checklist.

Observation: No detailed route survey or trial run has been completed. Evidence of this below as I have observed additional pinch points to what the developer has stated.

5.1 PINCH POINT LOCATION MAP

Figure 12 below shows each Pinch Point location along the Second and Final Leg of the TDR, between Ballina Town and the Wind Farm Site.

Observation: Figure 12 is very difficult to see the pinch points on the map. Unable to view the proposed pinch points.

5.1.2 Ballina Town Traffic Management As mentioned in Section 4.3, a Traffic Management Plan will be included as part of the CEMP, Appendix 2.1 of the EIAR. Prior to the commencement of the construction phase, this Traffic Management Plan will be updated to include further details of the route, with particular focus on the requirements for Ballina Town, it will include details regarding

Observation: Traffic management plan is incomplete as no RAMS have been conducted.

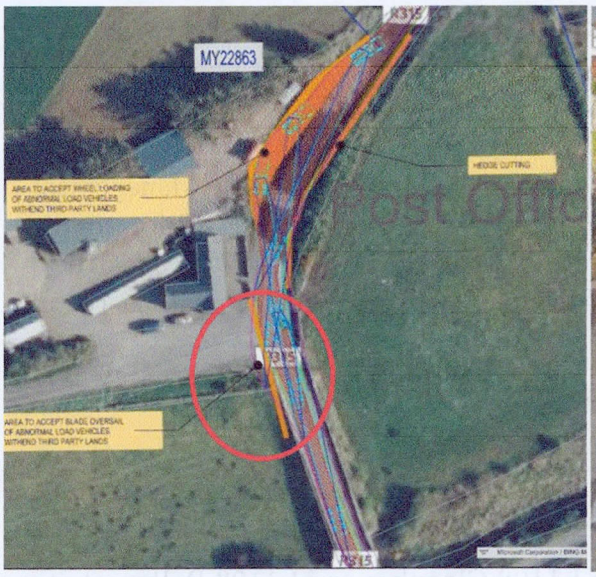
5.1.3 Ballina Town to the Wind Farm Site and Local Roads within the Wind Farm Site

Second Leg of the TDR goes by Ballyneety. Take L1108 Cloonkee and L1108 Ballyneety to R315 (7.8 km) Observation: Ref : 54°08'29.4"N 9°18'06.2"W as a potential pinch point. This is not listed as a potential pinch point and I believe it should be marked as one. There is not a minimum internal horizontal radius (Rint.min) of 40 m or indeed 50m for the transition from a drivable road width to turning the corner.



Figure 14 - Auto Track Analysis Ballina to Wind Farm Site Pinch Point 1

Observation: Landower of MY22863 has not given permission for their lands to be used by Constant energy. It appears by Figure 14 that a section of the bridge wall will be removed to give access for the Blade over tail. Hedge/Tree removal required on one side along with cutting required on both sides of the road only mentioned on one side. The widened road will bring the road right up to the existing building which will pose a Safety issue for residents of that house and road users. Major excavation required due to ground height being substantially over road level. Mayo Co.Co conducted remedial work on that bridge in the last 3 years which indicates it is vulnerable and may be unable to handle the weight of the TDR vehicles. Traditional stone walls will be removed to facilitate road widening which impacts on the amenity of the area.





Observation: On the R315 from 54°10'52.3"N 9°21'03.0"W to 54°10'57.8"N 9°20'58.4"W there are two potential pinch points which have not been documented. This will lead to hedge row, electricity cables being moved. One side of the road is considerably higher than the road than the other side so excavation or filling will be required. This has not been factored in so will increase the number of material required, journeys, hedgerow removal, soil, traffic disruptions etc to the area. There is a local creche/primary school not far from here so will affect these people along with the wider community.





Observation: On the R315 location 54°11'45.0"N 9°20'59.7"W there is another potential pinch point not documented. The road does not appear wide enough to accommodate an abnormal load.



Observation: No report or acknowledgement of the Bridge located at REF Google Maps: 54°11'49.8"N 9°21'03.3"W. Will it be able to support a large volume of abnormal loads.



Observation: A further undocumented pinch point REF Google Maps: 54.209613, -9.360294 which is not mentioned in the Pinch point analysis



Observation: A further undocumented pinch point REF Google Maps: 54.214490, -9.360578



Observation: There is no third party consent stated or given for pinch point 1, also there is no oversail stated at this pinch point but it is required so this is misleading. Has the developer got consent from the land owner?

Observation: In Figure 15 Pinch Point 2 it stated that Oversail is required. Throughout the TDR section there is no permission from any land owners for road widening, hardening, oversail etc. This is a SID and must have all relevant information forthcoming, I urge you not to take the Developers word that all these landowners have legally given permission. Lacken is on the North Mayo coast and the first pinch point that the developer states is over 15Km away. I estimate the first pinch point to be over 20Km from the proposed development. There are a lot of people to get consent from in order for the Turbines to be delivered to the proposed wind farm. Legal proof is needed to confirm all access has been obtained. A proposed development of this size cannot proceed until all consent is presented and signed off otherwise this application is purely speculative.

Observation: Plate 2 of pinch point 2 shows a significant drop in ground level from the field where the proposed widening and strengthening is indicated. This is bog and may have protected habitat there. An assessment needs to be carried out by the developer on this. Also the removal of a place name is not mentioned which will be required. Will it be reinstated and where?

Observation: The developer has not mentioned that he will adhere to the Wildlife Act to ensure the hedge cutting referred to in a number of pinch points. This work is permitted between September 1 to February 28.

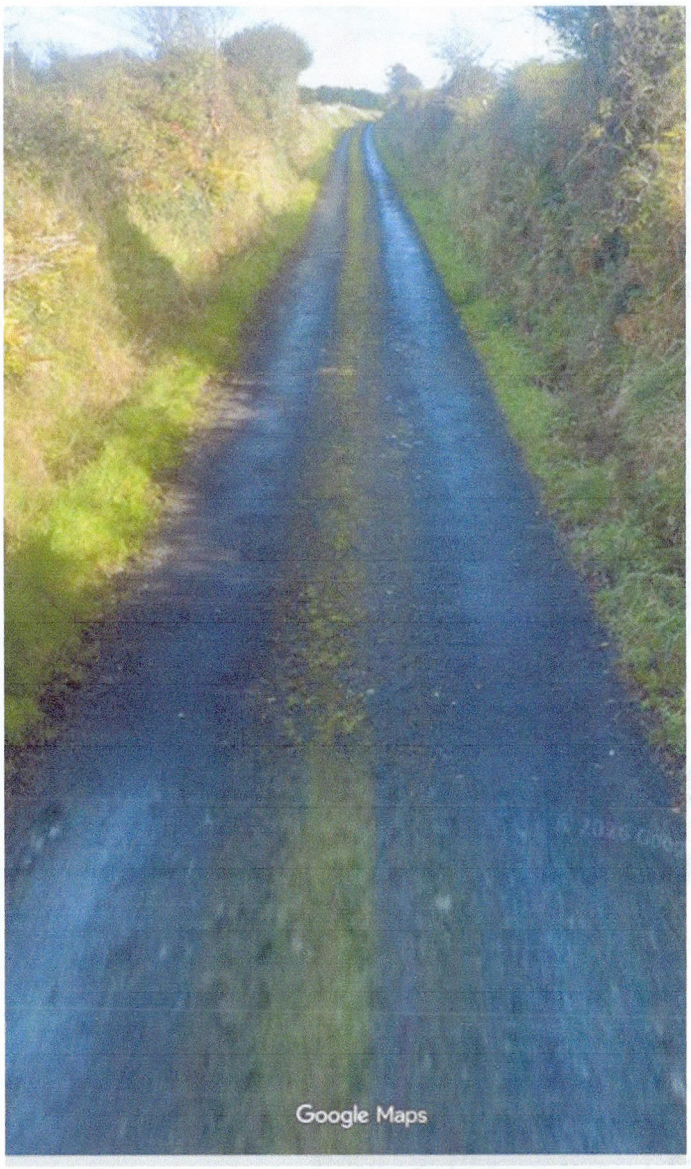
Observation: Pinch point 3 will require significant works on both sides of the road. It requires the removal of hedgerow at folio MY1627F which is not stated in this and many other pinch

points where work needs to be carried out. Removal of hedge row may have serious consequences for that land owner if they are in certain Agricultural programs. This pinch point has an archaeological aspect as MA014-050--- Megalithic structure: Annagh Beg. ITM Coordinates: 510623,832430 Latitude and Longitude: 54.232931,-9.370909 is in this area. Vehicular traffic, vibrations and spoil may have a detrimental effect on the monument. There is no mention of this historical monument nor any mitigation measures put in place. This is very unprofessional and indicates a sloppy approach to a major development with no regard to the heritage of the area.

Observation: There has been no mention of preserving the water table in any of these road works. What happens when drains are covered? Will these be piped into the existing water table or will it just be covered over.

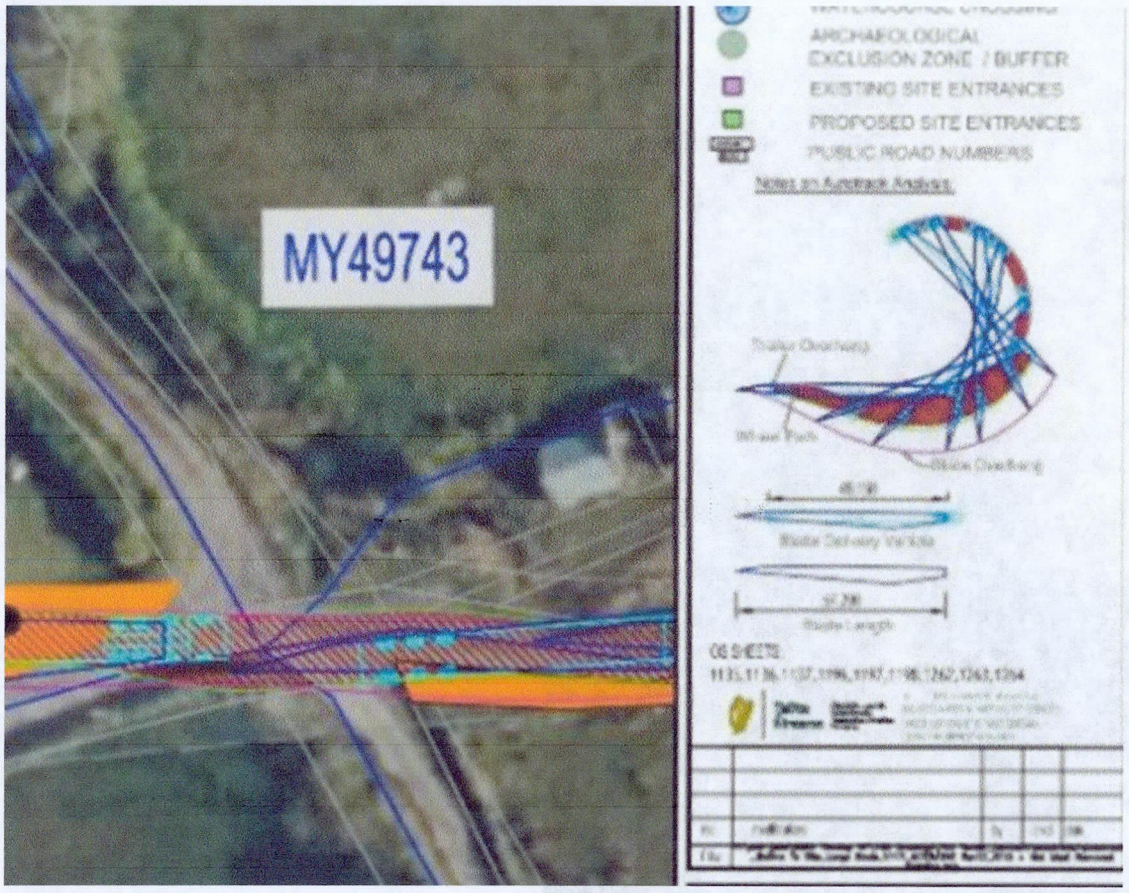
Observation: The L51772-0/Annagh beg rd off the R315 is very narrow and will not cope with the proposed abnormal load. Major road widening in excess of 400m will be required, hedge row removal, soil removal. The ground is 1.5M/2M in places over road level so the amount of soil removal is significant but is not documented. This is very obvious to see even as a Desk study but the developer has omitted this completely. This is hugely concerning and again shows a poor quality submission.

Observation: The incline is steep so the tractor unit may not be able to progress this way without even further removal of the existing road. See pic below. Does it come to a point where all the excavation, disturbance and destruction of the area becomes too much. The area is simply not suitable for a wind farm.



Observation: There is another pinch point which is not documented REF: 54.233044, -9.365402. How and Why has the developer omitted this.

Observation: Very difficult to see the legend on Figures throughout the report especially Autotrack information in Figure 17



Observation: No mention of hedgerow removal in pinch point 4 which is clearly visible in the picture below.

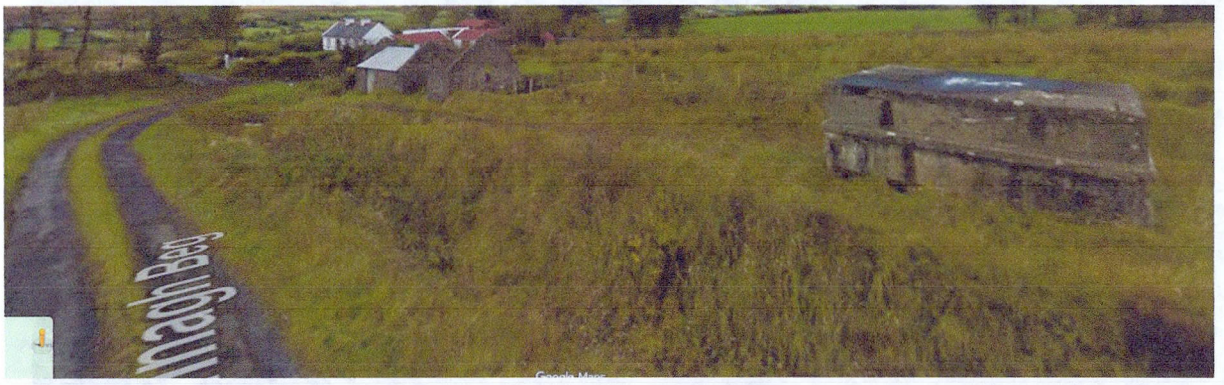


REF: 54.233032, -9.364265

Observation: The water table is not mentioned in pinch point 5 and is highlighted in the picture below. There are a number of open drains, will these be covered over, there is no details on this. There are also two structures and a permanent water tank that may need to be demolished to accommodate the abnormal load. This is not pictured and skipped over by the developer nor has it been mentioned in this document. Does the demolition of the buildings have any hazardous materials? Will the road widening affect the quality of water in the area. Figure 18 is misleading and unclear, it fails to illustrate a true route for the abnormal load between Folio MY 71508F and the commonage located on the other side of the road. This proposed pinch requires commonage, has consent been given by all parties with a claim to the commonage.



Open water table above

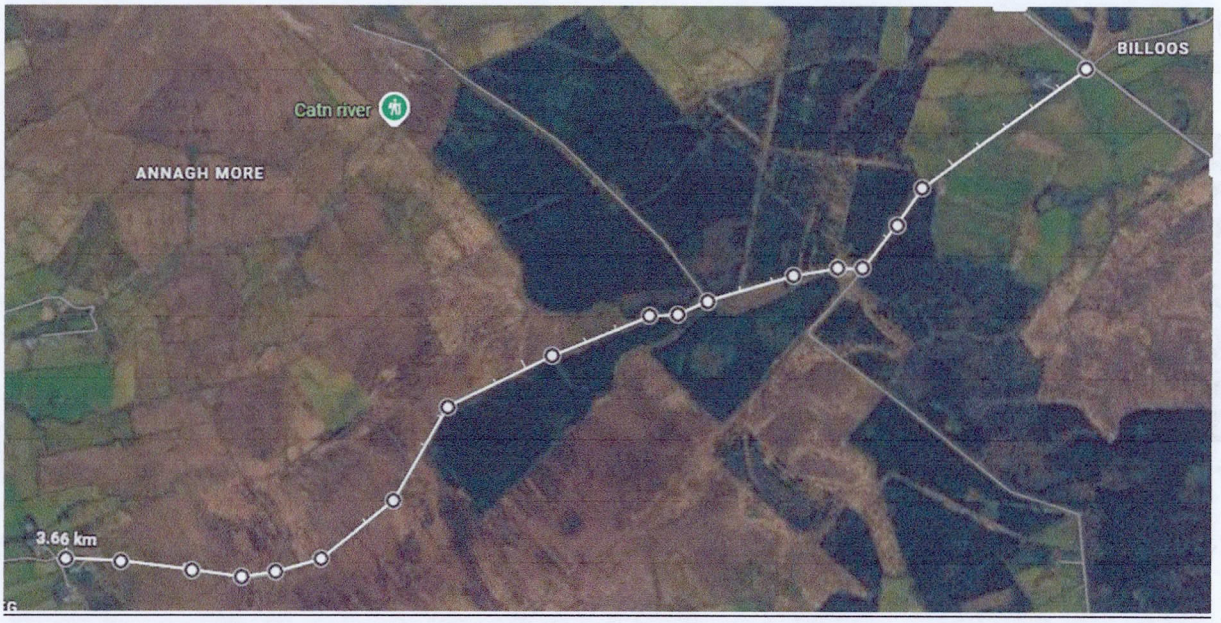


Two structures and a permanent water tank above. Will this be affected as going by the TDR it does not state that it will but in practice it looks like it will be.

Observation: There is a serious omission between Pinch point 5 and Pinch point 6. The TDR goes through Annagh beg peat bog. This is not a tar road, it has a stone dressing for a period but then reduces to a stone/cobble road. It is undriveable in a car hence the reason Google maps does not show this. There is no mention of this in the TDR. This is hugely concerning as this track is over 3.66KM long and hardly wide enough for a car with a very poor surface

surrounded by bog and drains. This raises a huge peat excavation question, was this assessed in the Soils and Geology Assessment Peat Landslide Hazard or any Peat studies? This stretch needs peat removal so will increase the 0.68 of estimated blanket bog stated in Chapter 3, major road widening, hardening, hedge removal and hardfill. This area is across peat so there will be a lot of water to deal with as once bog is dug out it will fill with water, where will this water go, how will it be managed? What wild life resides in this area in drains and banks, will it be interfered with or worse destroyed. The bog is active and local residents cut turf there annually. Has permission been sought from land owners to conduct work? This area is owned privately but also areas of commonage. Along with the works mentioned above there is also a pinch point on this route highlighted by the yellow circle. This area is forested so tree felling may be required to accommodate abnormal loads.



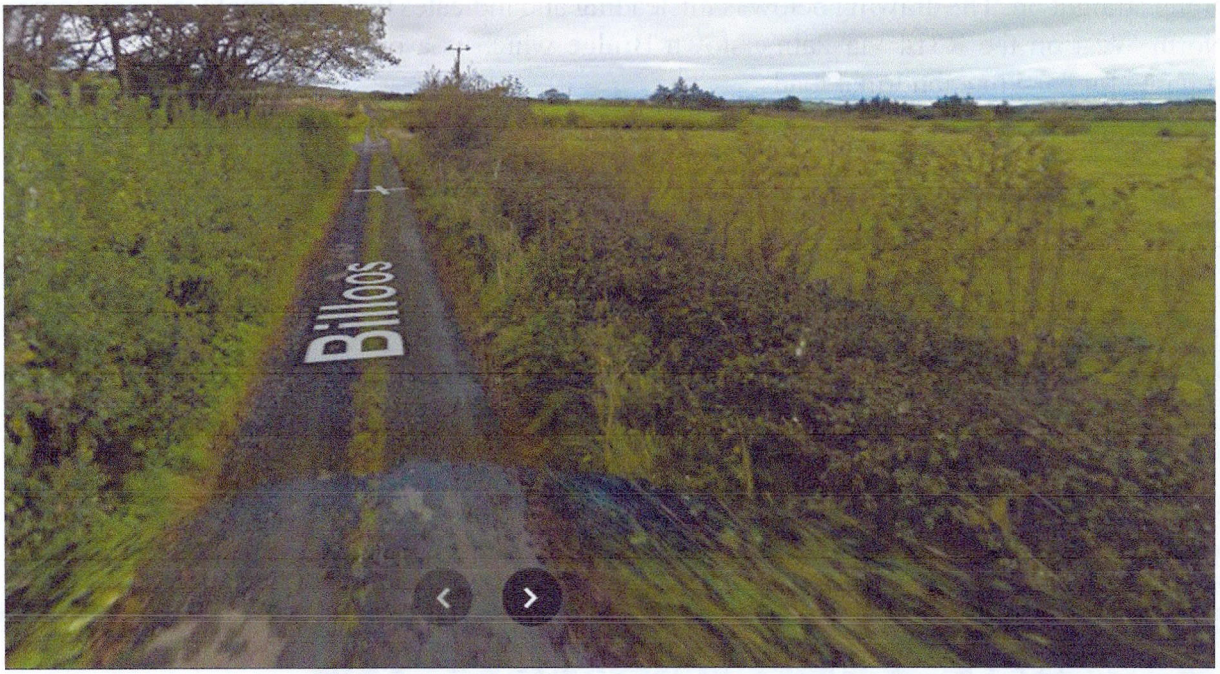


Observation: There is a large drain on the right hand side on the Annagh beg road as you approach R314. REF: 54.245155, -9.318466. The road is not 4.5M/6M for clearance so this will need to be filled in or the hedgerow on the left will need to be removed. There is no mention of this in this or any report. Permission will need to be sought to have a new entrance and I see

no evidence of this in the example below or in any of other entrances that may be effected throughout this proposed development.

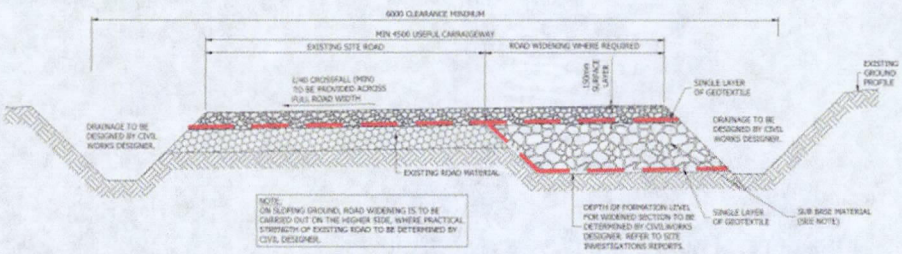


Observation: Further hedge removal needed at Billos before approaching R314. This is stated as trimming in the application but one can see it is not. This is misleading and substantial excavation and road widening/hardening is required all along this road from the R315 to the R314 across Annagh Beg mountain: 54.245702, -9.317365



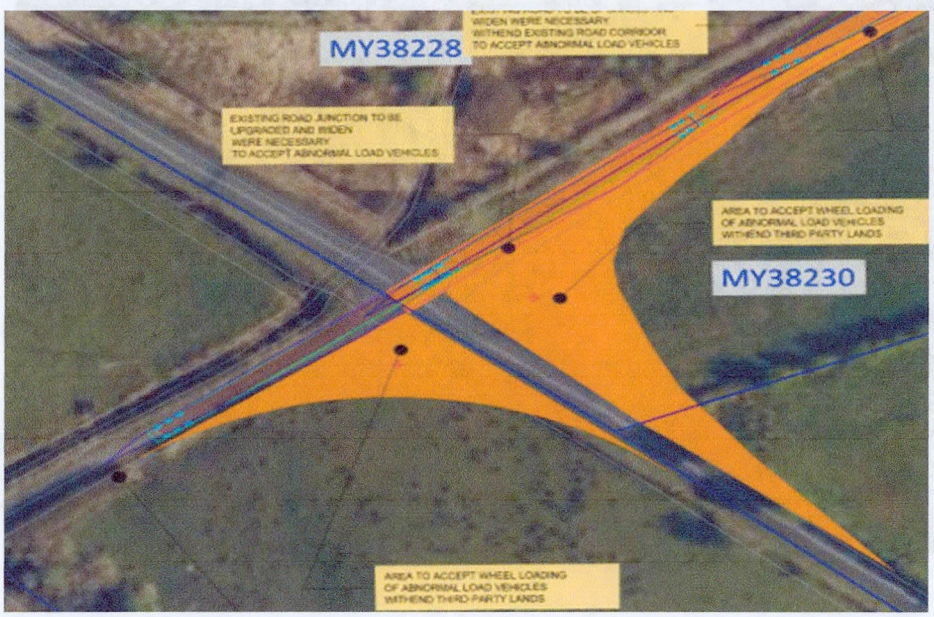
Observation: The figure below from Figure 2.10 - Road Construction Details (Sheet 1 of 2).pdf highlights that a carriageway of 4.5M is required and 6M metre clearance. I noted that there is a page missing from the above Figure 2.10, there is no page 2 of 2. The amount of road

widening that needs to be conducted is a major project in itself. I feel this have been very poorly documented and illustrated through this report. There are very few roads that are 4.5M/6M on the Second and fewer again on Final Leg TDR. This has not been documented accurately or assessed and will have a major impact on the road network, traffic management, spoil, environment, landscape. Eg What does the developer propose to do with this material? This will increase the number of lorries it will take to complete this work making their analysis incorrect.

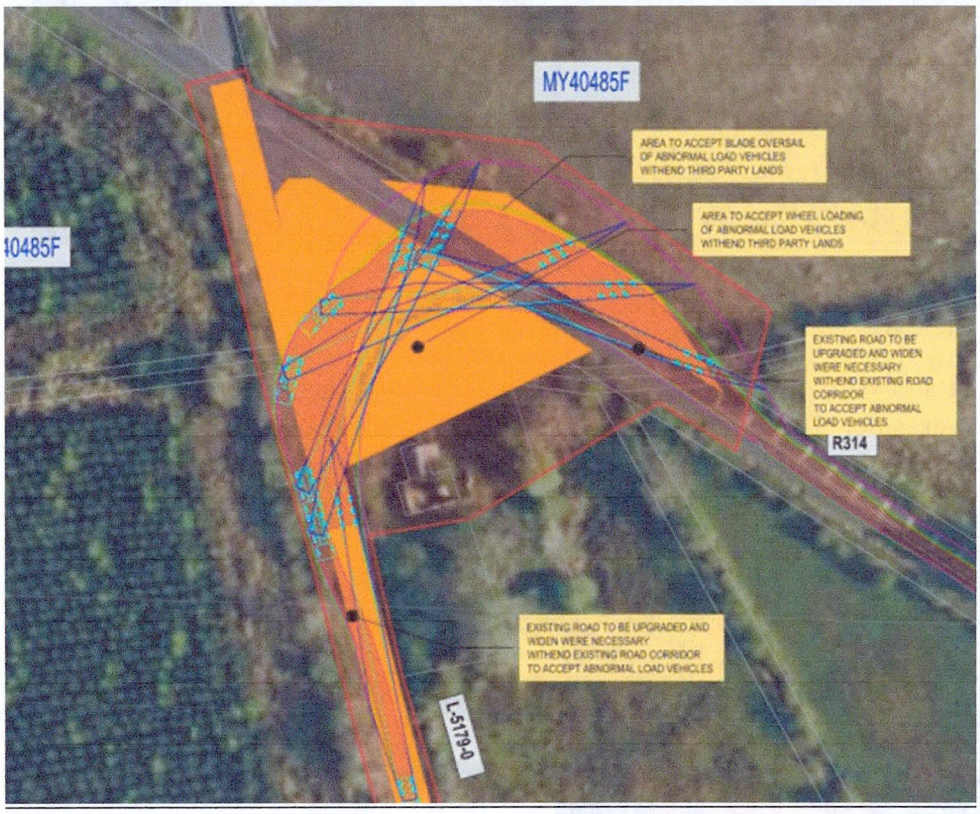


TYPICAL ROAD WIDENING ON EXISTING SITE ROADS WHERE REQUIRED CONSTRUCTION PHASE

Observation: Figure 19 – Auto Track Analysis Ballina to the Wind Farm Site Pinch Point 6. This shows a large section of MY38230 being widened on both sides of the road. It is unclear as to why both sides of the road need to be widened as the illustration shows the turbine blade going straight on. The drawing below is misleading and indicates that abnormal load may come North West on the R314 via Palmerstown Bridge which is a protected structure and is not suitable for carrying abnormal loads.



Observation: Pinch point 7 Figure 20 below indicates that the turbine is being delivered via north east (Killala to Ballycastle direction) on the R314. This is confusing and contradicts what is stated in 3.5.1 Final Leg TDR - Blue Route. Which is correct? This pinch point cannot be fully assessed with the information provided. I also note that a large portion of ground beside L-5179-0 is being taken. Why is this needed? Using the legend the red line indicates the windfarm development area. This area outlined by the red line includes the public road so this is misleading. The road widening is also very close to a building so vibrations and construction traffic may have a structural effect on this.



Observation: Pinch point 7 also requires significant tree felling and road hardening. The quantity of this will be sizeable as the area is 1.5/2M below road level. This will need to be dug out and made good. This will take large amounts of fill and is in an area of poor quality land/bog. This is not a simple widening task.



Observation: Pinch point 8 does not state road widening is required which is misleading as it is clear to see by the Plate 8.

Observation: Figure 21 shows road widening from two sides. Why is this required as the TDR will be from the lower side. This is the third such error around road widening in the Billoos/Carn area. It poses other questions around future access routes.

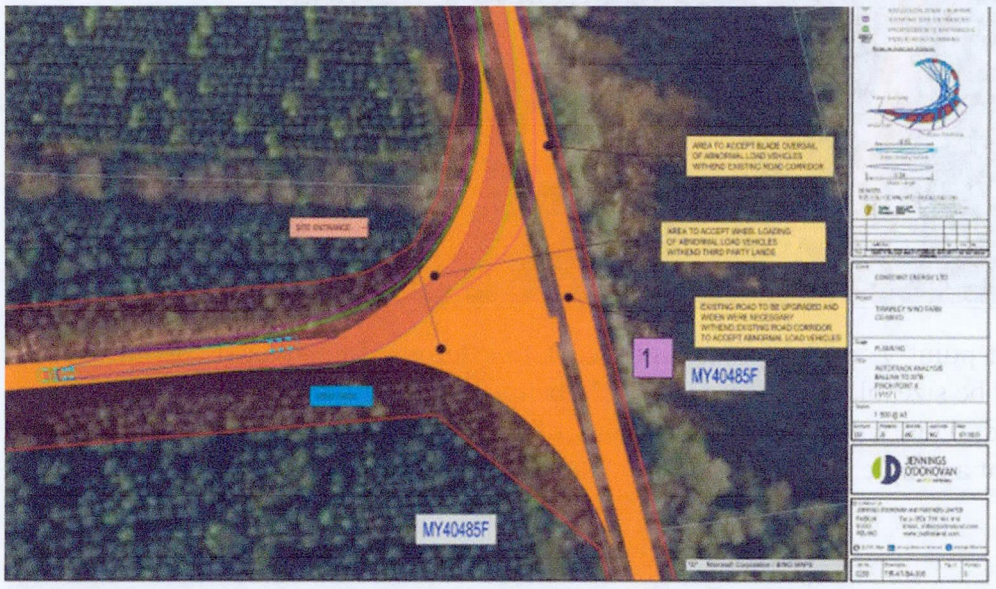


Figure 21: Auto Track Analysis Ballina to the Wind Farm Site Pinch Point 8

Observation: The road from Billos to Ballymurphy REF: 54.246749, -9.314743 will require significant road widening but this is not mentioned. This is incorrect and misleading.



Observation: Pinch point 10 is located close to a hump back bridge. No mention of this in the report. Will the structural integrity of this bridge remain intact? Will the construction haul route have a negative effect on this structure?

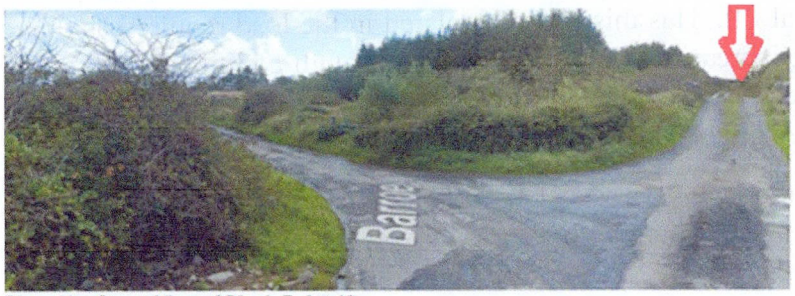


Plate 10 – Street View of Pinch Point 10

Observation: The road level at Pinch point 11 is considerably lower than the surrounding fields. As can be seen in the picture below it Plate 11 shows surface water so has there been adequate consideration given to this. I also note a surface ran piping on the left of the picture. This poses an environmental risk as we do not know what is in the pipe. It shows road widening required but no mention of stone wall removal and what will be done with the water from the drain on the left of the picture below. The road widening into verges is incorrect, boundary walls on both sides of the road need to be removed. In any of the road widening it does not state how much widening is required so how can the developer know how much material is required to widen the road.



Plate 11 – Street View of Pinch Point 11

Observation: Pinch point 12: This is a significant one as residents of these houses are extremely close to the BESS (Approx 350M) they have to enter and exit via a road shared by the BESS. It is a cul de sac so this will be very disruptive during construction. However a grave concern is from the safety aspect if there is a fire at the BESS, these residents may not be able to exit. No mitigation measures are in place to ensure residence safety.

Observation: Pinch point 13: Huge road widening and strengthening required at this location and again does not show any dimensions on the works required. Road widening is shown past MY16674F. What is this required for? Is there abnormal load coming this way too? This is misleading and needs to be clarified. Ground level is below the road level in MY20447 so significant fill will be required to strengthen and widen. Has this been adequately assessed in relation to material required and water table management.

Observation: Pinch point 14: Requires a road being made through a field which is of poor quality and may require substantial fill. Has this been calculated in the load required as this has a direct impact on everything increasing C02 (Air quality) through additional trucks to increase the road journeys required. This is a steep incline so will require major filling to graduate the approach, has this been given adequate consideration.

Observation: Pinch point 17: The road goes across a bog ,it is not known what depth and fill will be required for the road to be made. This will have a knock on effect similar to the point raised above regarding extra material/traffic (Pinch Point 14)

Observation: Pinch point 18: The road widening indicated is not sufficient for the abnormal load to exit the L-31142-0 into AT10. This needs to be reviewed. It has also failed to state that tree felling will be required even though the turbines are located in a forestry. Why was this omitted and is this omission carried forward to incorrectly calculate the Hectares of forestry that needs felling. It is significant as there are two proposed turbines in this location (AT09 + AT10).

Observation: Pinch point 19: This is one of the most significant pinch points in the whole development. The TDR is circling the Lacken Water Tower. This poses a huge risk to human health and should any event or contamination occur during Turbine construction or TDR works this could compromise the safety and supply of water to hundreds of houses in the Lacken and Ballycastle. This area would require robust mitigation measures. I see no reference to this in

Chapter 9 so this is of huge concern. There is also no mention of tree felling required at MY14413F at this Pinch point. No mention of removal of road furniture/signage and this is required ref Plate 17 – Street view of pinch point 19



Observation: Pinch point 20: There is a large drain on the upper side of the road which will need to be crossed, it is not documented as to how this will be managed. Where will the water be diverted to and will this cause any flooding. It is unclear if this is an oversight or the developer has no intention of addressing the issue. There is also a large bridge in Conaghera and it is not noted if the entrance to AT12 is before or after this. It is impossible to tell given no place name or accurate location of the proposed turbine entrance. This is not a specific point relating to AT12 but a general observation for all turbine entrances it is difficult to assess this properly. See pic below showing bridge. Has this bridge been adequately assessed under the Cultural and Heritage chapter?



Observation: Pinch point 21: The ground level where road widening is required is significantly lower than the road level indicated by the red arrow below so substantial fill will be required. There are also open and underground drains that have not been considered at this pinch point. The particular location is a water catchment area from the L-21147-0 and L-5187-47 so this could pose a flood risk to the nearby house included in the picture. Large amounts of stone walls will also be removed which is not stated.



As part of this pinch point there is Third-Party Lands and Over sail Required, Road Strengthening Required, Hedge and Tree Removal and Trimming Required significant road widening required. The residences of H11 located on the left of the picture, have not consented to over sail. The residents object to this proposed development. Indeed throughout the documents I see no reference to any consent from third parties. Is this a grounds for refusal in its own right? This is a major oversight and bar the people who are financially involved the Parish of Lacken and Mayo County Council are opposing this development. This can be seen as all Lacken community groups have put in a submission. This sends a resounding No to the proposed Tirawely Wind Farm from the people, community groups and Mayo Co.Co . How can the developer make the assumption that any consent is going to be granted if they cannot prove it. The amount of landowners required to give permission is sizeable so this is a point of significance and the burden of proof is on the developer to prove he has all the consent required for all aspects of this project not just limited to the TDR.

I also note the existence of an old dwelling in the area marked in orange which indicates road widening. This is not covered by any Plate picture in fact the viewpoint of Plate 19 is pointing away from the old dwelling so is misleading and does not give a true representation of the area. The old dwelling has not been mentioned in this report and going by the Figure 32 in Appendix 17.1 Tirawley Turbine Delivery Report.pdf indicates this will be demolished. This is a glaring omission and needs further investigation. See pic below:



Observation: Throughout the TDR I see no reference to townlands or place names on the maps , it simply states folio numbers. How is a reader expected to know these and why are the place/townland names omitted. This is a requirement for a SIDS development and sheds a poor light on the developer and Consulting firm Jennings O'Donovan in their approach. I also note that the developer continuously states "Area to accept wheel loading of Abnormal load vehicles withend third party lands". What does withend mean? See snippet below.



This is a common theme throughout the document which is misleading and time consuming for a reader to interpret. This is yet another example of mistakes and omissions in the application. The more you read , the more confusion it creates. This is not acceptable for a development of this type.

Observation: I have seen no agreement or consent to erect the Met Mast near AT02 and AT03. I see no agreement registered by a Solicitors or timeline on this.

Observation: Grid connection on L31143 will need widening but not stated

Observation: On the R314 near AT02/AT03/A04 there is a dangerous bend on the road and sadly there have been many fatalities. This is a major safety concern as the access road to the above turbine is 288Metres.

Observation: Have any mitigation measures been put in place for moving livestock across the proposed development. These include Dairy farmers where cows have to be walked twice daily to the milking parlour from fields all along the TDR, CHR, CGR. This will be very disruptive on the farm and will have a negative effect on livestock.

Table 17.2 Policy and Guidance

Traffic Management Guidelines 2012 used instead of **Rural Local Roads Speed Limit Bye-Laws (November 2024) and Special Speed Limit Bye-Laws 2018**

Observation: Incorrect guidelines used which makes any assumptions there after invalid and equates to non-conformance on the applicants part. No taken account of the above guidelines

Mayo County Council were consulted in person by the Applicant on the 18th of August 2023 regarding the use of the public road network for haul routes to proposed Wind Farm Site. Traffic count data from the TII traffic counter on the N59 near Corballa was used to inform the location and duration of classified traffic counts carried out on the local road network.

Observation: This has no relevance to the Local area as this data used (N59 near Corballa) is between 30-35KM away from the proposed site. Also it stated that the TDR has focused on the route from Ballina town to the proposed site (Second and Final Leg) so this data cannot be referenced for the proposed route. Dates of Street views vary significantly so the landscape may be different now compared to the maps.

Calculations

Observation: The total stated construction delivery figure across both tables in Section 17.5.1 is 5,247 loads (4,957 + 290) - this combined figure is not stated explicitly anywhere in the chapter and has to be calculated by the reader.

Observation: I could not find whether 'loads' and 'deliveries' in Chapter 17 represent one-way arrivals only, while a separate part of the same chapter is explicit that staff car trips are counted in both directions. There is no consistency in how calculations are derived or explained. This leads to confusion and could double the figures of the load calculations. Essentially the stated figure could be half of the actual figure. Further clarification needed. If that is the case it is another major oversight.

Observation: The chapter's headline road-capacity figure of '150 movements per day at peak' cannot be transparently reconciled against the individual delivery and staff figures in Table

17.27 - this is the figure actually used to judge whether the R314 can cope with the extra traffic, and its derivation is not shown. This again is a major oversight.

Observation: A discrepancy between chapters exists: the total spoil figure in Chapter 17 (157,785 m2, with an incorrect area unit) does not match the figure used three times in Chapter 2 (157,952 m3, correctly expressed as a volume). This is a major difference. Which is correct and was the correct figures to calculate the proposed development requirements.

Observation: I could not find any metrics stated in any table for the number of loads required for road strengthening and widening from current width to the required 4.5M and 6M clearance. This is a seismic omission and will increase the number of deliveries significantly. A lot of this road widening and strengthening is in bog/soft ground so will take even more fill therefore increasing the number of deliveries and further decimating our road network.

Observation: For the Substation Compound area (see Chapter 2: Development Description, Section 2.6.11) This refers to Transformers and Internal Cabling and has no relevance to the BESS compound.

Observation: Incorrect referencing on this chapter REF:17.4.4 grid connection refers to Sections 2.6.12, 2.6.13 and 2.6.14 for trenching, joint bay, and HDD methodology. However 2.6.12 is Grid connection, 2.6.13 is Barrow Pits and 2.6.14 is Onsite Drainage

Observation: On 6289 Tirawley WF- Planning - Drawing Schedule_Final.pdf it has incorrect referencing to drawings Eg 6289-PL-GR-1201 refers to water coursing along with additional drawings No 6289-PL-GR-1201 to 1214. This is confusing and is there a connection to the area or building that is not fully disclosed.

Observation: The entire traffic baseline for the EIAR relies on a single classified traffic count conducted on Friday 30th June 2023 at one location only (R314/Palmerstown Bridge junction). This count is now three years old. It was conducted on a single day, during summer (June), which the applicant's own TII expansion methodology flags as a non-peak month (an AADT correction factor of 0.96 is applied, reducing the figures). A Friday count in rural Mayo in June does not represent typical weekday construction traffic conditions. Analysing traffic on a Friday is not permitted and contravenes a SIDS application. The traffic report is null and void as a result. This stated clearly No counts were taken on the local road network routes that will carry the majority of HGV deliveries - the L-5177, L-5176, L-1107, L-1110 series roads used by the Construction Haul Route (CHR) and Grid Connection Route (GCR). The applicant confirms no count was taken on these roads, stating only that the Palmerstown Bridge location was 'where all the local road networks converge.' This is not a substitute for actual counts on individual road links that will carry up to 150 HGV movements per day.

Observation: Environmental concerns around the use of Urea on tree stumps. This is applied to the cut surface to prevent fungal disease. The felling is taking place in elevated areas totalling 14,486 tonnes ,will this urea make its way into the water ways causing pollution locally but ultimately journey into Lacken Salt Marsh SAC as this is the catchment basin for the whole Lacken area. I see no plan around this and is of grave concern to the integrity of our SAC.

Observation: There is a significant amount of deer in the area and these may be displaced in the construction stage of the proposed Wind farm.

Observation: Pedestrian Safety was not properly assessed. Road Safety Audit should be required as a condition of any permission, specifically addressing the school zones on the R314/R315. The current treatment does not meet the standard required by TII guidance. This shows a disregard for human safety and is a major oversight.

General Observation

Observation: I noticed in a number of places in Chapter 17 that the address for St Patrick College Lacken Cross has been referred to as the following:

Table 17.9:

St. Patrick's College, Ballina, Co. Mayo

Table 17.10:

St. Patrick's College, Carn, Co. Mayo

The is very misleading and confusing. Why would the developer have two different addresses for the same school located on the same page and in both cases omit Lacken Cross, Killala, Co. Mayo which is the correct address for St Patrick College. It goes back to one of my opening observation that the developer has intentionally omitted the Parish of Lacken in this application, and gives the reader an impression that Lacken is not a place/paris which is completely misleading and false.

Observation: It is estimated that the number of loads required for the proposed development is referred to as 11,022 Deliveries. My interpretation of this is that the figure needs to be double as the HGV /Vehicle needs to return. This is a staggering 22,044 and will be a major inconvenience to all road users for nearly 2 years. This is completely unacceptable for the Residence of Lacken, it will make the simplest of journeys a nightmare. It will absolutely decimate our road network. Disruption and delays like this will be felt all across Lacken and indeed North Mayo. Lacken has strong community spirit and can be seen by the various community groups (listed on the first page of Traffic and Transport observations). All these will be negatively affected . Lacken also has a large number of Dairy farms, strong network of home help, Meals on wheels, Local link bus, An Post/Deliveries, Bin Collection, Mobile Shop, Walking groups, to mention a few and all of these will be negatively affected by the proposed development.

Observation: In relation to the 22,044 trips this will pose a health risk due to the amount of dust that this will cause. This will affect people's health, homes, businesses and buildings.

Observation: The developer states that a road closure will be obtained. This will have a direct impact on residence. It also states that R314 will be closed which is a link for the North Mayo area and will cause major disruption for road users from surrounding areas.

Observation: 17.5.11 Severance is mentioned and dismissed when in fact it is applicable to the proposed development. This is another oversight by the developer. Lacken has 28 town lands surrounding Lacken Strand and Lacken Salt March SAC. The proposed development will cut

off the townlands of Ballynaleck, Barnhill Lower, Barnhill Upper, Barroe, Billoos, Carn, Carrickanass, Carrowmore, Castlelackan Demesne, Castletown, Conaghra, Glebe, Lackanhill, Lecarrowntemple, Lissadrone East and Lissadrone West from Cloonalaghan/Kilcummin/Banagher etc which are located on the East of the parish. Amenities are spread all across the Parish of Lacken so parties the entire parish will be affected. This has not been considered or assessed. Eg Church and Sensory garden are located in Carramore on the west side of the parish and the Lacken Gaa Pitch and Lacken Enterprise Centre are located in Banagher on the east side.

Observation: In 17.6 MITIGATION MEASURES 17.6.1 Construction Phase. The developer states that they will provide a footpath adjacent to the upgraded carriageway where works are being undertaken. This footpath should provide a safe method of permitting pedestrians to access the pre-existing carriageway at the terminations of the works. I have seen no reference to this in drawings or material calculations.

Observation: It is not clearly stated in the proposed development what monitoring will take place of the road network during the construction phase.

Grid Connection Route Observations

Observation: The proposed GCR is all along the Local and regional roads which Mayo Co Co raised concerns about but the developer had not responded to these concerns and that this was not the preferred GCR.

Observation: The Red line proposed site boundary covers the road network (both sides) from the BESS location in Carrickinass to Tawnaghmore. This was raised by Mayo Co Co in a previous meeting that the public road is not part of the proposed site and should not be included in the drawing but this was not done.

Observation: In relation to the proposed excavation. What guarantee will there be that the road surfacing works will be completed adequately. Will the road run into disrepair as only with time and traffic do you see the true settling.

Observation: Naming of 6289-PL-GR-1201 to 6289-PL-GR-1210 is different as described in the chapter compared to the actual report name. This makes it difficult to locate and reference.

Observation: While I can see the Watermains through the 6289-PL-GR series of drawings, what certainty do we have as a Parish that our water supply will not be disrupted or worse create a serious human health risk.

Observation on Palmerstown Bridge Structural Assessment Report

These observations address the Palmerstown Bridge Structural Assessment Report (EIAR Appendix 17.2), prepared by John McElvaney of Jennings O'Donovan & Partners, reviewed by David Kiely, dated 25th January 2023.

The Maintenance Inspection Notes state: 'Fast flowing and deep water made access to closely inspect the abutments and arches unsafe.' The Engineering Inspection Notes states: 'Close inspection of the arches, abutments and piers was not possible on the day of inspection. No obvious defects were observed. We recommend that a close inspection of the underside of the structure is undertaken when water levels are lower.'

Observation: Despite the above the Engineering Inspection's Component Condition Rating table assigns a rating of '1' (Insignificant Damage) to the Abutments, Piers, Arch Barrels and Riverbed - the same rating given to elements that could be properly inspected, such as the bridge surface. This rating of '1' for the abutments, piers and arch barrels is based only on the absence of 'obvious defects' visible from a distance, not on the close inspection the report's own author says was necessary and recommends should be carried out separately. I could find no record of that recommended follow-up inspection appearing anywhere in the application.

Observation: The inspection underlying this report was carried out in January 2023, when the project was configured differently from the current, final 16-turbine, BESS-inclusive design. Given the bridge's own inspector identified unresolved inspection gaps (Finding PB1) and explicitly recommended a follow-up inspection, and given more than three years have passed without any apparent update, the structural basis for concluding this bridge can safely carry the construction traffic of the current, final development design is itself outdated

Observation: The report states 'The carriageway width between the parapets is 4.6m. This should be checked against any abnormal delivery loads to confirm if it is sufficient. Abnormal loads for the delivery of turbine components have been assessed in the Turbine Delivery Route Report. If so will this be individually checked against Palmerstown Bridge's calculated 22.5 tonne axle capacity, rather than relying on the general 'standard roadworthy vehicles' conclusion in this report Eg. Will a 100-tonne crane or other abnormal loads have been individually checked against this specific bridge's calculated capacity.

Observation: I can see no reference to any collision assessment at Palmerstown bridge where cars have struck the parapet walls at speed at either end causing significant damage. Given a structure of this age and construction type (masonry arch, stone parapets) could in principle suffer cumulative or progressive weakening from repeated vehicle impacts even where each individual repair appears successful, the absence of any collision history review is a gap, particularly given a significant increase in construction-phase traffic volume is proposed for this exact route. Is this structure comprised at present?

Observation: This report does not include a formal water mark survey or scour assessment for a masonry arch bridge's foundations, abutments and piers - elements that are particularly vulnerable to scour damage from watercourse flow. Given the report's own stated reason for being unable to closely inspect these exact elements was 'fast flowing and deep water,' a proper understanding of this watercourse's normal and extreme flow/water level range would be directly relevant context for assessing both the inspection limitation and the underlying scour risk to the structure - and is not provided.

Observation: EIAR Chapter 2 confirms Palmerstown Bridge is also a Grid Connection Route HDD crossing point, in addition to its role as a Construction Haul Route. This Structural Assessment Report, dated January 2023, addresses only vehicle axle loading via the MEXE method and makes no reference anywhere to the HDD works, their depth, proximity to the bridge foundations, or any risk to structural integrity from underground drilling near a structure whose foundations and abutments could not be closely inspected. This omission also ties in with the Development Description and Cultural Heritage chapter, which noted that generic

HDD mitigation measures used elsewhere in the EIAR contain no provisions specific to this Protected Structure.

Conclusion

The statement of significance is completely false, it states "This assessment has identified that the potential effects of the Proposed Development on traffic and transport are considered to be not significant, given the mitigation measures embedded in the design of the Proposed Development. Chapter 17 Traffic and Transport has a litany of serious errors and omissions. The quality of this chapter is substandard for any planning application let alone a SID. The documents have been signed off by individuals with over four decades of experience which is even more staggering.

This chapter cannot be relied upon as a robust basis for decision-making. The TDR,CHR and GCR assessments all contain significant omissions, outstanding audits, and incorrect calculations which materially undermine its conclusions regarding traffic generation, abnormal load deliveries, road network capacity, and road safety impacts. The cumulative effect of these deficiencies is that the true scale and extent of the transport impacts have not been adequately identified, assessed, or mitigated. In the absence of a comprehensive, transparent, and technically sound assessment, one cannot be satisfied that the proposed development would not adversely affect the safety, efficiency, and operation of the local and strategic road network. I urge you to refuse this application on these grounds.

LANDSCAPE AND VISUAL AMENITY

Introduction

The Landscape and Visual Amenity assessment presented in Chapter 12 of the EIAR concludes that the proposed Tirawley Wind Farm will not result in significant effects on landscape and visual amenity. However, a detailed review of the chapter reveals a number of inconsistencies, omissions and methodological concerns that call this conclusion into question.

The proposed development comprises sixteen turbines with a blade tip height of 135 metres located on elevated terrain overlooking the north Mayo coastline. The development would be visible across a wide geographical area and would introduce large-scale industrial infrastructure into a landscape of recognised archaeological, cultural, tourism and community importance.

This review identifies concerns relating to the study area methodology, impacts on heritage and community amenities, cumulative effects, forestry removal, viewpoint selection and the overall conclusions reached by the applicant.

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1 Study Area and Zone of Theoretical Visibility

The EIAR confirms that the proposed turbines will have a blade tip height of 135 metres and that no flexibility in turbine dimensions is sought. The assessment therefore represents the maximum turbine size proposed rather than a worst-case scenario amongst alternative turbine models.

The Wind Energy Development Guidelines require a minimum study radius of 20 kilometres for turbines exceeding 100 metres in height and indicate that a radius of up to 25 kilometres should be considered where landscapes of national or international importance are present.

The applicant has limited the Zone of Theoretical Visibility (ZTV) study area to 20 kilometres on the basis that there are no landscapes of national or international importance requiring assessment beyond this distance. However, elsewhere within the same chapter, the applicant describes the Céide Fields as containing "the oldest known field patterns globally", thereby acknowledging their international significance.

This creates a clear inconsistency within the assessment methodology. If the landscape surrounding the Céide Fields is accepted as being of international significance, there is a legitimate question as to whether the assessment should have extended to the 25-kilometre study radius recommended by the Guidelines.

The decision to restrict the study area may therefore have excluded additional viewpoints, receptors and communities from assessment and undermines confidence in the robustness of the visual impact analysis.

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2 Impact on the Lacken Gazebo

The Lacken Gazebo is one of the closest heritage viewpoints assessed in the EIAR and is identified as Viewpoint VP36. The viewpoint lies approximately 300 metres from Turbine AT16 and is located on elevated ground overlooking the surrounding landscape.

The applicant's own assessment classifies receptor sensitivity at this location as "High-Medium" and concludes that the residual significance of effect will be "Substantial-Moderate". This represents one of the highest impact ratings assigned to any heritage or amenity receptor within the chapter.

The EIAR acknowledges that the turbines will create a marked increase in built development within the view and that there will be a detrimental effect on the visual setting of this historic landmark.

Despite this finding, the overall conclusions of the chapter state that impacts on heritage and amenity receptors are not significant. The substantial adverse effect identified at the Gazebo is effectively diluted within the broader summary because the assessor places emphasis on the fact that the principal viewing direction from the structure faces away from the proposed turbines.

This approach is difficult to reconcile with the applicant's own assessment findings. A heritage feature located only 300 metres from two large industrial turbines and experiencing a "Substantial-Moderate" residual impact should be recognised as a significant landscape and visual effect in its own right.



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3 Omission of Lacken Hill Cemetery

A significant omission within the EIAR is the absence of any assessment of Lacken Hill Cemetery, including both the old and new cemetery areas.

The chapter includes numerous cemeteries and graveyards as representative viewpoints, including:

- Kilbride Graveyard
- Lacken Old Graveyard
- Templemurry Graveyard
- Killala Cemetery
- Moygownagh New Cemetery
- St. Tiernan's Cemetery, Crossmolina

Several of these locations are situated between 5 and 15 kilometres from the proposed turbines.

In contrast, Lacken Hill Cemetery, which is actively used by the local community for funerals, memorial services and religious observances and is located in close proximity to Turbines AT15 and AT16, was not selected as a viewpoint and receives no assessment whatsoever.

The omission is particularly difficult to justify given that more distant cemeteries were considered worthy of detailed visual assessment. As a result, there is currently no information available regarding the impact that the proposed development may have on visitors attending funerals, memorial services, cemetery visits or outdoor religious ceremonies at this location.

Given its community importance and proximity to the proposed turbines, Lacken Hill Cemetery should have been included as a representative viewpoint and should be assessed through photomontages and detailed visual analysis before any decision is made on the application.

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4 Impact on the Céide Fields and Downpatrick Head

The EIAR confirms that the proposed turbines will be visible from both the Céide Fields and Downpatrick Head, two of the most important tourism and heritage destinations in north Mayo.

The nearest turbine lies approximately:

- 10.6 kilometres from the Céide Fields viewpoint.
- 5.9 kilometres from the Downpatrick Head viewpoint.

The assessment repeatedly downplays the significance of these effects on the basis that visitors are assumed to be looking primarily towards the Atlantic coastline rather than inland towards the turbines.

This assumption is questionable. Visitors do not experience landscapes from a single fixed direction and routinely view their surroundings from multiple vantage points. The fact that turbines may not lie directly within the primary viewing axis does not remove their presence from the wider landscape experience.

Given the international importance of the Céide Fields and the iconic status of Downpatrick Head within the Wild Atlantic Way, visibility of the development from these locations should be given greater weight than appears to have been afforded within the EIAR.

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5 Extent of Visibility

The assessment confirms visibility of the proposed development throughout large areas of County Mayo and into County Sligo.

The inclusion of the Enniscrone viewpoint confirms cross-county visibility into Sligo. However, the assessment is limited by the developer's chosen 20-kilometre study radius.

Given the combination of:

- 135-metre-high turbines,
- elevated site topography,
- coastal location,
- open Atlantic views, and
- extensive unobstructed sightlines,

it is entirely plausible that the turbines may be visible well beyond the assessed study area during clear weather conditions.

The EIAR provides no assessment of visibility from more distant elevated locations and therefore cannot either confirm or dismiss the possibility of longer-range visual impacts.

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6 Cumulative Landscape and Visual Effects

One of the most significant concerns arising from Chapter 12 relates to cumulative impact.

The applicant identifies sixteen separate wind energy developments within the cumulative study area, including existing, permitted, proposed and pre-planning projects.

The cumulative assessment demonstrates that:

- 68.9% of the study area is affected under the current cumulative scenario.
- 74.6% of the study area is affected under the future cumulative scenario.

The future scenario includes major developments such as Glenora and Keerglen in addition to the proposed Tirawley Wind Farm.

The applicant's own assessment classifies the cumulative magnitude of effect as "High-Medium".

This finding is highly significant. A High-Medium cumulative magnitude, when applied through the significance matrices used throughout the EIAR, would ordinarily indicate a major landscape impact.

However, despite this finding, the chapter concludes that no significant landscape and visual effects will arise.

The conclusion does not appear consistent with the evidence presented elsewhere within the chapter. The cumulative transformation of the north Mayo landscape resulting from over 200 existing, approved or proposed turbines cannot reasonably be characterised as insignificant.

The cumulative impact findings should therefore be given independent weight by An Coimisiún Pleanála rather than relying solely on the chapter's summary conclusions.

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7 Forestry Felling and Landscape Change

The proposed development requires the removal of approximately 31.86 hectares of mature coniferous forestry.

While this figure is acknowledged within the development description, the EIAR does not undertake any standalone assessment of the visual or landscape consequences arising from the forestry removal itself.

This represents a notable gap in the assessment.

The existing forestry currently:

- contributes to landscape character,
- provides visual screening,
- influences views from surrounding receptors, and
- reduces visibility of infrastructure from several directions.

The removal of such a substantial area of forestry has the potential to alter the character of the landscape independently of the turbines themselves and may increase turbine visibility from locations that are currently screened.

No assessment has been provided to determine these effects.

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8 Assessment Methodology

The cumulative assessment methodology relies partly on guidance published by NatureScot, the Scottish Government's nature agency.

While the use of international guidance is not necessarily inappropriate, the EIAR does not explain why Scottish guidance was selected or whether Irish-specific guidance was considered.

Similarly, while the photomontages are described as verifiable visualisations, the chapter does not provide sufficient information regarding camera settings, focal lengths, viewing distances or other technical parameters necessary to independently verify whether the visualisations accurately represent the scale and dominance of 135-metre turbines within the landscape.

This is particularly relevant for viewpoints located in close proximity to the turbines, including the Gazebo and nearby residential receptors.

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9 Conclusions

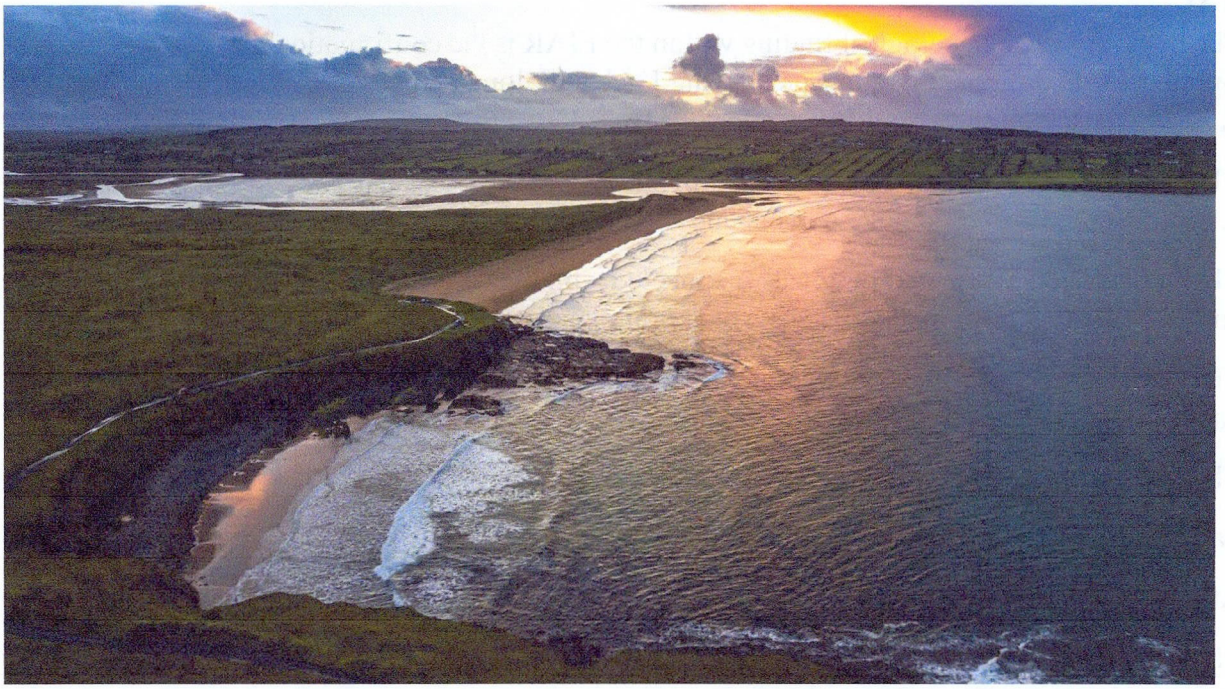
The conclusions presented in Section 12.7 of the EIAR do not appear to reflect a number of significant findings identified elsewhere in the chapter.

In particular:

- The Gazebo experiences a "Substantial-Moderate" residual visual impact.
- The cumulative future scenario is assigned a "High-Medium" magnitude of effect.
- Lacken Hill Cemetery has not been assessed despite its proximity to the turbines.
- The visual consequences of removing 31.86 hectares of forestry have not been evaluated.
- The justification for limiting the study area to 20 kilometres appears inconsistent with the chapter's own recognition of the international significance of the Céide Fields landscape.

Taken together, these issues raise serious concerns regarding the robustness of the landscape and visual assessment and undermine confidence in the conclusion that the proposed development will not result in significant effects on landscape and visual amenity.

For these reasons, An Coimisiún Pleanála should not accept the conclusions of Chapter 12 at face value and should require the applicant to address the identified omissions, inconsistencies and methodological shortcomings before any determination is made on the application.



BIODIVERSITY, ECOLOGY AND NATURE CONSERVATION

Introduction

This chapter addresses the biodiversity, ecological and nature conservation issues arising from the proposed Tirawley Wind Farm development as assessed within Chapter 6 of the Environmental Impact Assessment Report (EIAR), together with the supporting Bat Survey Report (Appendix 6.2), Aquatic Ecology Assessment (Appendix 6.3), Biodiversity Enhancement and Management Plan (Appendix 6.4), and Note on the Lifespan of Baseline Ecological Survey Data (Appendix 6.5).

Having reviewed the EIAR documentation in detail, a number of significant concerns arise regarding hydrological connectivity to designated European sites, the currency of ecological survey data, cumulative ecological effects, bat impacts, protected species, invasive species management, construction timing restrictions and water quality protection.

While the EIAR concludes that significant adverse ecological impacts can be avoided through mitigation measures, a number of important uncertainties and omissions remain. These matters should be fully addressed before any planning decision is made.

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1 Hydrological Connectivity to the Lackan Saltmarsh and Kilcummin Head SAC

The most significant ecological finding within the EIAR is the confirmation that the wind farm site itself is hydrologically connected to the Lackan Saltmarsh and Kilcummin Head Special Area of Conservation (SAC) (Site Code 000516).

Chapter 6, Section 6.3.2.1 and Table 6.4 of the EIAR state that the SAC lies approximately 1.2km from the proposed development and that:

"The Wind Farm Site is hydrologically connected with Lackan Bay via the Cloonalaghan River and several other small watercourses which drain the east of the site."

The EIAR further concludes that hydrological connectivity exists between the wind farm site and the SAC.

This SAC is designated for habitats including:

Salicornia and other annuals colonising mud and sand;

Atlantic salt meadows;

Mediterranean salt meadows;

Fixed coastal dunes; and

Shifting coastal dune systems.

These are precisely the habitats that local communities have identified as being potentially vulnerable to sedimentation, pollution and hydrological change arising from construction activities.

The EIAR also confirms hydrological connectivity between the Grid Connection Route and the Killala Bay/Moy Estuary SAC through the Cloonaghmore River catchment.

While Chapter 6 acknowledges these connections, the detailed assessment of impacts on these Natura 2000 sites is deferred to the Appropriate Assessment Screening Report and Natura Impact Statement (NIS). Given the direct hydrological pathway identified by the applicant's own consultants, the findings of the AA Screening and NIS should be subjected to detailed scrutiny by An Coimisiún Pleanála.

The existence of a direct hydrological connection between the wind farm site and the Lackan Saltmarsh SAC represents one of the clearest ecological impact pathways identified anywhere within the application.

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2 Bovine Tuberculosis Outbreak and Badger Activity

The EIAR contains no reference whatsoever to the ongoing bovine tuberculosis (bTB) issues that have affected the Billoos/Barnhill area in recent years.

This omission is noteworthy given the documented presence of badgers within the wider study area and the acknowledged role of badgers in national bTB management programmes.

Chapter 6 confirms evidence of badger activity through road mortality records and concludes that badgers are present within the wider area, despite no setts being identified within 100m of proposed infrastructure.

However, the badger surveys relied upon were undertaken between 2022 and 2024 and do not appear to consider any active disease management operations that may have subsequently altered badger distribution, behaviour or population density.

The Department of Agriculture's badger control and disease management activities are dynamic and may significantly influence local badger populations. Such information is directly relevant to the accuracy and currency of the ecological baseline used to assess impacts on protected mammal species.

Given the acknowledged presence of badgers and the existence of recent disease management activity within the locality, the applicant should be required to demonstrate that the ecological baseline remains valid and up to date.

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3 Ecological Survey Data Currency

A significant concern arises regarding the age of the ecological survey data relied upon throughout the EIAR.

Section 6.2.7.6 explicitly acknowledges that many terrestrial ecology and ornithology surveys commenced in 2021 and were largely completed by winter 2023/2024. The chapter further states that portions of the ecological dataset are approaching or exceed three years in age, with reference to the Chartered Institute of Ecology and Environmental Management (CIEEM) guidance on the lifespan of ecological surveys.

The CIEEM Advice Note on the Lifespan of Ecological Reports and Surveys (2019) recognises that many ecological datasets require revalidation within one to three years depending on habitat type, species sensitivity and site conditions.

The applicant's proposed response to this issue is not to update the baseline prior to determination but rather to undertake confirmatory surveys before construction.

This approach effectively asks the planning authority to determine the application on the basis of ecological information that the applicant itself acknowledges may be outdated.

Given the scale of the proposed development, including:

16 wind turbines;

extensive excavation works;

approximately 31.86 hectares of forestry felling;

battery energy storage infrastructure; and

over 9km of new access tracks,

it would be more appropriate for updated ecological surveys to be completed before any planning decision is made.

---

4 Bat Impacts and Operational Curtailment

The bat assessment identifies five bat species within the site:

Common Pipistrelle;

Soprano Pipistrelle;

Leisler's Bat;

Brown Long-eared Bat; and

Natterer's Bat.

Importantly, the EIAR concludes that nine of the sixteen proposed turbines require operational curtailment because of bat activity and collision risk.

A further three turbines require curtailment as an alternative to habitat modification.

This means that twelve of the sixteen turbines, representing approximately 75% of the proposed wind farm, require some form of bat-related operational restriction.

The proposed mitigation strategy involves a blanket curtailment regime during the initial operational years, followed by post-construction monitoring to determine whether a less restrictive smart-curtailment regime can subsequently be adopted.

This approach implicitly acknowledges that substantial uncertainty remains regarding actual bat mortality rates once turbines become operational.

The requirement for such extensive curtailment demonstrates that the site is a highly active bat landscape. While mitigation may reduce mortality risk, it cannot eliminate uncertainty regarding long-term impacts on local bat populations.

The applicant's own proposal to undertake several years of post-construction monitoring reflects this uncertainty and highlights the need for robust and enforceable mitigation measures.

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5 Protected Species at the AT15 and AT16 Quarry Site

Particular concern arises regarding the ecological value of the disused quarry where turbines AT15 and AT16 are proposed.

The EIAR confirms the presence of a common lizard population within the quarry. The assessment states that this population is likely to be confined largely to this location.

The chapter also acknowledges that smooth newt may occur within the permanent ponds located within the quarry, although targeted surveys have not confirmed its presence.

The quarry contains a diverse habitat mosaic including:

permanent ponds;

willow scrub;

gorse habitat;

exposed rock surfaces; and

transitional vegetation communities.

The concentration of ecological features within this single location means that the siting of turbines directly within the quarry raises particular concerns regarding habitat loss and disturbance.

Given that the applicant itself considers newt presence plausible, a dedicated amphibian survey should be undertaken to properly establish whether protected amphibian populations occur within the quarry before any planning determination is made.

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6 Invasive Species and Japanese Knotweed

The EIAR references Japanese Knotweed within the wider area but relies upon a record dating from 2015 at Carrowcor.

No current assessment appears to have been undertaken specifically for the Billoos area despite local reports of ongoing infestations.

This issue is particularly important given that:

road widening works are proposed;

extensive excavation and trenching activities will occur;

construction haul routes pass through the wider area; and

Japanese Knotweed is regulated under the Third Schedule of the European Communities (Birds and Natural Habitats) Regulations 2011.

Construction activities are recognised pathways for the spread of invasive species if appropriate controls are not implemented.

The absence of a current, site-specific assessment of knotweed occurrence in areas directly affected by construction works represents a gap in the baseline information.

---

7 Cumulative Biodiversity Effects

The cumulative effects assessment contains one of the most significant figures identified during review of the application.

The EIAR confirms that there are already 201 operational, consented or proposed wind turbines within a 20km radius of the site.

The proposed Tirawley Wind Farm would increase this total to 217 turbines.

Despite this substantial concentration of wind energy development, the cumulative assessment is focused primarily on hydrological pathways and effects on European sites.

While hydrological impacts are important, cumulative ecological impacts are not limited to water quality pathways.

Potential cumulative impacts also include:

bat mortality;

bird collision risk;

bird displacement;

habitat fragmentation;

barrier effects; and

cumulative disturbance across wider ecological networks.

These pathways are not assessed in the same level of detail as hydrological impacts despite the acknowledged scale of existing wind energy development in North Mayo.

Given the number of existing and proposed turbines within the region, a more comprehensive cumulative biodiversity assessment is warranted.

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8 Céide Fields and Blanket Bog Connectivity

The biodiversity chapter contains no reference to the wider Céide Fields landscape.

While the Céide Fields is principally considered within cultural heritage assessments, it is also intrinsically linked to the blanket bog habitat that has preserved the archaeological landscape for millennia.

Chapter 6 itself acknowledges that intact blanket bog is now scarce within the wind farm area.

The relationship between the remaining blanket bog resource and the wider Céide Fields landscape therefore warrants greater consideration, particularly in light of extensive forestry felling and habitat alteration proposed within the development area.

If ecological or hydrological connectivity exists between blanket bog habitats within the study area and the wider Céide Fields landscape, this should be explicitly acknowledged and assessed.

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9 Construction Timing and Protection of Breeding Birds

While the EIAR includes species-specific mitigation measures, a clear and binding commitment restricting vegetation clearance and forestry felling during the bird breeding season is not readily identified within the construction phase mitigation.

The decommissioning phase specifically references avoiding sensitive ecological periods, yet an equivalent commitment is not clearly stated for the construction phase.

Given that the development proposes:

approximately 32 hectares of forestry felling;

substantial vegetation clearance;

hedgerow removal; and

extensive construction activity,

a legally enforceable restriction preventing vegetation clearance during the bird breeding season should be imposed.

This would be consistent with obligations arising under the Wildlife Acts 1976–2023 and established ecological best practice.

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10 Existing Water Quality and Contamination Risk

The aquatic ecology assessment confirms that a number of local watercourses are already experiencing ecological pressures arising from agricultural activities.

One monitored site near Lacken Cross was classified as heavily impacted by agricultural pollution and recorded no fish populations.

Several other monitored locations were classified as moderately polluted.

These findings are significant because degraded watercourses have reduced capacity to absorb additional pressures from construction activities.

Although the mitigation measures proposed by the applicant are standard industry measures, including:

silt fencing;

spill kits;

exclusion zones;

drip trays; and

sediment controls,

the effectiveness of such measures becomes increasingly important where receiving watercourses are already under environmental stress.

Enhanced protections should therefore be considered for construction activities draining towards watercourses already identified as being in poor ecological condition.

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11 Conclusion

The biodiversity assessment identifies several important ecological constraints within and around the proposed development site. The most significant findings are the confirmed hydrological connectivity between the wind farm site and the Lackan Saltmarsh and Kilcummin Head SAC, the acknowledged ageing of baseline ecological survey data, the extensive bat curtailment requirements affecting 75% of proposed turbines, and the absence of a comprehensive cumulative biodiversity assessment despite the existence of 201 turbines within a 20km radius.

Taken together, these matters create significant uncertainty regarding the adequacy of the ecological assessment and the effectiveness of the mitigation measures proposed. Given the sensitivity of the receiving environment, the proximity of European sites, and the scale of the development proposed, the precautionary principle should apply. Additional survey work, updated baseline information and more comprehensive cumulative assessment should be required before any planning determination is made.

Marsh Fritillary Butterfly – Additional Records and Survey Adequacy

The submission of Brian and Jessie Brogan provides important new biodiversity information that was not reflected in the EIAR baseline data. Their observations record three separate confirmed sightings of Marsh Fritillary (*Euphydryas aurinia*) within the vicinity of the proposed development area during June 2026, including multiple individuals observed at Conaghra/Knockboha and Castlelackan Demesne. The observations are supported by photographic evidence and identify areas containing suitable habitat, including species-rich verges, rough grassland, meadow habitat, wet ditches and areas supporting forage plants associated with the species.

Marsh Fritillary is listed on Annex II of the Habitats Directive and is one of Ireland's most important protected invertebrate species. The confirmed presence of adults in multiple locations within the wider development area indicates that suitable habitat exists and raises the possibility that breeding habitat may also be present. These records were obtained after completion of much of the EIAR survey work and therefore represent material ecological information that was not available to the applicant's assessment.

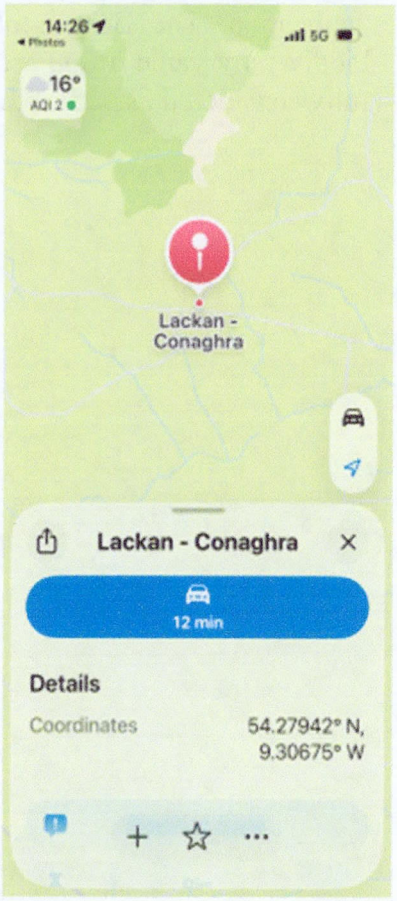
The existence of these records calls into question whether the full extent of suitable Marsh Fritillary habitat within and adjacent to the proposed development footprint has been identified,

surveyed and assessed. This is particularly relevant given the scale of habitat disturbance proposed, including extensive forestry felling, road construction, drainage works, excavation, spoil deposition and other ground disturbance activities. In the absence of targeted follow-up surveys to determine the distribution of breeding habitat and the significance of the local population, it cannot be concluded with certainty that the proposed development would not adversely affect this protected species.

Applying the precautionary principle, An Coimisiún Pleanála should require further dedicated Marsh Fritillary surveys and habitat assessments before any decision is made on the application. The Brogan observations constitute credible, site-specific evidence that the biodiversity value of the area may be greater than that presented in the EIAR and should be fully considered as part of the Board's assessment.

1. First siting was on Sunday 14th June 2026 involving four individuals at Conaghra/Knockboha.
Marsh Fritillary Butter is very weather sensitive, but the midday heat brought them out and made them active along the Western Way at Conaghra as well as round onto Knockboha Road. The breeze stopped them settling or resting with wings open. I tracked the individuals foraging on their preferred wild plants which grow in abundance here in the deep verges, for nearly the entire length of the road.I only managed to keep on the trail and get close enough to this one when it eventually settled within reach, on a Meadow Thistle on the Knockboha Road. This road also has an abundance of forage plants particularly tormentil at this time of year and ragged robin, and is close to a rough pasture likely, suitable for Devils-bit-Scabious, which could be professionally surveyed by NPWS.





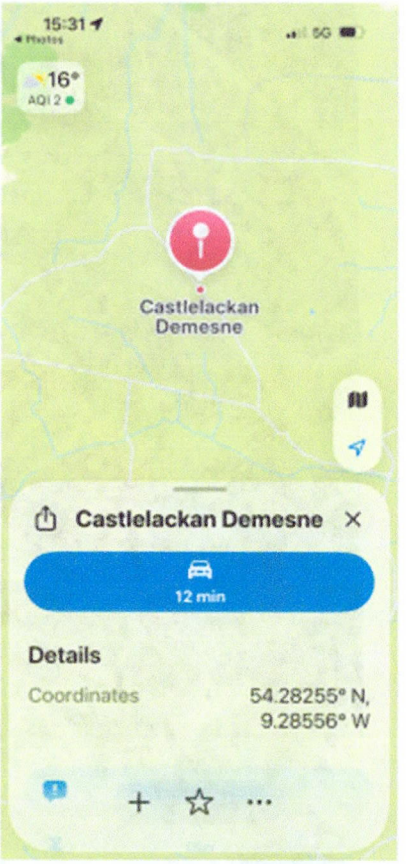


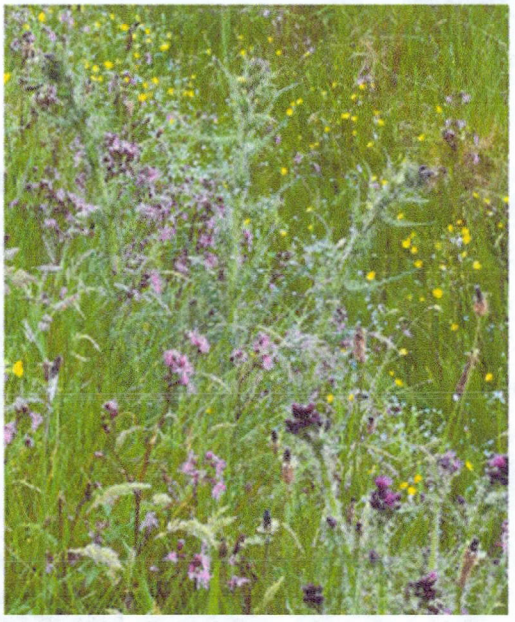


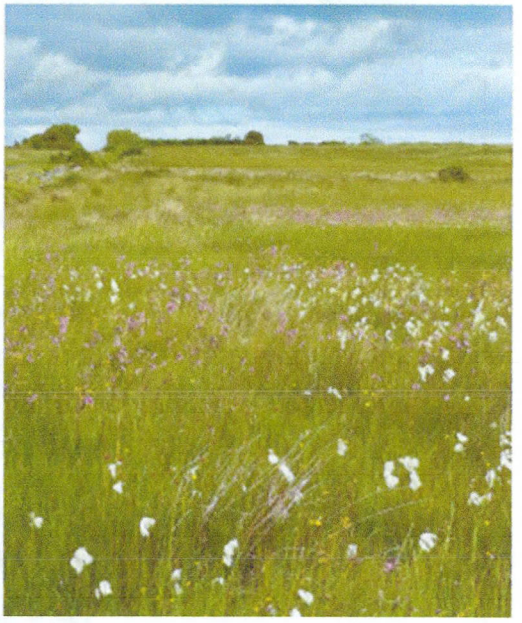
2. Second confirmation of Marsh Fritillary Butterfly was on Friday 19th June 2026 on the Lacken Trail in Castlelackan Demesne.

Again, with this location, there are excellent verges, flora filled ditches adjacent or close to meadows abundant with Marsh Fritillary's preferred forage plants. I have seen adults at distance on good days earlier in the month but this is the first time I had luck with a close photo capture for confirmation.

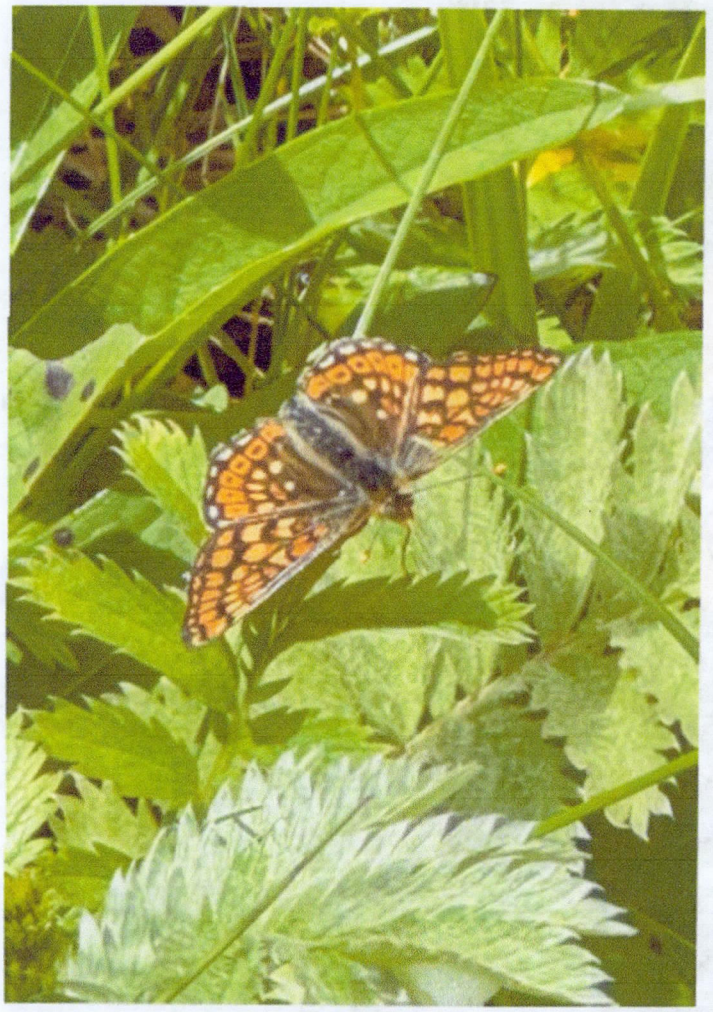




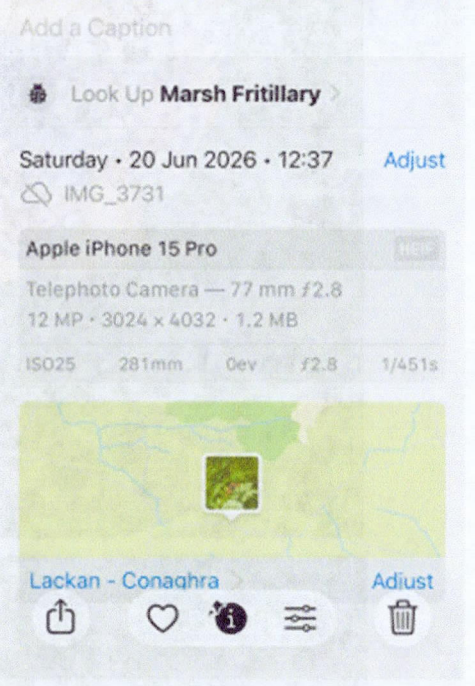


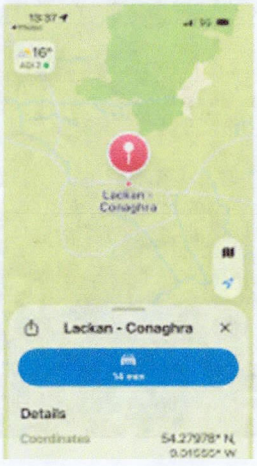


3. Observation number three of Marsh Fritillary was Saturday 20th June 2026 .We went up to the Conaghra western way and Knockboha Road to see if the adults were still present, which they were, though only two adults this time and photographed both, one with a Small Heath Butterfly- also heat sensitive species, resting beside it.











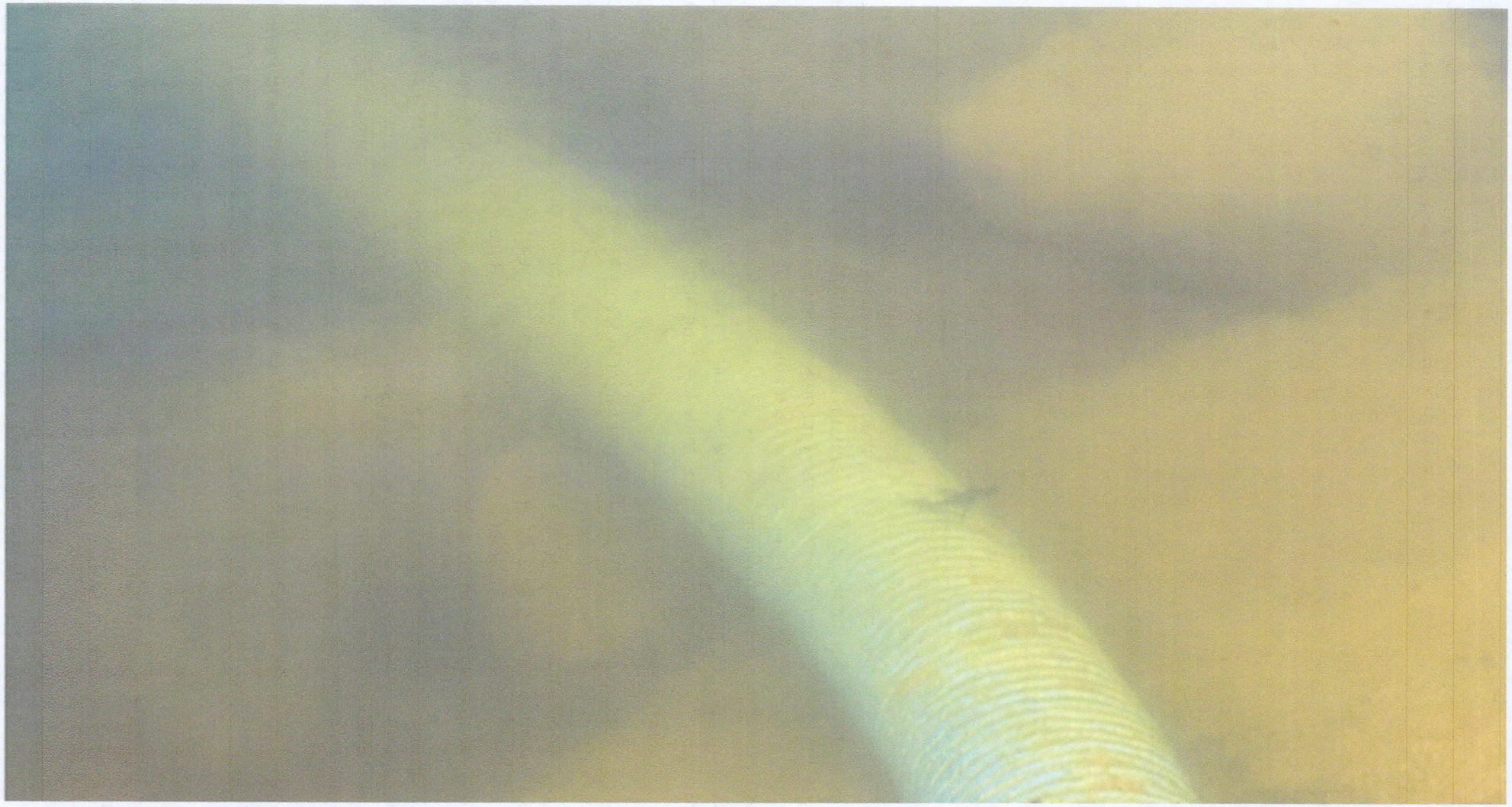
Amphibian Record at Castlelacken Quarry Pond

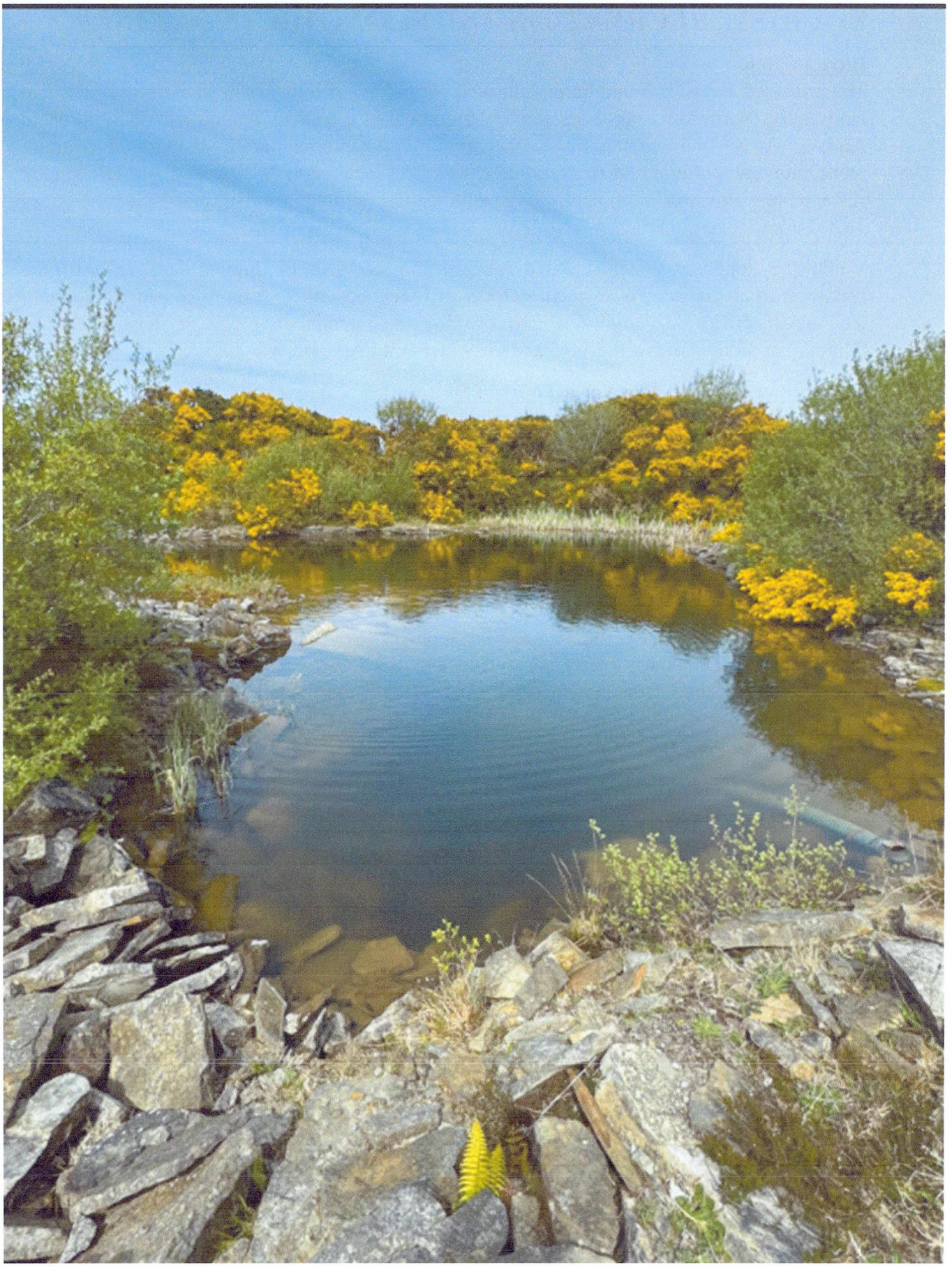
In addition to the concerns raised elsewhere in this submission regarding biodiversity survey coverage, a local resident has reported the presence of a newt within a pond located in the former quarry area at Castlelackan. Photographic evidence has been obtained and is included for consideration. The record is noteworthy because it indicates the potential presence of amphibians within the development area and demonstrates that ponds and associated wetland habitats may support a greater diversity of species than is reflected in the EIAR.

Amphibians are particularly sensitive to changes in water quality, hydrology, drainage patterns, habitat fragmentation and construction disturbance. The reported presence of a newt raises questions as to whether sufficient targeted amphibian surveys were undertaken to establish a complete ecological baseline for the site. Given the scale of the proposed development, including extensive excavation works, forestry felling, drainage modifications, road construction and associated infrastructure, it is essential that all aquatic and wetland habitats are properly assessed before any decision is made.

This record should not be viewed in isolation. It forms part of a wider pattern of biodiversity observations made by local residents which appear to identify species and ecological features not fully reflected in the EIAR surveys. These include the recent Marsh Fritillary observations submitted by Brian and Jessie Brogan, additional local bird records and evidence of increasing hen harrier activity in the area. Collectively, these observations suggest that the biodiversity baseline presented within the EIAR may not fully capture the ecological value of the site or the species currently utilising it.

In accordance with the precautionary principle, An Coimisiún Pleanála should require further targeted ecological investigations of the Castlelackan quarry pond and other wetland habitats within the development area to determine whether amphibian populations are present and whether additional mitigation or avoidance measures are required. Where credible evidence exists that protected or otherwise ecologically significant species may occur within a site, uncertainty should not be interpreted in favour of development but should instead trigger further assessment before consent is considered.





TOURISM, RECREATION AND ECONOMIC IMPACTS

Introduction

The proposed Tirawley Wind Farm is located within one of Ireland's most significant tourism landscapes. North Mayo has been actively promoted as a premier destination along the Wild Atlantic Way and contains a concentration of internationally recognised natural, archaeological, cultural and recreational assets. The local economy increasingly relies upon sustainable tourism development, outdoor recreation, heritage tourism and landscape-based visitor experiences.

While the applicant concludes that tourism impacts will be limited, a review of the Environmental Impact Assessment Report (EIAR), consultee responses and community feedback identifies substantial concerns regarding the potential effects of this development on the tourism product of North Mayo and the wider Wild Atlantic Way region.

Importance of North Mayo as a Tourism Destination

The EIAR itself acknowledges the exceptional tourism value of North Mayo. Chapter 5 describes the region as a destination that embodies the "wildness" of the Wild Atlantic Way and highlights the area's internationally significant attractions, including the Céide Fields, Downpatrick Head Signature Discovery Point and the Western Way Walking Trail.

The EIAR further notes that the area contains an exceptional combination of scenic landscapes, archaeological heritage, cultural traditions and coastal environments that collectively form the basis of the local tourism economy.

Of particular significance is the ongoing development of the Céide Coast Experience, a major tourism initiative intended to create a world-class 15-kilometre coastal trail linking the Céide Fields Visitor Centre with Downpatrick Head. This project has already received planning approval and funding support and is expected to significantly increase visitor numbers to North Mayo in the coming years.

The proposed wind farm would be situated within the landscape setting of these tourism assets and would introduce a large-scale industrial development into an area currently marketed on the basis of its natural scenery, archaeological significance and undeveloped coastal character.

Conflict with Tourism Policy Objectives

The Mayo County Development Plan 2022–2028 promotes sustainable tourism development while requiring the protection of environmental quality, Natura 2000 sites, residential amenity and visual amenity.

Similarly, Mayo's tourism strategies seek to expand tourism opportunities throughout the county, extend the visitor season and encourage visitors to explore areas beyond traditional tourism hubs. North Mayo has been identified as a key area for future tourism growth due to its unique landscape and heritage assets.

The introduction of sixteen industrial-scale wind turbines, associated infrastructure, extensive forestry removal, a battery energy storage system (BESS), substation and associated road works is fundamentally at odds with these objectives. Rather than enhancing the area's tourism appeal, the development risks undermining the very characteristics that attract visitors to the region.

Visibility from Tourism Assets and Scenic Routes

One of the most significant concerns identified within the application documentation relates to the visibility of the development.

Mayo County Council noted that the proposed site is highly visible from several designated Discovery Points along the Wild Atlantic Way touring route. The Council further stated that the large-scale and highly visible nature of the development has the potential to negatively impact the unique coastal landscape and sensitive natural environment of the area.

These concerns are particularly important given that landscape quality is a primary tourism asset in North Mayo. Visitors are attracted to the area because of its open coastal vistas, undeveloped horizons, archaeological landscapes and sense of remoteness. The introduction of turbines with a tip height of 135 metres would permanently alter many of these views and could diminish the visitor experience associated with the Wild Atlantic Way and related tourism initiatives.

Mayo County Council's Position

The concerns raised by Mayo County Council are particularly noteworthy.

In its consultation response, the Council highlighted the exceptional scenic, archaeological and cultural significance of Ballycastle, the Céide Coast and Downpatrick Head. It concluded that the visual sensitivity of the area and the importance of its coastal landscapes render the location unsuitable for a development of this nature.

The Council explicitly stated that it does not consider the proposal suitable at this location due to the visual sensitivity of the receiving environment.

This position carries considerable weight given the Council's responsibility for tourism development, landscape protection and implementation of local planning policy.

Community Concerns Regarding Tourism and Recreation

Community consultation undertaken by the applicant recorded concerns from residents regarding impacts on local amenities, tourism infrastructure and recreational facilities.

Residents highlighted the importance of local recreational assets and expressed concerns regarding the effect of the development on tourism-related amenities. Requests for enhanced local walking routes and recreational opportunities further demonstrate the value placed by the community on tourism and outdoor recreation.

While the applicant argues that road upgrades may improve sections of the Western Way and other routes, such infrastructure improvements do not address concerns regarding landscape degradation and visual intrusion. Improved road surfaces cannot compensate for the industrialisation of a landscape that forms a core part of the tourism product being promoted throughout North Mayo.

Potential Economic Consequences

Tourism supports accommodation providers, hospitality businesses, retailers, activity operators and numerous indirect services throughout North Mayo and the wider region.

The tourism offering in this area is heavily dependent on landscape quality, heritage assets and the perception of an unspoilt natural environment. Any reduction in visitor numbers, visitor

satisfaction or destination attractiveness has the potential to generate wider economic consequences for local businesses and communities.

The EIAR itself references visitor attitude surveys which found that a proportion of visitors consider wind farms to have a negative influence on tourism experiences. While responses vary, the findings demonstrate that wind farms can influence destination perceptions and should not be dismissed as having no tourism implications.

Given the scale of the proposed development and its location within one of Ireland's most sensitive tourism landscapes, a precautionary approach is warranted.

Traffic Impacts on Tourism

The development would also generate substantial construction traffic, including abnormal loads and associated road modifications.

Mayo County Council has highlighted concerns regarding the scale of these transport operations and the challenges associated with managing their impacts on local infrastructure and activities.

Road closures, traffic management measures, delays and disruption during construction have the potential to affect visitors travelling along tourism routes and accessing key attractions. Such impacts could damage the visitor experience during the construction phase and negatively affect tourism-dependent businesses.

Conclusion

The evidence contained within the EIAR, consultee responses and community feedback demonstrates that the proposed Tirawley Wind Farm would be located within an exceptionally sensitive tourism landscape that forms a critical component of the North Mayo economy.

The development would introduce a highly visible industrial-scale project into the setting of internationally recognised tourism assets including the Céide Fields, Downpatrick Head, the Western Way and the emerging Céide Coast Experience. Both Mayo County Council and Fáilte Ireland have recognised the importance of carefully assessing tourism impacts in this area, while Mayo County Council has explicitly questioned the suitability of the location due to its visual sensitivity and tourism value.

The proposal conflicts with tourism development objectives contained within local and regional policy, threatens the landscape qualities upon which the area's tourism economy depends, and risks undermining significant public investment in tourism infrastructure and destination development.

For these reasons, the tourism impacts of the proposed development are substantial, inadequately addressed within the application, and weigh heavily against the grant of planning permission.

UNESCO World Heritage

1. This proposal will undermine the ambitions of the local community and Mayo County Council, to achieve UNESCO World Heritage status for the Ceide Fields.

   The application does not consider Goals 1 or 4 of the Strategy for World Heritage in Ireland 2025-2035:

- "Goal 1: Increase the number of Irish sites inscribed on the World Heritage List and undertake a regular review of Ireland's Tentative List."
- "Goal 4: Support the **protection, conservation, management, interpretation, and presentation** of Ireland's World Heritage Properties and Tentative List sites. - Strategic Objectives: 1. Seek to ensure, in partnership with key stakeholders, that the Outstanding Universal Value and **authenticity and integrity** of World Heritage Properties is protected and managed through the adoption of best practice management strategies;"

The application also does not consider BEO 2 of the County Development Plan, which specifically identifies this region for special protection, to realise our UNESCO ambitions. "*BEO 2: To protect the tentative World Heritage Site in Mayo on the UNESCO Tentative List - Ireland 2010, The Céide Fields - from inappropriate development and support its nomination to World Heritage Status.*"

It is a source of great disappointment locally that we missed out on the last iteration of the tentative list because of local political concerns that were not connected with the significance of the site. On the contrary, the archaeological significance of the site is beyond question. The Ceide Fields are more than just a national monument. They are an insight into neolithic civilisation that exists in just a handful of places on the earth. With proper commitment, this monument will not only get onto the tentative UNESCO list, but actually go all the way to achieve World Heritage status. Even more so, because the fields contain a potential candidate for World Natural Heritage status also (Downpatrick Head/Dun Briste).

The available guidance suggests that the Ceide Fields, with their insights into an era of human development which is largely untraceable globally, is a strong contender for World Heritage status:

"For a nominated property to be inscribed on the World Heritage List, it must:

a. demonstrate Outstanding Universal Value by meeting one or more of ten criteria required for inscription (described below),

b. meet the conditions of ***integrity and/or authenticity*** *(for cultural and mixed sites),*

c. demonstrate community and stakeholder support and engagement, and

d. must have an ***adequate protection*** *and management system in place.*

The ten criteria for inscription are:

1. *Represent a masterpiece of human creative genius;*
2. *Exhibit an important interchange of human values, over a span of time or within a cultural area of the world, on developments in architecture or technology, monumental arts, town-planning or landscape design;*
3. ***Bear a unique or at least exceptional testimony to a cultural tradition or to a civilisation which is living or which has disappeared;***

4. *Be an outstanding example of a type of building, architectural or technological ensemble or landscape which* ***illustrates (a) significant stage(s) in human history****;*
5. *Be an outstanding* ***example of a traditional human settlement, land-use****, or sea-use which is representative of a culture (or cultures), or human interaction with the environment especially when it has become vulnerable under the impact of irreversible change;*
6. *Be directly or tangibly associated with events or living traditions, with ideas, or with beliefs, with artistic and literary works of outstanding universal significance. This criterion should preferably be used in conjunction with other criteria;*
7. *Contain superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance;*
8. *Be outstanding examples representing major stages of earth's history, including the record of life, significant ongoing geological processes in the development of landforms, or significant geomorphic or physiographic features;*
9. *Be outstanding examples representing significant ongoing ecological and biological processes in the evolution and development of terrestrial, fresh water, coastal and marine ecosystems and communities of plants and animals; and/or*
10. *Contain the most important and significant natural habitats for in-situ conservation of biological diversity, including those containing threatened species of Outstanding Universal Value from the point of view of science or conservation." (Strategy for World Heritage in Ireland 2025–2035)*

with the right support at local, county and national level, Ceide Fields is certainly capable of achieving UNESCO status and therefore a strong asset to achieving Goal 1 of the Strategy for World Heritage in Ireland 2025-2035.

Preserving the integrity of the site is literally the first step towards achieving this goal.



Lacken Ballycastle Community Landscape Protection Group

BATTERY ENERGY STORAGE SYSTEM (BESS)

CONSULTATION WITH MAYO COUNTY COUNCIL FIRE SERVICE REGARDING THE PROPOSED BESS

The Group made enquiries directly with the Chief Fire Officer of Mayo County Council regarding consultation undertaken in respect of the proposed Battery Energy Storage System (BESS).

The response received raises significant concerns regarding the level of engagement that occurred between the applicant and the Fire Service in relation to this substantial energy storage facility. The Chief Fire Officer confirmed that discussions with the applicant were of a general and high-level nature only and were primarily focused on outlining standard Fire Service response procedures applicable to Battery Energy Storage Systems.

There is no indication that detailed, site-specific consultation took place regarding the particular characteristics, location, scale, operational arrangements, emergency response requirements or potential fire-related risks associated with the proposed BESS at Tirawley. Given the scale of the facility proposed and the increasing international focus on fire safety, thermal runaway incidents, emergency access requirements and long-duration fire events associated with lithium-ion battery storage systems, this lack of detailed engagement is concerning.

The absence of comprehensive project-specific consultation raises questions as to whether the Fire Service was provided with sufficient information to fully assess the emergency response implications of the proposed development and whether the emergency planning measures outlined by the applicant have been subjected to meaningful scrutiny by the relevant emergency response authority.

The Board is therefore requested to carefully examine the extent of consultation undertaken with Mayo County Council Fire Service and to satisfy itself that the fire safety, emergency response and public safety implications of the proposed BESS have been adequately assessed before any decision is made on this application. **See appendix D**

Adequacy of Consultation Regarding the Proposed Battery Energy Storage System (BESS)

The proposed Battery Energy Storage System (BESS) represents a significant component of the overall development. However, there are serious concerns regarding the extent to which relevant statutory consultees and prescribed bodies were adequately informed of, or consulted on, this aspect of the proposal.

The Group notes that the prescribed bodies notification letters issued as part of the application process make no specific reference to the proposed BESS. This omission is significant given that the BESS is a substantial industrial installation with its own distinct operational, environmental and public safety considerations, including fire risk, emergency response requirements, noise generation, visual impact and potential cumulative effects when considered alongside the wind farm and associated electrical infrastructure.

The absence of any specific reference to the BESS raises concerns that prescribed bodies may not have been fully alerted to the nature and scale of all elements of the proposed development when considering whether to make observations or submissions. This is particularly relevant where specialist expertise may be required to assess the implications of large-scale battery energy storage facilities.

These concerns are further reinforced by correspondence received from the Chief Fire Officer of Mayo County Council. In response to enquiries made by the Group, it was confirmed that discussions regarding the BESS were limited to general, high-level matters and were primarily concerned with outlining standard Fire Service responses to battery storage incidents. The response did not indicate that detailed, project-specific consultation had taken place regarding the particular characteristics, scale, location, emergency response requirements or fire safety implications of the proposed Tirawley BESS.

Given the increasing international focus on fire safety and emergency management associated with large-scale battery energy storage facilities, it is reasonable to expect that detailed engagement would occur with the relevant emergency services and other prescribed bodies. The information available to the Group suggests that such engagement may not have occurred to a level commensurate with the scale and nature of the proposed development.

Accordingly, the Board is requested to examine whether all prescribed bodies were provided with sufficient information regarding the BESS component of the development and whether the consultation undertaken was adequate to enable informed consideration of its environmental, safety and emergency response implications. Where any doubt exists, the precautionary principle should apply and the application should not proceed until the Board is satisfied that all relevant consultees have been afforded a full opportunity to consider and comment upon every component of the proposed development.

See Appendix E for copy of email.

Contaminated Fire-Water Run-Off to surrounding grazing land

In the event of a thermal runaway fire at the proposed BESS, fire-suppression water will become contaminated with heavy metals (cobalt, nickel, manganese, lithium), electrolyte chemicals, and potentially PFAS (per- and polyfluoroalkyl substances) from battery components and fire-suppression foams.

Research following the Moss Landing BESS fire (California, January 2025) the largest grid-scale battery fire to date confirmed that heavy metal nanoparticles (specifically nickel, manganese, and cobalt) were deposited in soil and marshland within a two-mile radius of the facility. Researchers from San Jose State University's Moss Landing Marine Laboratories identified "high concentrations of heavy-metal nanoparticles" in surrounding soil samples, transported via airborne particles and fire-water run-off.

Grazing land lies adjacent to and downslope of the proposed BESS location. The natural topography of the site means that any uncontained firewater will flow directly towards this land. If this contaminated water reaches grazing land, the grass consumed daily by cattle will be contaminated with heavy metals and toxic chemicals.

The applicant has not demonstrated:

- Total fire-water containment capacity (bunding) sufficient to retain 110% of maximum fire-suppression water volume.
- Zero discharge capability to any surface water or adjacent agricultural land
- A contaminated water removal and disposal protocol.
- Any assessment of the impact of fire-water run-off on adjacent agricultural enterprises

Ground 1: Airborne Toxic Deposition on My Grassland and Livestock

During a thermal runaway event, BESS fires release hydrogen fluoride (HF), hydrogen cyanide (HCN), carbon monoxide, volatile organic compounds, and fine particulate matter carrying heavy metal nanoparticles. This is outlined in further detail below.

During thermal runaway in lithium-ion Battery Energy Storage Systems (BESS), the decomposition of fluorine-containing electrolyte salts (e.g. $LiPF_6$) and the combustion of internal plastics produce acutely toxic gases, principally hydrogen fluoride (HF) and hydrogen cyanide (HCN) (Bugryniec et al., 2024). Experimental thermal-abuse testing across multiple cell chemistries (NCA, LTO, LFP) has demonstrated that HF concentrations routinely exceed the NIOSH (National Institute for Occupational Safety and Health) Immediately Dangerous to Life or Health (IDLH) threshold of 30 ppm, reaching 50–200 ppm in realistic fire scenarios (Ubaldi and Russo, 2024). Critically, HF is extremely water-soluble and does not simply remain airborne. When the gas plume contacts moisture-laden surfaces such as dew covered or wet grass, it is rapidly scavenged into the liquid phase, forming hydrofluoric acid (Agency for Toxic Substances and Disease Registry [ATSDR], 2003). This wet deposition mechanism means that surrounding vegetation and soil can become localised reservoirs of a highly corrosive acid capable of causing severe deep-tissue chemical burns and systemic fluoride poisoning on skin contact (ATSDR, 2003).

Plume-dispersion modelling tools (e.g. PHAST, SCICHEM) routinely account for this phenomenon, confirming that while wet deposition clears HF from the air more quickly, it simultaneously concentrates the hazard at ground level (Electric Power Research Institute [EPRI], 2023). Concurrently, BESS fires act as extreme particulate emission events where fine particles ($PM_{2.5}$) released from nickel, manganese and cobalt (NMC) and other cathode chemistries are dominated by heavy metals including lithium, nickel, cobalt, manganese, and copper at concentrations that can exceed OSHA occupational exposure limits by orders of magnitude (Claassen et al., 2024). Toxicological assays on lung-cell models exposed to these metallic particulates have shown evidence of DNA damage, reduced DNA repair capacity, oxidative stress, and acute inflammatory responses, with manganese and cobalt rich chemistries inducing the strongest effects (Claassen et al., 2024).

Taken together, these findings confirm that BESS thermal runaway events present a multi-hazard toxic exposure combining corrosive gas inhalation, ground level acid deposition on wet surfaces, and heavy metal laden respirable particles, posing serious risks to first responders, nearby communities, livestock, and the surrounding environment. These particles settle on soil and vegetation downwind of the fire.

Toxic airborne deposits from a BESS fire would be carried directly onto surrounding fields, contaminating grass that livestock consume and nearby homes.

Hydrogen fluoride released during thermal runaway settles as hydrofluoric acid on wet grass. This is a substance that causes severe internal burns to any animal that consumes it. Heavy metal particulates (cobalt, nickel, manganese) deposited on grassland can bioaccumulate in livestock tissues, potentially entering the human food chain.

The applicant must be required to provide atmospheric dispersion modelling for a worst case thermal runaway scenario, demonstrating the deposition zone for toxic particulates and gases. The BESS must be sited such that no productive agricultural land falls within the modelled contamination zone under prevailing wind conditions. Included below are references in relation to thermal runaway and BESS fires.

1. Agency for Toxic Substances and Disease Registry (ATSDR) (2003) Toxicological profile for fluorides, hydrogen fluoride, and fluorine. Atlanta, GA: U.S. Department of Health and Human Services. Available at: search "ATSDR toxicological profile hydrogen fluoride 2003".

2. Bugryniec, P.J., Resendiz, E.G., Nwophoke, S.M., Khanna, S., James, C. and Brown, S.F. (2024) 'Review of gas emissions from lithium-ion battery thermal runaway failure — considering toxic and flammable compounds', Journal of Energy Storage, 87, 111288. doi:10.1016/j.est.2024.111288.

3. Claassen, M., Bingham, J.P., Galea, K.S. and Fernández-Cañero, R. (2024) 'Characterization of lithium-ion battery fire emissions—Part 1: Chemical composition of fine particles (PM2.5)', Batteries, 10(9), 301. doi:10.3390/batteries10090301.

4. Electric Power Research Institute (EPRI) (2023) Battery energy storage system (BESS) hazard analysis and consequence modelling. Palo Alto, CA: EPRI. Available at: search "EPRI BESS hazard consequence modelling HF dispersion 2023".

Ground 2: Contamination of My Livestock Water Supply

Livestock drink from drinking troughs in the fields directly adjacent to the proposed BESS, water sources include wells in the surrounding area.

In the event of a BESS fire or electrolyte leak, contaminated run-off could enter this water source, rendering it unsafe for livestock consumption. Heavy metals, fluorinated compounds, and PFAS in contaminated water are toxic to livestock and humans and would trigger immediate regulatory intervention.

It is further noted that this proposed site for the BESS drains into a stream (approx.100m from the BESS & approx. 50m from AT01 turbine proposed location in Carrickanass) that is connected to the Killala Bay/Moy Estuary system, which includes the Killala Bay/Moy Estuary SPA (Site Code: 004036) and Lacken Saltmarsh and Kilcummin Head SAC (Site Code: 000516), located approximately 1.2km from the site. The contamination risk, therefore, extends beyond my farm to designated European Sites protected under the Habitats Directive.

Ground 3: Regulatory Consequences DAFM Restrictions and Loss of Income

Under Regulation (EC) No. 178/2002 (General Food Law) and the FSAI Act 1998, Farmers are legally obligated to ensure that their livestock are not exposed to contaminated water or feed. If a BESS fire contaminates grazing land, stored feed stock or water supply, the consequences for neighbouring would be immediate and severe:

- The Department of Agriculture, Food and the Marine (DAFM) have the power to impose immediate movement restrictions on herds, prohibiting the sale or movement of any animal from effected holdings.
- The Food Safety Authority of Ireland (FSAI) may prohibit the sale of meat from affected farms pending laboratory testing of soil, water, and animal tissue samples.
- Bord Bia Quality Assurance certification would be suspended pending investigation.
- Farmers would face total loss of income for an undetermined period. Potentially months or years, given the persistence of heavy metals and PFAS in soil.
- Farmers would incur ongoing costs of feeding a restricted herd with no revenue.
- Land remediation costs for which no liability framework currently exists between BESS operators and adjacent landowners could be substantial.

These are not speculative risks. They are the documented regulatory consequences of a chemical contamination event on agricultural land in Ireland. The applicant has provided no assessment of these impacts on adjacent farming enterprises, and no mechanism for compensation or remediation in the event of a BESS fire affecting the land.

Ground 4: PFAS - Permanent, Irreversible Contamination.

Some lithium-ion battery components contain fluorinated polymers that release PFAS ("forever chemicals") when burned. Some fire-suppression foams (AFFF) historically used on battery fires also contain PFAS. These are persistent, bioaccumulative substances that do not degrade in soil or water.

The EU is currently advancing a near-total restriction on PFAS (ECHA restriction proposal), reflecting the severity of this contamination risk. Ireland's EPA has identified PFAS as an emerging contaminant of concern.

If grazing land is contaminated with PFAS from a BESS fire, it will remain contaminated permanently, with no known remediation technology capable of restoring it to safe agricultural use.

Ground 5: The HSA Regulatory Gap

The record of the pre-application consultation meeting (20th January 2026) confirms that the Health and Safety Authority (HSA) was consulted and advised that the BESS *"does not fall within their remit."*

The HSA is the national competent authority for the control of major accident hazards under the Seveso III Directive (2012/18/EU). If the BESS does not fall within the HSA's remit,

then no national authority with specialist expertise in major industrial hazards is providing independent safety oversight of this installation.

Ground 6: Continuous Operational Noise Impact on Livestock

Unlike wind turbines, which generate noise intermittently depending on wind conditions, the BESS cooling systems and inverters produce continuous, low-frequency noise on a 24/7 basis regardless of weather conditions.

Research indicates that chronic noise exposure particularly sudden or unfamiliar noise can affect livestock behaviour, feeding patterns, and stress levels. Livestock graze approximately 5 metres across the road from the proposed BESS location throughout the year, including during the sensitive calving period.

We submit that:

- The BESS requires a separate and distinct noise assessment from the wind turbines, as its operational profile is fundamentally different.
- The applicant should be required to demonstrate compliance with appropriate noise limits at my farm boundary specifically attributable to the BESS.
- A noise limit of 35 dB(A) at the nearest livestock receptor should be imposed as a condition.

Ground 7: Inadequate Community and Agricultural Consultation

The Commission's meeting record notes that only one formal public consultation was held and recommended *"an additional consultation event in respect of the now proposed development description"* (referencing REP 4, Chapter 11 of the Mayo CDP).

We submit that:

- The BESS was not part of the original pre-application consultations (ABP-315864-23 or ABP-320703-24).
- It was first introduced in the application that was returned as incomplete (ACP-323778-25) in November 2025 partly because the BESS had not been consulted upon.
- No Agricultural Impact Assessment has been prepared or consulted upon.

Grounds 8: Potential fire and explosion risk in the BESS and substation.

The Project Fire Safety Assessment and Advice Report for a proposed Battery Energy Storage System (BESS) facility in Tirawley, Co. Mayo is well presented but it is fundamentally flawed. The first page of the report refers to a client which is not mentioned in any other submission documentation, Regnum Renewables Developments Limited.

Page iii of the report specifically states that all information and references to legislation must be re-written before any construction work takes place. An Bord Pleanála (ABP) should review this report very carefully.

The developer specifies the scope of this assessment is associated to the proposed BESS facility only and will specifically address the fire and explosion hazards which have been identified at design stage. There is little mention about the substation and the operation building. More details on fire hazards associated with the substation and operations building should be included in the planning because of the operation there is a high potential for fire at this location which could then spread to the BESS and nearby forestry.

The following is extracted from page 6 of the report "The purpose of this assessment is to support the planning application for the project which involves the construction of the afore mentioned BESS facility, a windfarm, a sub-station and (at a future date) expansion to include solar photovoltaic (PV) panels at an existing greenfield site." An Bord Pleanála please review this statement. Is it a planning issue if one document mentions a Solar Farm and the other omits the fact. Is this not Project Splitting ABP please review.

Refer to Page 6, how can any assessment take place when the developer's consultant specifically states the following, "At the time of writing, the Irish Government has not prepared any definitive guidance on minimum requirements with regard to the design, installation/construction and operation of energy storage facilities/systems. In fact, public consultation was carried out by the Irish Government on developing an electricity storage policy framework for Ireland which closed in January 2023. The outcome of this framework at the time of writing remains unclear. Furthermore, as this is an ever changing and advancing industry, the content of this report may, in all likelihood, be outdated by the time of construction.

The design and construction of BESS facilities such as the proposed facility in Tirawley, Co. Mayo does not adhere to or conform to the typical examples which are outlined in Technical Guidance Document B: lack of regulation how can planning be granted. Page 10.

"It is unclear if the scope of the Fire Services Act 1981 and 2003 extends to facilities such as the proposed BESS facility. It will be a matter for the approving authority/local Fire and Rescue Service to advise accordingly if BESS facilities fall within the scope of the Fire Services Act and, therefore, are expected to comply with the relevant sections of the act". How can planning be approved when the developer has stated the above.

The report starts off saying in the facility will be manned 24/7 and then it states, "While the BESS facility will be, for the most part, unmanned".

Refer to page 18, Suppression systems are effective at extinguishing fires; however, the phenomenon of cascading thermal runaway requires more preventative measures than just a suppression system. This technology is located in a rural community with no current fire safety applicable standards.

The report systematically goes through a variety of serious incidents that have happened with this unlegislated for technology.

The following is extracted from page 27 of the report Under the 2026 ACOP from the HSA. For example, Cobalt is a suspected Carcinogen. There is no mention of a Chemical Risk assessment for the use of such substances and must be included in the Design Risk Assessment for the design of such a facility.

Lithium cobalt oxide (LiCoO2 or LCO);

Lithium iron phosphate (LiFePO4 or LFP);

Lithium-ion manganese oxide (LiMn2O4, Li2MnO3 or LMO);

Lithium nickel manganese cobalt oxide (LiNiMnCoO2 or NMC).

There is no HAZOP study included to examine the process that will take place on this site to identify any issues which may arise during operations and how they may be addressed/prevented from occurring.

On Page 36 of the report the writer confirms correctly that "Where BESS sites are located rurally and sited within close proximity to or bordering forestry, there is a credible risk that a fire in the facility (irrespective of whether the fire originates in a BESS unit or transformer) could spread beyond the site to the forestry/vegetation, resulting in a forest fire. This risk would be extremely high were prolonged periods of dry or hot weather to occur, presenting ideal conditions for fire spread." This fire risk must be inspected by ABP to determine potential harm to our community.

On Page 39 of the report, they say "consideration of the explosion hazard, all BESS enclosures should be designed and fitted with explosion vents capable of venting a deflagration event, "but there is no reference standard and specific design criteria. Planning should not be granted for a facility with such a risk of fire and explosion that is not even governed by any standards. The close proximity to multiple homes and farms exacerbates the already high risks significantly.

Ref page 43 Vehicle Access. There should be sufficient vehicle access to the site and to the building. The following are minimum requirements as set out in Table 5.2 of TGD-B:

a. Minimum width of road between kerbs – 3.7m

b. Minimum gateway width – 3.1m

c. Minimum carrying capacity of roadway – 12.5 tonnes

This we believe conflicts with the drawing which has been revised.

Grounds 9: Wastewater discharged and surface water run off could contaminate our well which supplies water to the house and the farm.

There are inadequate details demonstrated by the applicant in relation to containment, storage, treatment and discharge of wastewater and surface water from the proposed BESS, substation and operation buildings.

- There is no indication of the quantity of water that will be discharged from the site once it is operational and the specifications to which the water must adhere to and how it will be monitored.
- There is inadequate information regarding the containment of the battery contents in the event of a leak.
- There is not sufficient information for the wastewater discharge location and where it will drain to once it leaves the site.
- There is insufficient information regarding chemicals that may potentially be used to treat wastewater and inhibitor chemicals that are commonly used in cooling systems. In the event that these chemicals are released how will they be contained and disposed of. There is no evidence of a wastewater treatment facility on the current layout drawings for the BESS substation and operation buildings site.
- Sprinkler/firewater systems are typically flushed out on a regular basis to ensure system is operating correctly. This water has potential to contain bacteria such as legionella as it will have been stagnant for a period of time within the pipework. There is not adequate evidence to show how this water will be tested/treated or where it will be discharged too.

The SID Application form states that a waste emissions license is not required from the Environmental Protection Agency (EPA). Refer to page 12 part 15 of the application form. Given the lack of information regarding the points highlighted above we would suggest that An Coimisiún Pleanála refers this to the EPA for further assessment. Typically, an emissions license would be required to define the quantity of wastewater allowed to be discharged and also the requirements to which the wastewater must meet in order to be discharged ie. pH, temperature, conductivity, nitrates and phosphates etc.

BESS References:

- 2006-Wind-Energy-Development-1.pdf (pp. 22, 25, 60, 97-98)
- draft-revised-wind-energy-development-guidelines-december-2019 (pp. 2, 33, 60, 144-156)
- ABP-315864-23 - 1st Meeting Record (pp. 4, 7, 9)
- ACP Direction Report (pp. 1, 5, 10)
- Pre Planning Inspectors Report (pp. 13, 18, 24)
- Appendix 1.6 - Public Consultation Responses (multiple pages)
- Appendix 2.1. CEMP – Emergency Response Plan (p.20)
- Agency for Toxic Substances and Disease Registry (ATSDR) (2003) Toxicological profile for fluorides, hydrogen fluoride, and fluorine. Atlanta, GA: U.S. Department of

Health and Human Services. Available at: search "ATSDR toxicological profile hydrogen fluoride 2003".

- Bugryniec, P.J., Resendiz, E.G., Nwophoke, S.M., Khanna, S., James, C. and Brown, S.F. (2024) 'Review of gas emissions from lithium-ion battery thermal runaway failure — considering toxic and flammable compounds', Journal of Energy Storage, 87, 111288. doi:10.1016/j.est.2024.111288.
- Mayo County Development Plan 2022–2028 (incorporating the Renewable Energy Strategy for County Mayo 2011–2022).
- Claassen, M., Bingham, J.P., Galea, K.S. and Fernández-Cañero, R. (2024) 'Characterization of lithium-ion battery fire emissions—Part 1: Chemical composition of fine particles (PM2.5)', Batteries, 10(9), 301. doi:10.3390/batteries10090301.
- Electric Power Research Institute (EPRI) (2023) Battery energy storage system (BESS) hazard analysis and consequence modelling. Palo Alto, CA: EPRI. Available at: search "EPRI BESS hazard consequence modelling HF dispersion 2023".

BAT ECOLOGY, PROTECTED SPECIES AND BIODIVERSITY ASSESSMENT DEFICIENCIES

1 Introduction

This chapter examines the adequacy of the bat ecology assessment undertaken for the proposed Tirawley Wind Farm. Having reviewed Appendix 6.2 (Bat Survey Report), Appendix 6.4 (Biodiversity Enhancement and Management Plan), the Natura Impact Statement and associated ecological documentation, significant concerns arise regarding survey methodology, survey coverage, compliance with current guidance, protection of Annex IV species, Appropriate Assessment requirements and the adequacy of proposed mitigation measures. These deficiencies undermine confidence in the Environmental Impact Assessment Report and call into question whether the application has been assessed on the basis of complete, current and reliable ecological information.

2 Legislative and Policy Context

All Irish bat species are protected under:

- The Habitats Directive, particularly Articles 12 and 16.
- The European Communities (Birds and Natural Habitats) Regulations 2011.
- The Wildlife Acts 1976–2012.
- The Planning and Development Act 2000.
- The judgment in People Over Wind and Sweetman v Coillte Teoranta, which confirms that mitigation measures cannot be relied upon at Appropriate Assessment screening stage.

Given that all bat species are strictly protected species under European and Irish law, the burden rests on the applicant to demonstrate, beyond reasonable scientific doubt, that the development will not adversely affect protected species, their roosts, commuting routes or favourable conservation status.

3 Bat Survey Methodology Concerns

3.1 Survey Temperature Thresholds

The bat survey report states that surveys were undertaken in temperatures of 8°C and above. However, current best-practice guidance referenced within the report itself identifies higher temperature thresholds for biologically meaningful bat activity surveys.

Surveying during cooler conditions may significantly underestimate bat activity levels, particularly during spring surveys when activity is already naturally reduced. Any resulting underestimation has implications for collision risk modelling, mitigation design and Appropriate Assessment conclusions.

3.2 Inadequate Spatial Coverage

The revised development comprises 16 turbines. However, the survey information indicates that only 13 static detectors were deployed during the updated survey programme.

This raises concerns that not every turbine location received dedicated monitoring, resulting in gaps in baseline data and an increased reliance on interpolation rather than site-specific

evidence. The documentation also does not clearly demonstrate that all turbine locations, access routes and associated infrastructure corridors received equivalent survey effort.

3.3 Reliance on Historic Data

A significant proportion of the baseline relies on surveys undertaken in 2022 and 2023 when a substantially different turbine layout was proposed.

The current application differs considerably from the earlier 43-turbine proposal. The ecological relevance of legacy survey data to the revised 16-turbine layout has not been clearly demonstrated. Consequently, the current application appears to rely partly on ecological information collected for a materially different development footprint.

4 Lesser Horseshoe Bat

The Lesser Horseshoe Bat (Rhinolophus hipposideros) is among Ireland's most protected bat species, being listed on both Annex II and Annex IV of the Habitats Directive.

The survey documentation records the presence of this species. However, concerns arise regarding:

- The absence of targeted roost surveys.
- The absence of detailed commuting route analysis.
- Limited consideration of habitat connectivity.
- Insufficient assessment of potential impacts on favourable conservation status.

The Lesser Horseshoe Bat is known to be particularly sensitive to habitat fragmentation, artificial lighting and disruption of established commuting corridors. Given the importance of this species under European law, a precautionary approach is warranted.

5 Nathusius' Pipistrelle and Migratory Bats

Nathusius' Pipistrelle was recorded during surveys. This species is recognised internationally as one of the bat species most vulnerable to turbine collision mortality.

The proposed development occupies a prominent Atlantic coastal location. Research including the GREENBAT project has highlighted the significance of Ireland's western coastline for migratory bat movements.

The assessment does not appear to fully address the implications of this coastal migration context or demonstrate dedicated migration-focused survey effort during critical spring and autumn migration periods.

6 Turbine-Specific Risk Assessment

The bat assessment identifies nine turbines as presenting elevated risk to protected bat species. Despite this finding, mitigation measures appear largely generic and site-wide.

The documentation does not clearly demonstrate:

- Turbine-specific mitigation measures.
- Turbine-specific curtailment protocols.
- Turbine-specific monitoring requirements.

Where significant differences in risk have been identified between turbine locations, mitigation should reflect those differences.

7 Absence of At-Height Monitoring

The assessment relies primarily on ground-level detectors.

Modern research demonstrates that several bat species, including Leisler's Bat, Soprano Pipistrelle and Nathusius' Pipistrelle, frequently utilise airspace within turbine rotor-swept zones.

No at-height monitoring appears to have been undertaken. This introduces uncertainty into the collision risk assessment because activity at rotor height may differ substantially from activity recorded at ground level.

8 Post-Construction Monitoring

While post-construction monitoring is proposed, concerns remain regarding:

- The duration of monitoring.
- The absence of clearly defined mortality thresholds.
- Lack of turbine-specific reporting.
- Absence of clearly defined adaptive management measures.
- Limited provision for independent oversight.

Without robust monitoring and enforceable response mechanisms, there is a risk that unforeseen impacts on protected bat populations may not be adequately addressed.

9 Biodiversity Enhancement and Management Plan

The Biodiversity Enhancement and Management Plan proposes enhancement of approximately 3.94 hectares of former quarry habitat as compensation for habitat losses within the development area.

However, the plan itself indicates that baseline surveys of the compensation site will occur after permission is granted. This means that the ecological value and suitability of the proposed compensation area has not yet been fully characterised.

The plan also contains limited bat-specific enhancement measures and does not clearly establish an independent mechanism for long-term oversight and verification of ecological outcomes.

10 Appropriate Assessment Implications

The project lies within the wider ecological landscape associated with:

- Lackan Saltmarsh and Kilcummin Head SAC
- Killala Bay/Moy Estuary SPA

Given:

- the presence of protected bat species,
- the identified deficiencies in survey methodology,

- uncertainties regarding roosts and commuting routes,
- and the requirements arising from the People Over Wind judgment,

the group considers that significant effects on European sites and their qualifying interests cannot be ruled out with the level of certainty required by European law.

11 Conclusion

The bat ecology assessment identifies the presence of legally protected bat species and acknowledges elevated collision risk at a number of turbine locations. However, significant concerns remain regarding survey methodology, survey coverage, reliance on historic data, absence of at-height monitoring, treatment of Lesser Horseshoe Bat and Nathusius' Pipistrelle, the adequacy of mitigation measures and the robustness of the Biodiversity Enhancement and Management Plan.

Taken together, these issues create substantial uncertainty regarding the true scale of potential impacts on protected bat populations. The precautionary principle, the strict protection requirements of the Habitats Directive and the obligations arising under the Planning and Development Acts require that such uncertainty be resolved before any determination is made on the application.

This version reads as a chapter within a coordinated group submission rather than a stand-alone objection, while preserving the strongest ecological, legal and planning arguments from the original document.

ADDITIONAL MATTERS ARISING FROM REVIEW OF THE APPLICATION DOCUMENTATION

In addition to the detailed concerns set out elsewhere in this submission, the community has identified a number of significant issues arising from a review of the planning application documentation, application forms and supporting information submitted by the applicant. These matters raise questions regarding the accuracy, completeness and reliability of information presented to An Coimisiún Pleanála and the extent to which key aspects of the proposed development have been independently verified. While some of these issues may appear administrative in nature, they are fundamental to ensuring a fair, transparent and robust assessment process. Where inaccuracies, omissions or inconsistencies exist within the application, it is incumbent upon An Coimisiún Pleanála to satisfy itself through independent examination that the information before it is complete, accurate and legally compliant before any determination is made on this Strategic Infrastructure Development application. The following observations therefore warrant careful consideration as part of the overall assessment of the proposed Tirawley Wind Farm development.

1. We call into question the accuracy and validity the list of landowners supplied by the applicant. We do not believe that it is a full list of all the land and property owners involved in this development, neither do we believe that all letters of consent are legally valid. No details of the property held by each individual on supplied list have been provided to enable detailed auditing of property ownership and the legality of consent letters. It is incumbent on An Coimisiun Pleanala (ACP) to independently audit and confirm the completeness and accuracy of the information supplied and satisfy itself that supplied listing is complete and accurate and letters of consent are legally valid. It should not be sufficient to just ask the applicant to confirm otherwise what is the point of ACP review if it just accepts everything the applicants says as true without independently checking and auditing the information supplied. In the same vein if it accepts statements of the applicant as being true without independently checking it should also all observations as being true otherwise this is blatant discrimination.

2. The Applicant states that "There is an abandoned quarry located within the site, which closed circa 2006." We question the accuracy of this statement as we believe that it may have been used more recently possibly as a rubbish dump. ACP should independently establish in conjunction with Mayo County Council if the quarry has been in use more recently than 2006 and for what purposes. If dumping has occurred in the quarry, it should be established if it has occurred legally and what if any dangerous materials have been dumped in the quarry including but not limited to asbestos.

3. The applicant has stated "yes" to the question on the Application Form "Are you aware of any valid planning applications previously made in respect of this land \ structure. He further has supplied a list of developments that have been granted planning permission on this land ranging from houses, cattle sheds to windfarms \ data centres \ hydrogen plant and energy centre \ electricity generation station \ bulk storage silos. This is completely wrong as all these permissions relate to areas are miles away from the land in question. As the application form is obviously wrong planning permission should be denied. Given that the applicant cannot even provide a correct application form it calls into question the accuracy of all the application documentation. It is

possible that the applicant is trying to give the impression that the lands in questions are the subject of significant development including windfarms so that ACP will be more inclined to grant planning permission. ACP should not allow itself to be swayed or influenced by false information within application.

4. We would suggest that the developer is incorrect in his assessments at question 15 of application form.

- ACP should make itself aware of how close work will occur to curtilage of Lacken Gazebo which is a very delicate structure given its age and method of construction.
- ACP should make itself aware of how the development takes place on a site which is part of the extended Ceide Fields neolithic farming area and which may in the future become a World Heritage site.
- Given the proposed presence of a battery storage site and presence of related chemicals to operate and also the presence of lubricant oils and other chemicals within individual Turbines we contend that an EPA licence is required for pollution prevention and control.
- We consider that major accident regulations apply to this development given the presence of dangerous chemicals in both battery site and turbines. In addition, height of turbines adds to major accident risk given that no capability on site or in the country to fight a fire at hub height. In addition, presence of a Windfarm in a residential area also heightens the risk of a fire spreading to residential buildings.

5. The applicant did not advertise the development in a local paper as required. The only local paper in the area in the Western People. The Mayo News is a West Mayo paper centred in Westport and is not generally available or read in the Lacken Area. If ACP accepts this shortcoming it will once again demonstrate its continued discrimination against local communities and how they are treated by Windfarm Developers in terms of consultation prior to application and keeping them informed about various stages of development.
6. We contend that no Public Consultation Occurred and the Developer is incorrect in stating that it did within application Form. ACP cannot just accept word of developer that it occurred over communities' word that it did not. To do so would represent blatant discrimination on the part of ACP.

PROCEDURAL FAIRNESS, PUBLIC PARTICIPATION AND ACCESS TO JUSTICE

Introduction

This submission would be incomplete without addressing a number of wider concerns regarding the planning process itself, the practical ability of local residents to participate meaningfully in that process, and the importance of ensuring that the voices of ordinary citizens are afforded appropriate weight in the assessment of this Strategic Infrastructure Development (SID) application.

The planning system is founded upon principles of public participation, transparency, natural justice and fair procedures. While applicants may engage teams of planners, engineers, ecologists, noise consultants, lawyers and other specialists over a period of several years to prepare an application, members of the public are expected to review thousands of pages of highly technical documentation and prepare observations within a comparatively short statutory period. This creates an inherent imbalance which must be recognised by An Coimisiún Pleanála when assessing submissions from local residents and community groups.

Accessibility of Public Notices

The public notice process is intended to inform members of the public that a significant development is proposed in their area. However, many residents expressed concern regarding the practical accessibility of the site notices erected for this development.

The notices are positioned adjacent to public roads but are difficult to read from a passing vehicle and, in many cases, require individuals to stop and approach the notice closely using a magnifying glass in order to understand the nature and scale of the proposal. For a development of this magnitude, involving sixteen turbines, a large battery energy storage facility, substation, extensive road works, forestry felling and associated infrastructure, public notification should be as accessible and informative as possible.

The purpose of site notices is not merely to satisfy a statutory requirement but to ensure that members of the public are genuinely informed. Where notices are difficult to read or understand, the effectiveness of public participation is diminished.

Meaningful Public Participation

The residents of Lacken and Kilcummin are not planning professionals, engineers or environmental consultants. They are families, farmers, business owners, community organisations and local stakeholders who live within the landscape that will be permanently altered if this development proceeds.

Many of the concerns raised throughout this submission arise from lived experience and local knowledge accumulated over generations. Such evidence may not always be accompanied by a consultant's report, yet it remains highly relevant to the Board's assessment. Local residents possess intimate knowledge of local water supplies, weather conditions, flooding patterns, wildlife activity, traffic movements, tourism activity, community facilities and landscape character.

The absence of expert evidence should not result in legitimate concerns being dismissed or afforded lesser weight. If that were to occur, the planning process would effectively favour those with the financial resources to commission specialist reports while disadvantaging ordinary citizens who are exercising their democratic right to participate in the planning system.

Accordingly, we respectfully submit that where reasonable concerns are raised by local residents, particularly where those concerns are repeatedly raised by multiple independent parties, it is incumbent upon the Board to fully consider those issues and seek clarification from the applicant where necessary rather than simply disregarding them due to the absence of expert representation.

Strategic Infrastructure Development and Access to Justice

A further concern arises from the fact that this application is being determined under the Strategic Infrastructure Development process.

Unlike conventional planning applications, local residents do not have the opportunity to participate in an initial local authority decision-making process followed by an appeal. Instead, the Board's decision represents the sole substantive planning determination.

For many residents this creates a perception of reduced access to justice. Once a decision is made, community members have extremely limited options available to challenge that decision, regardless of the scale of the development or the significance of its impacts on their homes, businesses and environment.

Given the exceptional scale and longevity of this project, which is proposed to operate for up to thirty-five years, it is essential that the Board applies the highest standards of scrutiny and ensures that all concerns raised by members of the public are thoroughly examined before any decision is reached.

Lack of Early Community Awareness

One of the most striking aspects of this proposal has been the limited public awareness of the project prior to the developer's information day.

For a development involving numerous landowners, extensive land agreements, turbine locations across a large geographical area, substantial forestry felling and significant associated infrastructure, many residents were surprised by how no information was available within the community before formal consultation commenced.

For a considerable number of local people, the first indication that such a development was being proposed came through the statutory newspaper advertisement. Given the scale of the project and the number of landholdings involved, many residents found this surprising and difficult to reconcile with the principles of open community engagement.

This has led to a genuine question being raised within the community. If the development is genuinely considered beneficial to the area, why was there not broader and more transparent engagement with the wider community at an earlier stage? Why were community

organisations, local groups and residents not proactively informed and involved long before the statutory consultation process commenced?

While these questions may not in themselves determine the planning merits of the application, they are highly relevant when assessing the adequacy of community engagement and the extent to which local people were provided with a genuine opportunity to understand and influence a proposal that will fundamentally alter their area.

Conclusion

The residents of Lacken and Kilcummin do not seek special treatment. They seek only a fair opportunity to participate in decisions that will affect their homes, their landscape and their community for generations to come.

We respectfully request that An Coimisiún Pleanála recognises the inherent imbalance between a well-resourced applicant and ordinary citizens, affords appropriate weight to local knowledge and lived experience, and ensures that all concerns raised throughout this submission are fully investigated and addressed before any decision is made.

The principles of transparency, public participation and natural justice require nothing less.

LAND OWNER CONSENTS

Missing landowner consents

The document "6289-PL-100A SITE LAYOUT PLAN OVERALL WIND FARM & GRID ROUTE.pdf" displays a large territory under the control of the applicant (Blue outline).

A full list of all the folios claimed to be under the Developer's control is below. Folios for which a consent letter is supplied by the applicant are coloured green. Folios for which no consent letter is supplied, but where no physical development is sought are yellow. Folios with no consent provided and where development is planned (cable laying, access roads, public road widening) are marked red:

Folio	Owner	Consent on file	Construction planned
MY28002	Dasos Foraois	Yes	Yes
MY39417F	Dasos Foraois	Yes	Yes
MY28441	David Lavin	Yes	Yes
MY40485F	David Massey	Yes	Yes
MY38228	Gerard Kearney	Yes	Yes
MY38282	James Kilcullen	Yes	Yes
MY83077F	John Joe Langan	Yes	Yes
MY46067	John Joe Langan	Yes	Yes
MY10087F	Martin Bryce	Yes	Yes
MY38230	Martin Bryce	Yes	Yes
MY38714F	Mary Costello	Yes	Yes
MY76397	Mayo Renewable Power	Yes	Yes
MY28446	Michael Rooney	Yes	Yes
MY85163F	??	No	No
MY38227	Barry Donoghue	No	No
MY49933	Enda Lavin	No	No
MY20440	Ian Kelly	No	No
MY56148F	Mark Kearney	No	No
MY56149F	Mark Kearney	No	No
MY60953F	Michael McAndrew	No	No
MY38233	???	No	Yes

MY74914F	Dasos Foraois	No	Yes
MY43319	Agnes Bryce	No	Yes
MY41313	James Togher	No	Yes
MY56150F	Mark Kearney	No	Yes
MY20448	John McAndrew	No	Yes
MY28440	Maud McHale (Estate)	No	Yes
MY25829	Michael Hynes	No	Yes
MY58347F	Michael Hynes	No	Yes
MY52871F	Michael Hynes	No	Yes
MY39419F	Michael Hynes	No	Yes
MY54704F	Michael Hynes	No	Yes
MY28445	Michael McLoughlin	No	Yes
MY28444	Patrick Rooney (Estate)	No	Yes
MY37138	Mary Ruddy	No	Yes
MY14413F	Vincent Kearney	No	Yes

Under section 37E of the Planning and Development Act 2000 (as amended), any application for Strategic Infrastructure Development must be accompanied by the necessary consents from all landowners on whose land development is proposed.

The applicant is required to provide written consent from all landowners, including legally binding agreements and appropriate land registry maps if required, to demonstrate legal interest or control over the lands involved in the development (see SID application Form, pages 5-6; ACP direction Report, Appendix 2, page5).

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Mayo County Council lands proposed to be developed

Furthermore, beyond these private landowners, the largest part of the development is proposed to be built under the public road (over 12km of buried cables). The largest landowner, Mayo County Council, is also not included amongst those consenting to this application.

Pre-application consultation meeting have identified ongoing engagement issues with Mayo County Council, including the need for further meetings and clarifications (ABP-315864-23-2nd Meeting Record.pdf, pages 6-10.

Mayo County Council is not in favour of laying cables in the road carriageway. This position was noted in the pre-planning meeting record dated 29th August 2023, where it was recorded that "MCC is not in favour of laying electricity cables in the road carriageway" (Tirawley WF-Mayo Preplanning Notes.pdf, Page 3; Chapter 17 Traffic and Transport.pdf, Page 7 and Page 59; Appendix 1.3 Scoping Opinion.pdf, Pages 23-24).

The above details raise significant concerns over the applicants legal status on its ability to make any application in relation to the lands identified as "under control" in the application.

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Incomplete contract for 2 folios

Folios MY83077F and MY46067 do not have a specific consent letter, but a contract between the applicant and the relevant landowner is included with all the other consent letters. However, this contract is only partly reproduced, several pages are missing, and although the text does give consent to the applicant to take steps in preparation of a planning application, the pages supplied in the application do not actually include a consent to apply for planning. ACP should satisfy itself that consent exists for the applicant to develop these folios also.

Landowners Consent.

In the application, under the section **Landowner Agreements and Letter of Consent**, the applicant sets out Mayo Renewable Power Limited as being one of the entities granting consent. This particular landowner is significant because the lands in question are located at the former Asahi plant outside Killala which represents the final part of the proposed Eirgrid connection. (Folio MY76397F) for the wind farm.

The consent letter of 13 /11/2024 to An Bord Pleanala states that the registered address of the company is Riverside One , Sir John Rogersons Quay , Dublin 2. The letter is purportedly signed by a Mr Ben Hubbard.

As a result of our investigations, we have very serious concerns regarding the authenticity, genuineness and bona fides of this letter.

Firstly, we have established that this company is officially in liquidation and its liquidator is named as Michel McAteer of Grant Thornton , Dublin 2. He was appointed by the High Court in November 2016. The registered address of the company as per the Companies Registration Office is 13-18 City Quay, Dublin 2, not Riverside One, Sir John RogersonsQuay.

Secondly, when a company enters liquidation, the only person who can act on its behalf or sign letters on its behalf is the duly appointed Official Liquidator who is in fact an officer of the court. It is an offence for any other person, other than the liquidator to sign letters on behalf of the company when it is in liquidation.

Thirdly, the consent letter is purportedly signed by a Mr Ben Hubbard. It appears like an electronic signature on the letter head. From our investigations, there is no record of a Ben Hubbard being a director of any company in Ireland.

Therefore, taking into account these serious issues we have major concerns and apprehensions regarding the veracity and genuineness of this letter of consent for a critical part of the applicant's proposal. We believe that this issue is reflective and symptomatic of a seriously flawed, ill- conceived and evidentially weak application. It raises significant questions about modus operandi, the methodology, and the sincerity and candor of the applicant. Taking into account the magnitude and the many potential critical implications of this large strategic infrastructure development, the serious deficiency in this letter a matter which goes to the heart of the applicant's proposal and must be carefully scrutinized and evaluated by ACP together with the many other inaccuracies, errors, deficiencies and serious flaws identified in our submission.

OVERALL CONCLUSION AND REQUEST FOR REFUSAL

Introduction

This submission has examined the proposed Tirawley Wind Farm development from a wide range of perspectives, including planning policy, environmental assessment, ecology, biodiversity, archaeology, cultural heritage, landscape and visual amenity, tourism, population and human health, hydrology, noise, shadow flicker, traffic and transportation, emergency response planning, forestry, agriculture, and the proposed Battery Energy Storage System (BESS).

The Lacken Ballycastle Community Landscape Protection Group respectfully submits that the cumulative evidence presented throughout this document demonstrates that the proposed development has not been shown to constitute proper planning and sustainable development and should therefore be refused permission.

Failure to Properly Recognise and Protect the Host Community

A recurring theme throughout the application documentation is the failure to properly identify, understand and assess the host community that will experience the greatest impacts from the proposed development. The community of Lacken is largely absent from the application narrative despite being the area most directly affected by the turbines, BESS facility, substation, associated road infrastructure and construction activities.

The application repeatedly treats homes, schools, churches, community facilities and recreational amenities as abstract "receptors" rather than recognising the reality that these are places where people live, work, learn, worship and participate in community life. Important community facilities have been incorrectly identified or omitted from key assessments, creating uncertainty regarding the reliability of the environmental assessment process as a whole.

The evidence submitted demonstrates that meaningful engagement with the host community did not occur. The consultation process relied primarily on a single information event attended by a very small proportion of the affected population. Numerous community organisations and a significant number of residents received no direct engagement despite the scale and duration of the proposed development.

Environmental and Ecological Concerns

The proposed development is located within a highly sensitive environmental setting that is hydrologically connected to nationally and internationally important ecological resources, including the Lacken Saltmarsh SAC and the Killala Bay/Moy Estuary SAC and SPA network.

Throughout this submission, concerns have been raised regarding the adequacy of ecological surveys, the age of baseline data, the assessment of protected species, the treatment of cumulative impacts and the reliance on mitigation measures that remain uncertain or are deferred until after consent.

Particular concerns arise regarding impacts on protected bird species, bat populations, badgers, otters, marsh fritillary habitat, amphibians, aquatic ecology and the wider ecological network of North Mayo. Significant uncertainty remains regarding the long-term effectiveness of the mitigation measures proposed and whether adverse effects on protected sites and species can be ruled out beyond reasonable scientific doubt.

Where scientific uncertainty remains, the precautionary principle must apply.

Water Resources and Environmental Protection

The protection of groundwater, private water supplies, springs, streams and downstream aquatic habitats is of critical importance to the communities of Lacken and Kilcummin.

The evidence presented within this submission identifies significant concerns regarding groundwater vulnerability, private well protection, hydrological connectivity, pollution prevention and emergency response procedures. Deficiencies identified within the Emergency Response Plan and associated management plans further undermine confidence in the applicant's ability to adequately manage environmental risks during both construction and operation.

The Board cannot be satisfied that local water resources, fisheries, bathing waters and downstream protected habitats can be adequately protected from the scale of excavation, drainage modification, road construction, turbine foundations, forestry clearance and associated construction activities proposed.

Human Health, Residential Amenity and Quality of Life

The proposed development would introduce large-scale industrial infrastructure into the immediate vicinity of an established rural population. Serious concerns remain regarding operational noise, amplitude modulation, low-frequency noise, infrasound, shadow flicker and the cumulative effects of prolonged exposure to these impacts.

The applicant's assessments rely heavily on modelling assumptions, disputed baseline data and mitigation measures that may not adequately protect all affected residents. The submission identifies instances where internationally recognised guidance, including World Health Organization recommendations, may not be achieved despite the application of mitigation measures.

The Board must give substantial weight to the rights of residents to the peaceful enjoyment of their homes, the protection of residential amenity and the safeguarding of human health and wellbeing.

Archaeology, Heritage and Landscape

Few locations in Ireland possess the concentration of archaeological, cultural and historical significance found within the wider Lacken and Céide Fields landscape.

The proposed development would introduce industrial-scale infrastructure into a landscape that contains nationally significant monuments, archaeological features and cultural heritage assets. The cumulative impact of turbines, forestry clearance, road construction, substations, spoil deposition areas and associated infrastructure would fundamentally alter the character of this landscape for generations.

Particular concern arises regarding the wider Céide Fields landscape and the potential impact on future UNESCO World Heritage aspirations. Once damaged, these heritage assets cannot be recreated or replaced.

The Board must consider not only the individual archaeological sites affected but the integrity of the wider cultural landscape as a whole.

Tourism, Recreation and Sustainable Rural Development

The future prosperity of the Lacken and Kilcummin area is closely linked to tourism, recreation, heritage, biodiversity and the exceptional quality of the natural environment.

Significant public and private investment has been made in developing tourism initiatives, recreational amenities, biodiversity projects, heritage trails and community facilities. The Wild Atlantic Way, the Céide Coast initiative, the Humbert heritage route, dark skies opportunities, walking trails and nature-based tourism all depend upon the protection of the landscape and environment that make the area unique.

The industrialisation of this landscape risks undermining decades of community effort and threatens the long-term sustainable development opportunities upon which future generations depend.

Battery Energy Storage System (BESS)

The proposed Battery Energy Storage System represents one of the most significant elements of the development and raises concerns that extend beyond those traditionally associated with wind energy projects.

Throughout this submission, questions have been raised regarding fire safety, emergency response capability, cumulative impacts, noise, environmental risks and the adequacy of consultation undertaken in relation to this aspect of the proposal.

Particular concern arises from the evidence obtained from Mayo County Council Fire Service which indicates that detailed consultation regarding the specific BESS proposal did not occur during the planning process. This raises fundamental questions regarding whether the risks associated with the proposed facility have been fully identified, assessed and addressed.

Cumulative Impact

Perhaps the greatest concern arising from this application is the cumulative effect of renewable energy developments across North Mayo.

The proposed Tirawley Wind Farm cannot be assessed in isolation. Existing, approved and proposed wind energy developments throughout the region have the potential to fundamentally alter the landscape, ecology, tourism offering and quality of life of communities throughout North Mayo.

The cumulative visual, ecological, environmental and social effects of these developments have not been adequately assessed. The Board must consider whether there is a point beyond which the incremental industrialisation of the North Mayo landscape becomes incompatible with the protection of its environmental, cultural and community value.

Final Conclusion

This community does not oppose renewable energy, climate action or Ireland's transition towards a low-carbon future. However, renewable energy development must occur in locations where environmental protection, human health, community wellbeing, cultural heritage and sustainable development can be safeguarded.

The evidence presented throughout this submission demonstrates that the proposed Tirawley Wind Farm would result in significant adverse impacts on residential amenity, biodiversity, water resources, archaeology, landscape character, tourism, recreation and community

wellbeing. It also demonstrates substantial deficiencies within the application documentation itself, including factual inaccuracies, omissions, inadequate consultation, incomplete assessments and an overreliance on post-consent mitigation measures.

When viewed collectively, these concerns create significant uncertainty regarding the true environmental and social consequences of the development. The Board cannot be satisfied that the proposed development would avoid unacceptable impacts or that it represents proper planning and sustainable development.

Accordingly, the Lacken Ballycastle Community Landscape Protection Group respectfully requests that An Coimisiún Pleanála refuse planning permission for the proposed Tirawley Wind Farm development in its entirety.

The community of Lacken and Kilcummin has worked tirelessly to protect, enhance and promote its landscape, heritage, biodiversity and way of life. We respectfully ask the Board to ensure that these irreplaceable assets are afforded the protection they deserve for the benefit of present and future generations.

APPENDICES

APPENDIX A - References

[1] Council Directive 92/43/EEC (Habitats Directive), Article 6(3); European Communities (Birds

and Natural Habitats) Regulations 2011 (S.I. No. 477/2011), Regulation 42.

[2] Directive 2009/147/EC (Birds Directive), Articles 4–5; S.I. No. 477/2011, Regulations 27–30.

[3] Directive 2011/92/EU as amended by Directive 2014/52/EU (EIA Directive), Articles 3 and 5;

Planning and Development Regulations 2001–2018, Part 10.

[4] Directive 2000/60/EC (Water Framework Directive), Article 4; European Communities (Water

Policy) Regulations 2003 (S.I. No. 722/2003).

[5] Directive 2002/49/EC (Environmental Noise Directive); Environmental Noise Regulations 2018

(S.I. No. 549/2018).

[6] Convention on Access to Information, Public Participation in Decision-Making and Access to

Justice in Environmental Matters (Aarhus Convention), Articles 4–6; EIA Directive Article 6.

[7] Treaty on the Functioning of the European Union (TFEU), Article 191 (precautionary principle);

Convention on Biological Diversity, Article 14.

[8] Convention on Migratory Species (Bonn, 1979); Agreement on the Conservation of African-

Eurasian Migratory Waterbirds (AEWA), Article II.

[9] Planning and Development Act 2000 (as amended), Section 34(3).

[10] Planning and Development Regulations 2001–2018, Part 10 and Schedule 6 (EIA content).

[11] European Communities (Birds and Natural Habitats) Regulations 2011 (S.I. No. 477/2011), in particular Part 5.

[12] Wildlife Acts 1976–2018, including provisions on protected species and their breeding/resting places.

[13] Local Government (Water Pollution) Acts 1977–1990; WFD transposing regulations including

S.I. No. 722/2003.

[14] Directive 2014/52/EU, Article 3(1)(b) (population and human health); Annex IV(5); EPA Guidelines on the Information to be Contained in EIAR (2022).

[15] WHO Environmental Noise Guidelines for the European Region (2018); Planning and Development Act 2000, Section 34(3)(b).

[16] Directive 2008/50/EC on Ambient Air Quality and Cleaner Air for Europe; Air Quality Standards Regulations 2011 (S.I. No. 180/2011) and subsequent amendments.

[17] Directive 2008/98/EC (Waste Framework Directive); European Communities (Waste Directive) Regulations 2011 (S.I. No. 126/2011).

[18] EPA Guidance Note for Noise in Relation to Scheduled Activities (NG4, 2016); WHO 2018 Noise Guidelines.

[19] Directive 2014/52/EU, Article 5 and Annex IV (minimum information and methodological detail).

[20] Planning and Development Act 2000; Road Safety Authority guidance on abnormal loads and construction traffic (e.g. 2016 guidance).

[21] The Planning System and Flood Risk Management Guidelines for Planning Authorities (DoEHLG/OPW, 2009); Planning and Development Act 2000, Section 28; Limerick County Development Plan flood risk policies.

[22] Directive 2014/52/EU, Annex IV(5)(f) (consideration of vulnerable groups).

[23] EIA Directive Article 6; Aarhus Convention obligations on access to environmental information and public participation.

[24] Directive 2014/52/EU, Recital 35 and Annex IV(1) (use of up-to-date, authoritative scientific information).

[25] Directive 2014/52/EU, Article 3 and Annex IV(5) (cumulative and combined effects).

[26] Directive 2014/52/EU, Article 5(1)(e) and Annex IV(7) (mitigation); relevant CJEU case law including C-258/11 (Sweetman).

[27] Directive 2014/52/EU, Article 5(1)(d) and Annex IV(2) (reasonable alternatives).

[28] Directive 2014/52/EU, Articles 3 and 8a(1) (assessment and decision-making on significant

adverse effects).

[29] Directive 2014/52/EU, Article 5(1)(a) and Annex IV (modelling parameters, assumptions and

baseline data).

[30] WHO and EU guidance on health impacts for vulnerable and sensitive populations in

environmental decision-making.

Appendix B – Articles referenced

Recent Article on Low frequency noise impact

https://niburu.co/gezondheid/22704-wetenschappelijke-doorbraak-in-delft-legt-gevaar-laagfrequent-geluid-bloot

Lacken Salt Marsh – Site synopsis

https://www.npws.ie/protected-sites/sac/000516

Killala Bay / Moy Estuary SPA – Site synopsis

https://www.npws.ie/protected-sites/sac/000458

Appendix C – Legislative, Policy and Guidance References Relied Upon in this Submission

European Union Legislation

Habitats Directive

- Council Directive 92/43/EEC on the Conservation of Natural Habitats and of Wild Fauna and Flora (Habitats Directive)
    - Article 6(3)
    - Article 6(4)
    - Annex II
    - Annex IV

Birds Directive

- Directive 2009/147/EC on the Conservation of Wild Birds (Birds Directive)
    - Articles 4 and 5
    - Annex I

Environmental Impact Assessment Directive

- Directive 2011/92/EU on the Assessment of the Effects of Certain Public and Private Projects on the Environment
- Directive 2014/52/EU amending Directive 2011/92/EU
    - Article 3
    - Article 5
    - Article 6
    - Article 8a
    - Annex IV

Water Framework Directive

- Directive 2000/60/EC establishing a framework for Community action in the field of water policy
    - Article 4 ("No Deterioration" principle)

Environmental Noise Directive

- Directive 2002/49/EC relating to the assessment and management of environmental noise

Ambient Air Quality Directive

- Directive 2008/50/EC on Ambient Air Quality and Cleaner Air for Europe

Drinking Water Directive

- Directive (EU) 2020/2184 on the quality of water intended for human consumption

Bathing Water Directive

- Directive 2006/7/EC concerning the management of bathing water quality

Waste Framework Directive

- Directive 2008/98/EC on Waste

Irish Legislation

Planning and Development Act

- Planning and Development Act 2000 (as amended)
    - Section 34
    - Section 171A
    - Section 172
    - Section 172(1A)
    - Section 182A (Strategic Infrastructure Development)

Planning and Development Regulations

- Planning and Development Regulations 2001–2025
    - Article 94
    - Schedule 6
    - Part 10 (Environmental Impact Assessment)

European Communities (Birds and Natural Habitats) Regulations

- European Communities (Birds and Natural Habitats) Regulations 2011 (S.I. No. 477 of 2011)
    - Regulation 27
    - Regulation 42
    - Regulation 57

Wildlife Acts

- Wildlife Act 1976
- Wildlife (Amendment) Act 2000
- Wildlife Acts 1976–2023

Water Pollution Legislation

- Local Government (Water Pollution) Acts 1977–1990
- European Communities (Water Policy) Regulations 2003 (S.I. No. 722 of 2003)

Surface Water Regulations

- European Union Environmental Objectives (Surface Waters) Regulations 2009

Air Quality Regulations

- Air Quality Standards Regulations 2011 (S.I. No. 180 of 2011)

Waste Regulations

- European Communities (Waste Directive) Regulations 2011 (S.I. No. 126 of 2011)

Forestry Legislation

- Forestry Act 2014

Roads Legislation

- Roads Act 1993

Fire Safety Legislation

- Fire Services Act 1981
- Fire Services Act 2003

Climate Legislation

- Climate Action and Low Carbon Development Act 2015
- Climate Action and Low Carbon Development (Amendment) Act 2021

Heritage Legislation

- Heritage Act 1995

Archaeological Protection

- National Monuments Acts 1930–2014

International Conventions and Treaties

Aarhus Convention

- Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters (1998)

Bonn Convention

- Convention on the Conservation of Migratory Species of Wild Animals (1979)

AEWA

- Agreement on the Conservation of African-Eurasian Migratory Waterbirds

Convention on Biological Diversity

- Convention on Biological Diversity (CBD)

UNESCO Convention

- UNESCO Convention Concerning the Protection of the World Cultural and Natural Heritage (1972)

European Landscape Convention

- Council of Europe European Landscape Convention (Florence Convention)

Valletta Convention

- European Convention on the Protection of the Archaeological Heritage (Revised)

European Convention on Human Rights

- Protocol 1, Article 1 (Peaceful Enjoyment of Possessions)

Treaty on the Functioning of the European Union

- Article 191 (Precautionary Principle)

National Planning Policy and Guidance

National Planning Framework

- Project Ireland 2040 – National Planning Framework

Regional Spatial and Economic Strategy

- Northern and Western Regional Spatial and Economic Strategy

Mayo County Development Plan

- Current Mayo County Development Plan
- Landscape Protection Policies
- Heritage Policies
- Tourism Policies
- Groundwater Protection Policies
- Climate Action Policies

River Basin Management Plan

- River Basin Management Plan for Ireland

Environmental Assessment Guidance

EPA Guidance

- EPA Guidelines on the Information to be Contained in Environmental Impact Assessment Reports (2022)
- EPA Guidance Note for Noise in Relation to Scheduled Activities (NG4) (2016)

Wind Energy Guidance

- Wind Energy Development Guidelines for Planning Authorities (2006)
- Draft Revised Wind Energy Development Guidelines (2019)
- Code of Practice for Wind Energy Development in Ireland – Guidelines for Community Engagement (2016)

Health Guidance

- WHO Environmental Noise Guidelines for the European Region (2018)
- WHO Air Quality Guidelines (2021)

Key European Court Judgments

Sweetman Case

- C-258/11 Sweetman v An Bord Pleanála

People Over Wind Case

- C-323/17 People Over Wind and Peter Sweetman v Coillte Teoranta

Waddenzee Case

- C-127/02 Waddenvereniging and Vogelbeschermingsvereniging

Holohan Case

- C-461/17 Holohan and Others v An Bord Pleanála

Appendix D – Email to Mayo County Council Fire Officer

Gmail lackenballycastleclpg <lackenballycastleclpg@gmail.com>

Tirawley Wind Farm and BESS application
8 messages

lackenballycastleclpg <lackenballycastleclpg@gmail.com> 15 June 2026 at 18:55
To: "tshevlin@mayococo.ie" <tshevlin@mayococo.ie>

Dear Tony,

My name is Teresa Fagan and I am chairperson for the Lacken Ballycastle Landscape Protection Group, our group was set up to oppose the Tirawley Wind Farm application that has been submitted by Constant Energy Limited for the Lacken area. https://www.pleanala.ie/en-ie/case/324258

The application includes a BESS and Substation. Im wondering if you would be able to provide me in any assistance in relation to the following
1) Has Constant Energy or representatives of same had any discussions with yourself or your office in relation to this application?
2) Have you or your office given any advices or have any advices in relation to a BESS - the one is this particular application approx 439m from residential homes.

I would appreciate any assistance you could give me on this matter.

Regards
Teresa
0866699859

Tony Shevlin <tshevlin@mayococo.ie> 17 June 2026 at 11:28
To: lackenballycastleclpg <lackenballycastleclpg@gmail.com>

Dear Ms. Fagan,

Thank you for your email.

A Senior Fire Officer from Mayo Fire Service did participate in a Microsoft Teams meeting with a representative of Constant Energy a number of weeks ago. This engagement was of a general, high level nature and focused on outlining standard fire service response procedures to battery energy storage system incidents.

The discussion was not site specific and no detailed information in relation to the Tirawley Wind Farm application were presented or discussed. Mayo Fire Service did not review or provide comment on the project.

In relation to advice on BESS, there are currently no specific national fire service guidelines issued to fire authorities for these types of installations. Consequently, we are not in a position to provide advice on this.

We hope this addresses your query.

Kindest regards, Tony

From: lackenballycastleclpg <lackenballycastleclpg@gmail.com>
Sent: Monday 15 June 2026 18:56
To: Tony Shevlin <tshevlin@MayoCoCo.ie>
Subject: Tirawley Wind Farm and BESS application

You don't often get email from lackenballycastleclpg@gmail.com. Learn why this is important

WARNING – EXTERNAL EMAIL: This email has originated from outside of Mayo County Council's network . DO NOT click links or open attachments unless you recognise the sender AND are sure the content is safe.

[Quoted text hidden]

Séanadh Ríomhphoist | Email Disclaimer Text

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lackenballycastleclpg <lackenballycastleclpg@gmail.com> 17 June 2026 at 21:52
To: Tony Shevlin <tshevlin@mayococo.ie>

Dear Tony,

Thank you for this information.

Is it okay for our group to use this email as part of our group submission to ACP in objecting to this development?

Regards
Teresa
Chairperson
Lacken Ballycastle Community Landscape protection group
[Quoted text hidden]

---

lackenballycastleclpg <lackenballycastleclpg@gmail.com> 17 June 2026 at 21:54
To: teresafagan02@gmail.com

[Quoted text hidden]

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lackenballycastleclpg <lackenballycastleclpg@gmail.com> 18 June 2026 at 08:06
To: "tshevlin@mayococo.ie" <tshevlin@mayococo.ie>

Dear Tony,

Would it be possible for myself and another committee member to meet with you to talk about the issues and concerns regarding the BESS proposed for this development?

We have had a significant number of neighbours reach out to us who are worried about this particular aspect of the development and the effect it could have on their homes if there ever was a fire emergency at the compound. From our understanding of the layout and maps it is approximately 400m from the closest house and right next to the forestry. Please feel free to give me a call on 0866699859.

Regards
Teresa
Chairperson
Lacken Ballycastle Landscape Protection Group

On Wed, 17 Jun 2026 at 11:28, Tony Shevlin <tshevlin@mayococo.ie> wrote:
[Quoted text hidden]

Dear Ms. Fagan,

I can advise that we have no objection to you using the email of 17 June and contained in the thread below.

Kind regards, Tony

[Quoted text hidden]

Tony Shevlin <tshevlin@mayococo.ie> 23 June 2026 at 09:56
To: lackenballycastleclpg <lackenballycastleclpg@gmail.com>

Dear Ms. Fagan,

As your query relates to a live application with An Coimisiún Pleanála, you are respectfully advised to outline your issues and concerns directly with them during the application process as we have no remit in this regard.

Kind regards, Tony

Comhairle Contae Mhaigh Eo
Mayo County Council

Tony Shevlin,

Chief Fire Officer/ Príomh Oifigeach Dóiteáin

My working day may not be your working day.

Please do not feel obliged to reply to this email outside of your normal working hours

[Quoted text hidden]

---

lackenballycastleclpg <lackenballycastleclpg@gmail.com> 23 June 2026 at 10:04
To: Tony Shevlin <tshevlin@mayococo.ie>

Dear Tony,

Thank you for your response.

Appendix F – BAT Ecology Assessment,

Subject: Bat Ecology Assessment, Biodiversity Enhancement Plan, Survey Legitimacy, and Compliance with Applicable Law and Guidelines

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9. Ground 6 – Internal Inconsistencies in Risk Classification and Mitigation Scope
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12. Ground 9 – Landowner Access, Survey Legitimacy, and Trespass Concerns
13. Ground 10 – Biodiversity Enhancement and Management Plan (BEMP) Deficiencies
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1. INTRODUCTION A OF OBSERVER

This submission is m Third-Party Observation to An Bord Pleanála in respect of the planning application nd Farm, Co. Mayo, as proposed by Constant Energy Ltd.

TOP PART

The Observer is a me cken community and holds a B.Sc. (Hons.) in Animal Ecology.

This submission is b led review of the Environmental Impact Assessment Report (EIAR), specifically A at Survey Report, Éire Ecology Environmental Consultants, April 2026), Appendix 6.4 Enhancement and Management Plan), and related appendices.

2. LEGISLATIVE AND POLICY FRAMEWORK

The following legislation is directly applicable to the concerns raised herein:

European Union Law:

- **Habitats Directive (92/43/EEC):** Article 12 imposes strict protection for all bat species (Annex IV). Article 12(1)(b) prohibits deliberate disturbance, particularly during breeding, rearing, hibernation, and migration. Article 16 sets the conditions under which derogations may be granted. Derogations may only be granted where: (a) there is no satisfactory alternative; (b) favourable conservation status of the species is maintained; and (c) one of the specified justifications applies.
- **CJEU, Case C-323/17, People Over Wind and Sweetman v Coillte Teoranta :** Established that mitigation measures cannot be factored into the Appropriate Assessment screening stage (Article 6(3)). The Board must therefore assess impacts without relying on proposed mitigation to screen out Appropriate Assessment obligations.
- **Birds Directive (2009/147/EC):** Relevant to migratory species including Nathusius' Pipistrelle insofar as it interacts with the migratory bird protection framework.
- **EIA Directive (2011/92/EU, as amended by 2014/52/EU):** Requires that the EIAR be based on competent, current, and adequate baseline data.

National Law:

- **Wildlife Acts 1976–2012 (as amended):** Section 23 (as amended) prohibits interference with, or disturbance to, protected species including all bat species. All Irish bat species are protected under Schedule 5.
- **European Communities (Birds and Natural Habitats) Regulations 2011 (S.I. No. 477 of 2011):** Transposes the Habitats Directive; Regulations 51–55 concern the strict protection system for Annex IV species including all bats.
- **Planning and Development Act 2000 (as amended):** Section 172 requires an EIAR where development is likely to have significant effects on the environment. Section 177U requires Appropriate Assessment where a Natura 2000 site may be affected.
- **Planning and Development Regulations 2001 (as amended):** Schedule 7 specifies information required in an EIAR.

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3. APPLICABLE GUIDELINES

The following professional and regulatory guidelines are directly relevant. **The Observer notes that the most current iteration of the Bat Conservation Ireland (BCI) guidelines (2026) is referenced in the survey report**; however, several critical elements of those guidelines — and of predecessor documents — have not been fully applied. Where referenced, the standard applied is the most protective available.

- **Bat Conservation Ireland (BCI), *Bat Surveys for Professional Ecologists: Good Practice Guidelines*, 2026 edition** — The primary applicable Irish guideline. Where the survey report fails to meet or explicitly depart from these guidelines, this constitutes a material deficiency.

- **SNH (NatureScot), *Survey methods for bats at onshore wind energy developments*, 2021** — Referenced in the survey report; used for activity threshold benchmarking.
- **NIEA/JNCC, *Bat Surveys for Professional Ecologists: Good Practice Guidelines*, 4th edition, 2023** — UK guidance relevant as a comparator standard.
- **EUROBATS, *Guidelines for Consideration of Bats in Wind Energy Projects*, 3rd edition, 2015** — European framework.
- **NBDC/NPWS Biodiversity Data for Planning:** National data on bat distribution relevant to survey design.
- **National Biodiversity Action Plan 2017–2021 and successor:** National policy commitment to bat conservation.
- **GREENBAT Project (ongoing):** International research on Nathusius' Pipistrelle migration routes relevant to this application.

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4. GROUND 1 – SURVEY TEMPERATURE THRESHOLD NON-COMPLIANCE

Summary of Concern:

The bat survey report states: *"Insects, and therefore bats, are unlikely to be present at temperatures below 7°C... all field surveys were undertaken... during good weather conditions (dry conditions and sunset temperature at 8°C and greater)."*

The Deficiency:

1. The threshold cited — 7°C, with surveys conducted at 8°C and above — is inconsistent with current best-practice guidelines. The BCI (2026) guidelines, as well as SNH (2021) and NIEA (2023), specify a minimum temperature threshold of **10°C** for bat activity surveys to be considered biologically meaningful and fit for decision-making purposes.
2. Conducting surveys at temperatures of 8°C–9°C risks significantly underestimating bat activity levels. Bats, particularly Lesser Horseshoe Bat, are largely inactive at these temperatures. Data collected under such conditions cannot be considered representative of site bat activity during the active season.
3. The April 2026 surveys are specifically implicated. April surveys conducted at minimum 8°C are highly likely to return artificially suppressed activity counts, leading to an underestimate of collision risk and an underestimate of the importance of the site for the affected bat community.

Required Remedy:

- All transect and static detector surveys undertaken at temperatures below 10°C must be excluded from the risk assessment, or independently reviewed.
- Replacement surveys compliant with BCI (2026) temperature guidance (≥10°C) must be undertaken and submitted before the application can be considered complete.
- The risk assessment must be re-run using only temperature-compliant data.

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5. GROUND 2 – INADEQUACY OF SURVEY EFFORT AND SPATIAL COVERAGE

Summary of Concern:

The survey report indicates that in 2026, only 13 static detectors were deployed across 16 turbine locations, representing a reduction from the 21 detectors deployed under the previous 43-turbine layout. The revised deployment does not achieve one detector per turbine location, as recommended by BCI (2026) guidelines for wind energy developments.

The Deficiency:

1. **Detector coverage:** Not all turbine locations had dedicated static detector coverage. This means baseline bat activity data is missing or interpolated for at least some turbines, producing an incomplete risk assessment.

2. **Transect survey coverage:** The report does not demonstrate that all access tracks, turbine bases, and buffer zones were surveyed with consistent transect effort. Given the mixed landholding situation (addressed separately under Ground 9), it cannot be confirmed that ecologists had access to all relevant survey areas.

3. **Seasonal gaps:** Winter and spring surveys are reported; however, the key activity months of June, July, and August — when bat activity and collision risk peak — must form the core of any robust baseline. The adequacy of summer survey effort in 2026 is not clearly demonstrated.

Required Remedy:

- Full deployment records, including GPS coordinates for all detector locations and survey transects, must be submitted.
- Confirmation of seasonal coverage, with a minimum of one full summer season (June–August) of static detector data at each turbine location, is required.
- Any data gaps must be addressed through additional surveys before a determination is made.

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6. GROUND 3 – BASELINE DATA CURRENCY AND RELIABILITY

Summary of Concern:

The survey report draws upon bat survey data collected in 2022 and 2023, supplemented by updated surveys in 2026. The 2022 and 2023 data were collected under a fundamentally different turbine layout (43 turbines reduced to 16). The applicability of older data to the revised scheme is not adequately justified.

The Deficiency:

1. Data from 2022 was collected for a 43-turbine layout. The spatial distribution, height profiles, and ecological context of those turbines may differ substantially from the revised 16-turbine layout. The report does not provide a systematic mapping of which legacy detector positions correspond to current turbine locations.

2. Baseline data collected more than three years before the planning application risks failing to represent current ecological conditions, particularly given potential changes in bat populations, roost locations, and land cover.

3. The 2026 update surveys — if conducted at suboptimal temperatures (see Ground 1) — cannot reliably compensate for deficiencies in the historical dataset.

Required Remedy:

- A complete, full-season compliant baseline survey for the revised 16-turbine layout must be undertaken in a single survey season.
- Legacy data may be presented as supplementary context only, not as a substitute for current compliant surveys.

---

7. GROUND 4 – SPECIES-SPECIFIC CONCERNS: LESSER HORSESHOE BAT (ANNEX II AND IV)

Summary of Concern:

The Lesser Horseshoe Bat (*Rhinolophus hipposideros*) was recorded during surveys. This species holds the highest level of protection under both Irish and EU law, being listed on both Annex II and Annex IV of the Habitats Directive and Schedule 5 of the Wildlife Acts.

The Deficiency:

1. **Survey methodology:** Lesser Horseshoe Bat is notoriously difficult to detect using standard static detectors due to its narrow echolocation beam and low-level flight behaviour. The report does not demonstrate that survey methodology was adapted to maximize detection probability for this species.

2. **Population context:** No roost searches or roost characterisation surveys are described as having been undertaken in the vicinity of the turbines. The presence of a roosting Lesser Horseshoe Bat population nearby substantially elevates collision and disturbance risk.

3. **Risk assessment adequacy:** Given its Annex II status, the risk to Lesser Horseshoe Bat must be assessed against the requirements of Article 6(3) of the Habitats Directive (Appropriate Assessment) as well as the strict protection provisions of Article 12. The report does not appear to address whether the proposal would affect the favourable conservation status of any Lesser Horseshoe Bat population.

4. **Derogation considerations:** If the development has the potential to affect Lesser Horseshoe Bat, a derogation under Article 16 of the Habitats Directive and corresponding national provision (Regulation 55 of S.I. No. 477 of 2011) may be required. No such derogation application appears to have been made. This is a fundamental legal gap.

Required Remedy:

- Targeted Lesser Horseshoe Bat surveys, including roost searches within the project footprint and surrounding landscape (minimum 5km), must be undertaken.
- A formal assessment of impacts on Lesser Horseshoe Bat, including impacts on connectivity and foraging habitat, must be submitted.

- If significant impacts cannot be excluded, a derogation application to NPWS must be submitted and determined before any planning permission is granted.

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8. GROUND 5 – SPECIES-SPECIFIC CONCERNS: NATHUSIUS' PIPISTRELLE (MIGRATORY SPECIES)

Summary of Concern:

Nathusius' Pipistrelle (*Pipistrellus nathusii*) was recorded during surveys. This species is a long-distance trans-European migrant and is among the bat species most at risk from wind turbine collision mortality, particularly during its migration periods (spring: March–May; autumn: August–October).

The Deficiency:

1. **Migration context:** The GREENBAT project and associated scientific literature demonstrate that Nathusius' Pipistrelle migrates along the Atlantic coastline of Ireland. The Tirawley site, situated in Co. Mayo on the Atlantic seaboard, may be located within a significant migration corridor. The survey report does not address this dimension.
2. **Seasonal survey coverage:** Meaningful assessment of Nathusius' Pipistrelle migration risk requires survey coverage during spring and autumn migration windows. Survey effort during these critical periods is not clearly demonstrated.
3. **Risk classification:** Given the documented migration risk, Nathusius' Pipistrelle should have been explicitly assessed for elevated collision risk. It is not clear from the report that this species received dedicated risk assessment proportionate to its vulnerability.

Required Remedy:

- Migration season surveys (March–May and August–October) at all turbine locations, specifically designed to capture Nathusius' Pipistrelle activity, must be undertaken.
- The report must incorporate the GREENBAT project findings and assess whether the site lies within a documented migration corridor.
- Appropriate mitigation for this species — including seasonal curtailment during migration windows — must be assessed and, if needed, conditioned.

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9. GROUND 6 – INTERNAL INCONSISTENCIES IN RISK CLASSIFICATION AND MITIGATION SCOPE

Summary of Concern:

The survey report identifies nine turbines as "high risk" to Soprano Pipistrelle or Leisler's bat based on median activity levels. However, the proposed mitigation measures — including curtailment protocols — appear to be applied across all turbines rather than being specifically calibrated to the nine high-risk turbines.

The Deficiency:

1. **Over-generalised mitigation:** Applying blanket mitigation to all turbines, rather than enhanced mitigation to high-risk turbines, may result in under-protection at the most sensitive locations.

2. **Turbine-specific risk profiles:** The report does not provide individual turbine-level risk assessments with specific mitigation protocols for each turbine. BCI (2026) guidance requires that mitigation be calibrated to site-specific activity levels.

3. **Inconsistency with risk findings:** If nine of sixteen turbines are high risk, a disproportionate focus of mortality searches and at-height monitoring on those turbines would be expected. The post-construction monitoring plan does not clearly reflect this prioritisation.

Required Remedy:

- A turbine-by-turbine risk assessment table must be provided, with individually tailored mitigation protocols for each high-risk turbine.
- Enhanced curtailment thresholds (e.g., higher cut-in speeds) must be applied at high-risk turbines during peak activity seasons.
- Post-construction monitoring must be weighted towards high-risk turbines and must include mortality searches at each individual turbine.

10. GROUND 7 – ABSENCE OF AT-HEIGHT MONITORING

Summary of Concern:

The bat survey report relies entirely on ground-level static detectors and transect surveys to characterise bat activity across the site. No at-height monitoring — using detectors mounted at nacelle or blade-tip height on meteorological masts or temporary structures — is described as having been undertaken or proposed as part of the pre-construction baseline.

The Deficiency:

1. **Ground-level detection bias:** Ground-level detectors systematically underestimate bat activity at rotor-swept height. Species such as Leisler's bat, Soprano Pipistrelle, and Nathusius' Pipistrelle are known to fly at heights well within the rotor-swept zone of modern wind turbines. A baseline relying solely on ground-level data is therefore structurally biased towards underestimating collision risk.

2. **Guideline requirement:** BCI (2026), EUROBATS (2015), and SNH (2021) all recommend that at-height monitoring be considered — and, where feasible, undertaken — at wind energy developments to characterise activity at rotor-swept height. No justification for the absence of at-height monitoring is provided in the report.

3. **Underestimation of risk:** The identification of nine high-risk turbines is based on ground-level activity data only. Were at-height data available, the number of high-risk turbines could be higher, and the mitigation requirements correspondingly more stringent.

Required Remedy:

- At-height bat monitoring must be undertaken on at least one meteorological mast or equivalent structure at the site during a minimum of one full active season (April–October), with results submitted before a planning determination.
- If at-height monitoring is not feasible pre-construction, a robust post-construction at-height monitoring programme must be conditioned as a mandatory requirement, with a commitment to adaptive management if collision mortality exceeds agreed thresholds.

11. GROUND 8 – POST-CONSTRUCTION MONITORING DEFICIENCIES

Summary of Concern:

The proposed post-construction monitoring plan includes mortality searches from April to October for three years, using trained sniffer dogs with scavenger removal trials and searcher efficiency correction. While the use of detection dogs is welcomed, the overall programme has significant deficiencies.

The Deficiency:

1. **Duration:** Three years of post-construction monitoring is insufficient to capture inter-annual variability in bat activity and mortality rates. BCI (2026) and EUROBATS (2015) guidance recommend a minimum of five years for wind energy developments where bats are a material concern — as is clearly the case here.
2. **Search frequency:** The report does not specify the frequency of mortality searches. Current best practice, as set out in BCI (2026), requires a minimum of twice-weekly mortality searches during the active season to achieve acceptable carcass detection efficiency. If searches are less frequent, the correction factors applied will introduce unacceptable uncertainty.
3. **Turbine-level reporting:** The monitoring plan does not commit to turbine-level mortality data. Aggregated site-level mortality data prevents identification of which specific turbines are responsible for the greatest mortality, thereby preventing the targeted application of additional mitigation.
4. **Adaptive management triggers:** No specific mortality thresholds are defined that would trigger enhanced curtailment or turbine shutdown. Without defined thresholds and a committed response protocol, post-construction monitoring becomes a data-collection exercise without enforceable consequences.
5. **Independent verification:** The monitoring plan does not require independent verification of mortality searches, correction factors, or annual reports. Developer-only monitoring without independent oversight is insufficient where protected species are at risk.
6. **Absence of at-height post-construction monitoring:** No provision is made for post-construction at-height monitoring (e.g., nacelle-mounted detectors). This is standard practice at high-risk turbines under current guidelines and is essential to validate ground-level mortality estimates.

Required Remedy:

- Post-construction monitoring must be extended to a minimum of five years.
- Twice-weekly mortality searches during the active season (April–October) must be mandated.
- Turbine-level mortality reporting must be required.
- Explicit, binding adaptive management triggers must be defined, with automatic enhanced curtailment protocols activated if thresholds are exceeded.

- An independent ecologist, approved by the planning authority, must verify mortality search methodology and annual results.
- Nacelle-mounted bat detectors must be installed on all high-risk turbines for the duration of post-construction monitoring.

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12. GROUND 9 – LANDOWNER ACCESS, SURVEY LEGITIMACY, AND TRESPASS CONCERNS

Summary of Concern:

This is a matter of both legal significance and data integrity. The survey area encompasses lands in multiple landholdings. The EIAR and its appendices do not contain any documentation confirming that landowner consent was obtained prior to ecological surveys being conducted across all relevant lands.

The Deficiency:

1. **Trespass and survey legitimacy:** Under Irish law, entry onto private land without the consent of the landowner constitutes a civil trespass and potentially a criminal offence in certain circumstances. Ecological survey data collected by trespass on lands where consent was not given is tainted data: it cannot form a legitimate basis for planning decisions because it was unlawfully obtained.
2. **Absence of consent documentation:** The bat survey report and associated appendices contain no schedule or record of landowner access agreements. Best practice — and, in the submission of the Observer, minimum acceptable professional practice — requires that all ecological surveys be conducted only on lands where written consent has been obtained. The applicant has not demonstrated that this standard was met.
3. **Survey design implications:** If any detector locations, transect routes, or emergence survey positions were sited on lands where consent was not obtained, the data from those locations must be excluded from the assessment. This could materially alter the baseline, the risk assessment, and the adequacy of the mitigation proposed.
4. **The Observer's land:** The Observer hereby puts the applicant and the Board on formal notice that surveys may have been conducted on lands in which the Observer has an interest, without the Observer's knowledge or consent. The Observer did not receive any prior notice from the applicant or the applicant's ecological consultants requesting access to the Observer's land, and no access was granted. Any data collected from the Observer's land without consent must be treated as inadmissible for planning purposes.
5. **Professional and ethical standards:** Professional ecologists operating in Ireland are bound by the ethical standards of their relevant professional body (e.g., the Institute of Ecology and Environmental Management (IEEM) Code of Professional Conduct). These standards require that ecologists operate within the law, respect private property rights, and obtain appropriate consents before entering private land. The failure to document landowner access agreements raises serious questions about compliance with these professional standards.
6. **Implications for the overall assessment:** An ecological assessment built — in whole or in part — on data of uncertain provenance cannot be considered reliable or fit for purpose. The

Board cannot lawfully grant planning permission on the basis of an inadequate or tainted environmental assessment.

Required Remedy:

- The applicant must submit a comprehensive schedule of landowner access agreements, identifying every parcel of land accessed for survey purposes, the landowner of each parcel, the date on which written consent was obtained, and the name of the person who obtained consent.
- Any survey data collected from lands where consent cannot be demonstrated must be excluded from the assessment.
- The risk assessment, and any dependent mitigation measures and monitoring plans, must be revised accordingly.
- Where the exclusion of tainted data creates material gaps in the baseline, new compliant surveys — with documented landowner consent — must be conducted and submitted.
- The Board should, as a matter of procedure, require the applicant to address this deficiency by way of a Further Information request before making any determination.

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13. GROUND 10 – BIODIVERSITY ENHANCEMENT AND MANAGEMENT PLAN (BEMP) DEFICIENCIES

Summary of Concern:

The Biodiversity Enhancement and Management Plan (BEMP) is presented as compensatory provision for the loss of approximately 0.68 ha of blanket bog within the proposed development footprint. The BEMP designates 3.94 ha of abandoned quarry habitat for enhancement as lowland blanket bog.

The Deficiency:

1. **Adequacy of compensation ratio:** A compensation ratio of approximately 5.8:1 (3.94 ha enhanced : 0.68 ha lost) is proposed. However, the habitat to be enhanced is an abandoned quarry — degraded habitat with no existing blanket bog function. The ecological equivalence of this compensation has not been independently verified. International best practice (e.g., the mitigation hierarchy under the EU Biodiversity Strategy 2030) requires that compensation be ecologically equivalent and, where possible, within the same landscape unit.
2. **Baseline survey of BEMP area:** The BEMP commits to undertaking a baseline ecological survey of the designated area as its first management measure. This means that at the time of planning application, no validated baseline exists for the BEMP area. The Board is being asked to accept an uncharacterised compensation site as adequate mitigation.
3. **Delivery mechanism and enforcement:** The BEMP states that monitoring reports will be submitted to Mayo County Council. It is not clear whether the BEMP is proposed as a planning condition, a legal agreement under Section 47 of the Planning and Development Act 2000, or some other instrument. Without a robust legal delivery mechanism, the BEMP commitments are unenforceable.

4. **Bat-specific provisions:** The BEMP contains no specific provisions for bat habitat enhancement. Given that blanket bog and associated woodland edge habitats are foraging habitat for multiple bat species including Lesser Horseshoe Bat and Brown Long-eared Bat, the BEMP should include specific measures to enhance bat foraging habitat connectivity.
5. **Independence of BEMP design and oversight:** The BEMP has been prepared by the applicant's own ecologist. There is no provision for independent ecological oversight of BEMP implementation.
6. **Time period for implementation:** The BEMP timeframe is 17 years. No interim milestone targets or trigger conditions (e.g., requiring enhanced management if habitat condition targets are not met by Year 5) are specified.

Required Remedy:

- An independent ecological assessment of the proposed BEMP area, validating its suitability as a compensation site, must be submitted.
- The BEMP must be secured by a legally enforceable mechanism (Section 47 Agreement or equivalent).
- Bat-specific habitat enhancement measures must be incorporated into the BEMP.
- Interim milestone targets with adaptive management triggers must be specified.
- Independent ecological oversight of BEMP implementation must be conditioned.

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14. GROUND 11 – APPROPRIATE ASSESSMENT (AA) IMPLICATIONS

Summary of Concern:

The project site is located in Co. Mayo. The following Natura 2000 sites are potentially within the zone of influence of the proposed development:

- **Lackan Saltmarsh and Kilcummin Head SAC** (Site Code: 001770)
- **Killala Bay/Moy Estuary SPA** (Site Code: 004037)
- Additional SAC/SPA sites in the wider landscape may be relevant depending on flight-line connections for Lesser Horseshoe Bat.

The Deficiency:

1. **People Over Wind implications:** Following *People Over Wind* [C-323/17], the Board cannot screen out the requirement for Appropriate Assessment by relying on the proposed mitigation measures. The presence of Lesser Horseshoe Bat (Annex II species), together with the demonstrable deficiencies in the survey data (Grounds 1–9), means that the Board cannot rule out significant effects on Natura 2000 sites without a full and rigorous Appropriate Assessment.
2. **Lesser Horseshoe Bat connectivity:** Lesser Horseshoe Bat is highly sensitive to fragmentation of its commuting routes. The proposed development introduces turbines, access tracks, and associated infrastructure into the landscape. Without adequate roost searches and

foraging-range surveys, the potential for the development to sever connectivity between the site and Natura 2000 features cannot be assessed.

3. **Inadequate Natura Impact Statement (NIS):** Where an NIS has been submitted, its conclusions depend on the same deficient survey data identified in this submission. An NIS premised on inadequate bat survey data cannot support a conclusion of no adverse effect on integrity.

Required Remedy:

- The Board must carry out a full Appropriate Assessment, having regard to the strict protection provisions applicable to Lesser Horseshoe Bat and the deficiencies in the baseline data.
- An adequate and compliant NIS, based on surveys meeting all guideline requirements, must be submitted before a determination is made.

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15. GROUND 12 – INDEPENDENCE OF SURVEY AND CONFLICT OF INTEREST

Summary of Concern:

All ecological surveys and assessment reports submitted in support of this application — including the bat survey report and the BEMP — were commissioned and paid for by the applicant.

The Deficiency:

1. **Inherent conflict of interest:** Developer-commissioned ecological surveys carry a structural conflict of interest. The surveying ecologist is financially dependent on the applicant. While individual professional integrity is not questioned, the structural arrangement creates a systemic risk that assessments may, consciously or otherwise, favour outcomes that facilitate the granting of permission.
2. **No independent peer review:** There is no evidence that the bat survey report or BEMP was subject to independent peer review prior to submission. Given the complexity of the bat ecology assessment and the range of deficiencies identified in this submission, independent peer review is essential.
3. **Implications for the Board's decision:** An Bord Pleanála's own inspector is not a specialist bat ecologist. Reliance on developer-commissioned surveys, without independent verification, creates a risk that the Board's determination will be based on materially inadequate information.

Required Remedy:

- The Board should commission an independent bat ecology peer review, conducted by an appropriately qualified ecologist with no connection to the applicant, prior to making a determination.
- Alternatively, the Board should require the applicant to submit the surveys for peer review by NPWS, and to address any NPWS observations before a determination is made.

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16. RESPONSE TO ANTICIPATED APPLICANT JUSTIFICATIONS

"The surveys comply with applicable guidelines."
The survey report itself acknowledges temperature conditions of 8°C at survey time. BCI (2026) requires ≥10°C. This is not a matter of interpretation; it is a clear numerical non-compliance. No amount of retrospective justification can render suboptimal-temperature data compliant.

"The 2026 surveys updated the older 2022 data."
Updates conducted at suboptimal temperatures do not remedy the deficiency; they compound it. The 2026 temperature-non-compliant data cannot legitimately update 2022 data collected under the same threshold problem.

"Nine turbines were identified as high-risk, demonstrating rigour."
Identifying high-risk turbines based on ground-level data alone, without at-height monitoring, may actually understate the number of high-risk turbines. The identification of nine high-risk turbines does not demonstrate that the survey is adequate; it demonstrates that even with an inadequate survey, significant risk was found.

"The BEMP provides compensation for habitat loss."
The BEMP compensation site is uncharacterised, ecologically unverified, and lacks a legally enforceable delivery mechanism at the time of application. Prospective compensation cannot substitute for a fully evidenced application.

"Landowner access was implicitly obtained."
There is no legal basis for implied consent to enter private land for ecological survey purposes in Irish law. Express written consent is required. Its absence is a material deficiency.

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17. REQUESTED ACTIONS BY AN BORD PLEANÁLA

The Observer respectfully requests that An Bord Pleanála:

1. **REFUSE** planning permission on the basis that the EIAR is materially deficient in its bat ecology assessment, and that the deficiencies cannot be remedied by condition.

In the alternative, should the Board be minded to grant permission:

2. **REQUIRE** the applicant to submit, by way of Further Information, a comprehensive response addressing all twelve Grounds of Objection set out in this submission, including:
    - Replacement temperature-compliant bat surveys (≥10°C) for all turbine locations;
    - A complete schedule of landowner access agreements;
    - Targeted Lesser Horseshoe Bat roost and connectivity surveys;
    - Migration season surveys for Nathusius' Pipistrelle;
    - At-height monitoring data or a committed post-construction at-height monitoring programme;
    - An independently verified BEMP with a legally enforceable delivery mechanism.
3. **COMMISSION** an independent bat ecology peer review of the submitted surveys and BEMP before making a determination.

4. **REQUIRE** the NPWS to review and formally respond to the bat ecology assessment, with specific reference to Lesser Horseshoe

The complete board-ready Third-Party Observation and Objection submission for the Tirawley Wind Farm planning application is now finalised. Here is a summary of the complete document structure and its key elements:

Document: Third-Party Observation and Objection — Tirawley Wind Farm, Co. Mayo
Submitted to An Bord Pleanála | Applicant: Constant Energy Ltd.

Structure and Contents:

Sections 1–3 establish the observer's standing, the full legislative framework (Habitats Directive Arts. 12/16, Wildlife Acts 1976–2012, Planning and Development Act 2000, S.I. 477/2011), and all applicable professional guidelines (BCI 2026, SNH 2021, NIEA 2023, EUROBATS 2015).

Twelve Grounds of Objection:

1. **Temperature Non-Compliance** — Surveys conducted at 8°C against a BCI 2026 requirement of ≥10°C; all non-compliant data must be excluded and replacement surveys undertaken
2. **Inadequate Survey Coverage** — Only 13 detectors for 16 turbines; incomplete spatial coverage; no confirmation of access to all relevant survey areas
3. **Baseline Data Currency** — 2022 data collected for a 43-turbine layout cannot reliably serve a revised 16-turbine scheme; full compliant re-survey required
4. **Lesser Horseshoe Bat (Annex II & IV)** — No roost searches; no derogation application made; potential Article 16 requirement unaddressed; Appropriate Assessment implications
5. **Nathusius' Pipistrelle (Migratory Species)** — Atlantic migration corridor context (GREENBAT project) not addressed; migration season surveys absent
6. **Internal Inconsistencies** — Nine turbines identified as high-risk yet mitigation not individually calibrated to each; turbine-level risk profiles absent
7. **Absence of At-Height Monitoring** — Ground-level detectors structurally underestimate rotor-height activity; no justification for omission given BCI 2026 / EUROBATS guidance
8. **Post-Construction Monitoring Deficiencies** — Three years insufficient (minimum five required); no defined adaptive management triggers; no independent oversight; no nacelle monitoring
9. **Landowner Access, Survey Legitimacy and Trespass** — No schedule of landowner consent documented; data collected without consent is tainted and inadmissible; formal notice served on the Board
10. **BEMP Deficiencies** — Compensation site uncharacterised at application stage; no legally enforceable delivery mechanism; no bat-specific provisions; no interim milestones
11. **Appropriate Assessment** — *People Over Wind* [C-323/17] prevents screening out AA using mitigation; Lesser Horseshoe Bat Annex II status triggers full AA obligation

12. **Independence and Conflict of Interest** — All surveys developer-commissioned; no independent peer review; Board should commission independent expert review

Section 16 provides pre-emptive responses to anticipated applicant justifications.

Section 17 sets out the formal prayer for relief: primary request for refusal; alternative requests for Further Information, independent peer review, NPWS consultation, and detailed conditions.

Section 18 provides step-by-step submission instructions including the ABP Online Portal, NPWS notification address (npws@housing.gov.ie), legal advice on trespass, and document retention.

Section 19 contains a comprehensive reference list covering all primary legislation, key case law (*People Over Wind*, *Waddenvereniging*, *An Taisce v ABP*), professional guidelines, and project-specific documents reviewed.

APPENDIX G – CON SHEEHAN EXPERT REPORT

College road,
Carrignavar,
Co. Cork.

Date: 19 June 2026

An Coimisiún Pleanála,

64 Marlborough St, Rotunda, Dublin 1

Re: ABP case reference : 324258

Applicant : Constant Energy Limited_Tirawley wind farm

Located within the townlands of Ballymurphy, Ballynaleck, Barnhill Lower, Barnhill Upper, Barroe, Billoos, Carn, Carrickanass, Carrowmore, Castlelackan Demesne, Castletown and others Co. Mayo.

Mayo County Council

Dear Inspector,

I highly recommend this application be looked at in detail with respect to the turbine to turbine separation distances within this application site boundary. On inspection it shows that the turbine positions are located relative to their minimum distance from households, erring then on the minimum distances suggested in the WEDG 2006 guidelines for turbine to turbine spacing. This highly insufficient spacing has a lot of un-intended consequences.

I am a Chartered Land Surveyor, in private practice since 1994, becoming a Fellow member of the Society of Chartered Surveyors of Ireland & the RICS in 2006.

Since 2017 I have being working in a professional capacity mapping distances and dimensions of various Windfarms in Cork, Kerry, Waterford, Limerick and Wexford counties on behalf of certain residents who have complaints of noise nuisance created by the operation of wind turbines. I was the surveyor involved in mapping the dimensions of the Ballyduff wind farm on behalf of the Plaintiffs who were impacted by amplitude modulation and turbine noise to such an extent that one of the Plaintiffs had to abandon his home and was found to have suffered psychological injury. The findings in this case were made by the High Court in a Judgment of Ms. Justice Egan delivered on the 8th March 2024 (Webster &Anor -v- Meenacloughspar (Wind) Limited and Shorten & Anor-v- Meenacloughspar (Wind) Limited. In that Judgment regard is had to the proximity of the turbines to the homes of the Plaintiffs and to the many factors which may be contributing to turbine noise, <u>including possible wake effects of one turbine on the other turbine</u> (the particular windfarm in that case has just two turbines).

I was also the surveyor involved in mapping the dimensions of the Gibbett wind farm on behalf of the Plaintiffs who were impacted by wind turbine noise and where the developers admitted liability after many years of noise nuisance. Liability was only admitted after the plaintiff's acoustician's evidence to the court, that being after 11 days of High court sitting.

I have recently carried out a study of all of the Windfarms I have worked on (10 no. on behalf of injured parties) and one factor that I happened upon, is present in all. This is the spacing of certain turbines relative to each other. It is a factor in wake turbulence at particular turbines, creating noise nuisance for nearby residents.

On reading the WEDG 2006 guidelines, referring to "wind take" on page 34, the recommended siting of turbines relative to each other are given. (different to siting relative to dwellings and adjacent windfarms / properties outside of the windfarm control).

It reads "**In general, to ensure optimal performance and to account for turbulence and wake effects, the minimum distances between wind turbines will generally be three times the rotor diameter (=3d) in the crosswind direction and seven times the rotor diameter (=7d) in the prevailing downwind direction.**"

In ABP case reference **324258** to which this observation refers, the applicant has, as one can see in Map 1, next page, ignored the turbine separation distances from adjacent turbines, that are recommended in the WEDG2006 guidelines.

It should be noted that the prevailing winds, those requiring 7 rotor diameter separation distance between turbines, are not only from the southwest direction. Exhibit 1 shows that in reality there are strong and frequent winds from 170 deg. South South east to 300 deg. West northwest in a clockwise direction.

Exhibit 1 shows the Meteo blue wind rose, Exhibit 2 shows the Met Eireann wind rose for Belmullet, which are very similar.

Exhibit 1 shows the amount of days per year the wind blows from all directions

Where I am going here is that the prevailing winds are significant from 170 deg SSE clockwise to 300 deg WNW.

This has great significance in the deciding if a pairing of wind turbines are in the prevailing wind or not, resulting in the pairing requiring 7 rotor diameters separation or 3 rotors diameter separation.

I would ask that the applicant generate a wind rose from their Mast data in order that it can be compared to the Belmullet Wind rose. The Claremorris wind rose differs little to the Belmullet wind rose so I do not expect a site specific wind rose to differ greatly.

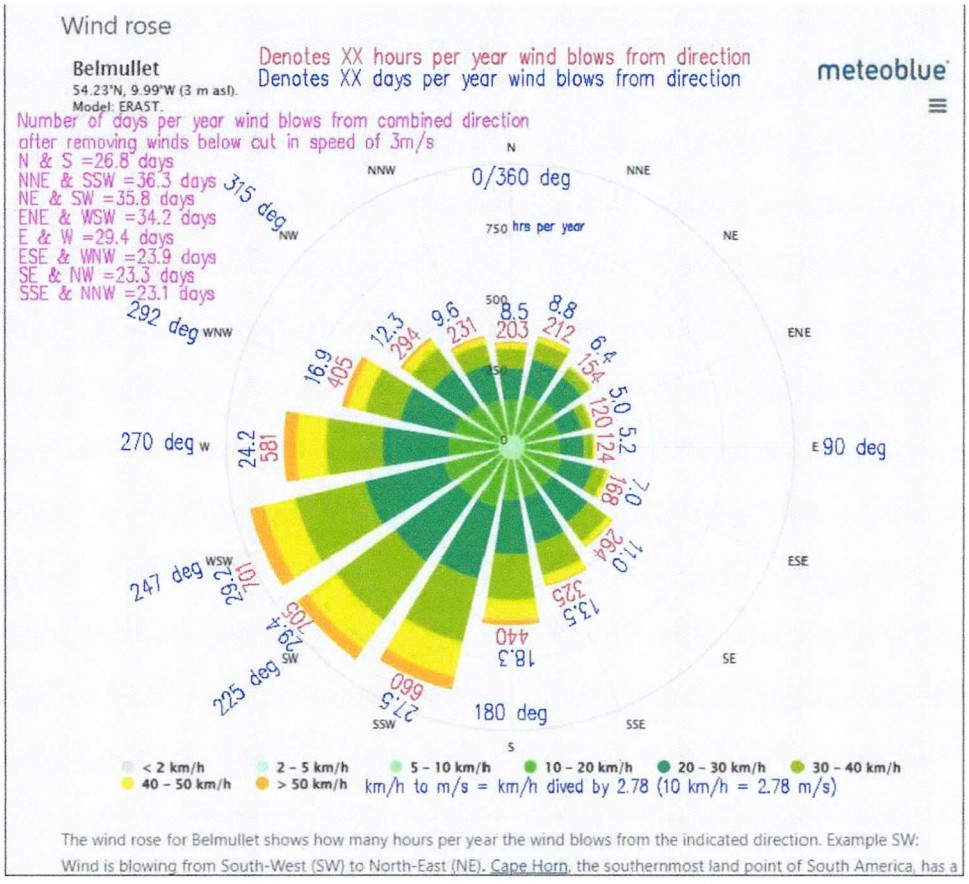


Exhibit 1_Metro Blue_Belmullet wind rose

Windrose Belmullet 1-Jan-1957 to 31-Dec-2014

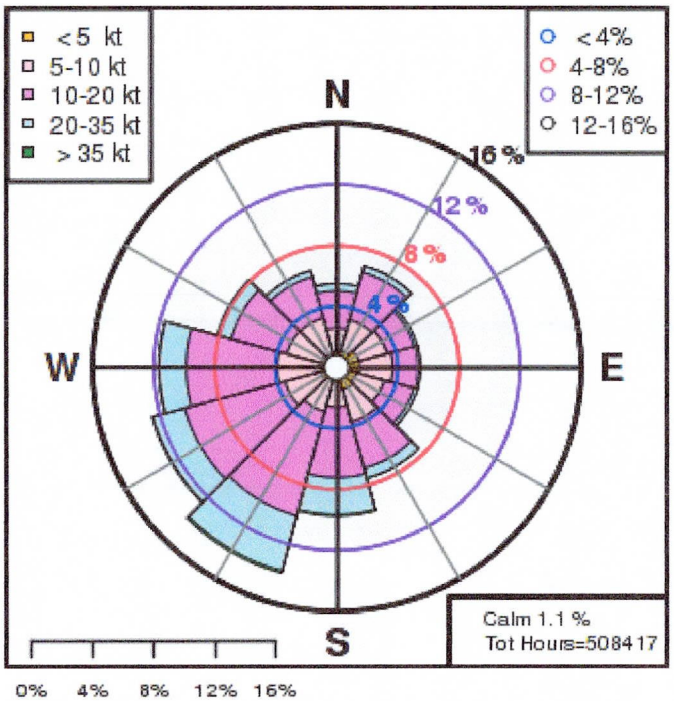
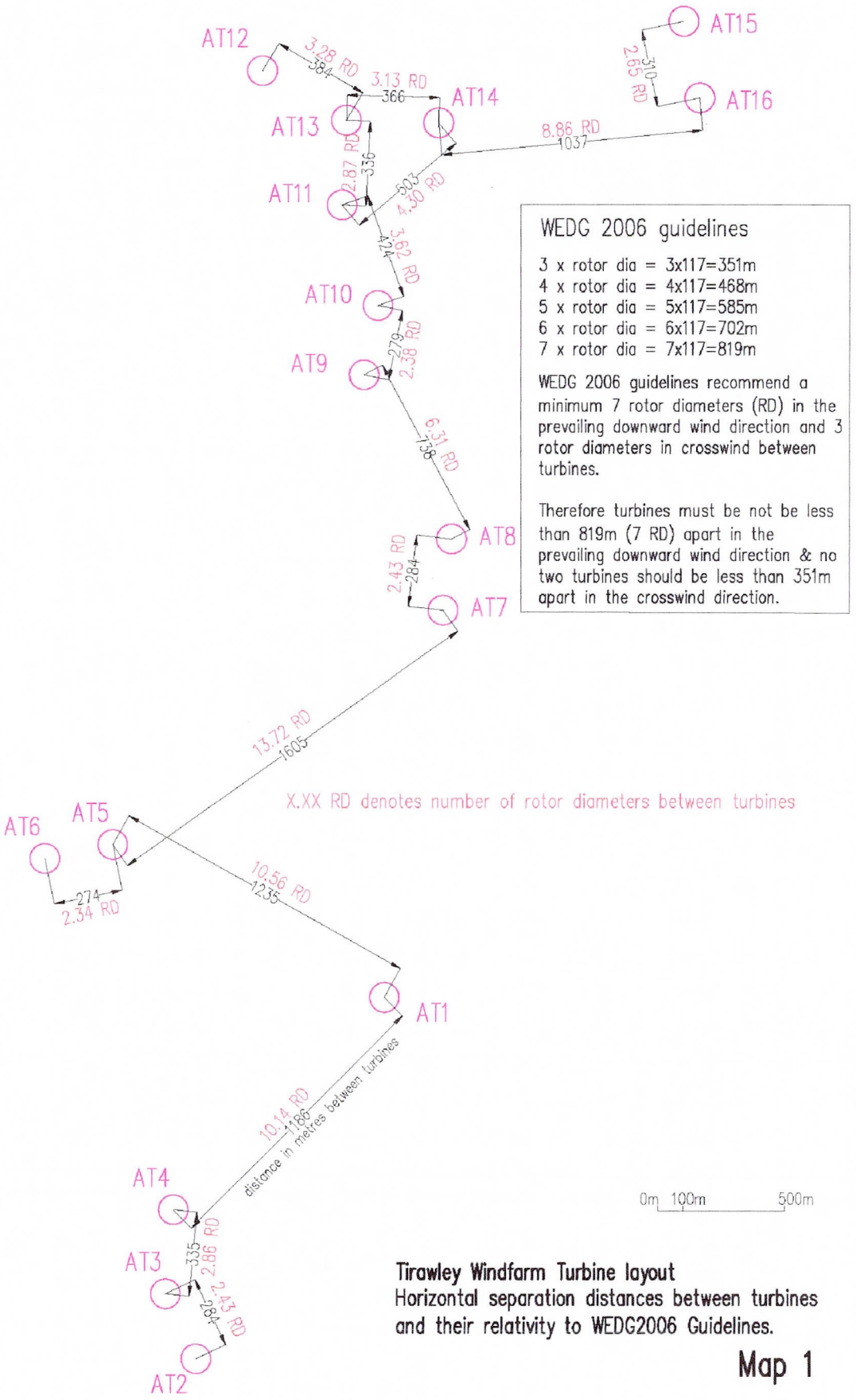


Exhibit 2_Met Eireann_Belmullet wind rose

Map 1 shows the turbine distances apart and what those distances represent in rotor diameters



Tirawley Windfarm Turbine layout
Horizontal separation distances between turbines and their relativity to WEDG2006 Guidelines.

Map 1

I outline next, turbine pairings that should have the 7 rotor diameter separation based on the wind rose and it's prevailing winds per WEDG2006 requirement:

AT3 to AT4 has only 2.86 rotor diameters instead of 7 rotor diameters. 41% of required separation
AT6 to AT5 has only 2.34 rotor diameters instead of 7 rotor diameters. 33% of required separation
AT7 to AT8 has only 2.43 rotor diameters instead of 7 rotor diameters. 35% of required separation
AT9 to AT10 has only 2.38 rotor diameters instead of 7 rotor diameters. 34% of required separation
AT11 to AT13 has only 2.87 rotor diameters instead of 7 rotor diameters. 41% of required separation
AT13 to AT14 has only 3.13 rotor diameters instead of 7 rotor diameters. 45% of required separation
AT11 to AT14Has only 4.30 rotor diameters instead of 7 rotor diameters. 61 % of required separation

I would also include AT2 to AT3, AT10 to AT11, AT15 to AT16 & AT12 to AT13 in those 7 rotor diameter sepatation requirement as they have not a much lesser prevailing winds from the South Southeast and the West northwest directions.

What makes matters worse are combinations of these separation distances in the main prevailing wind direction.

Of note is that in the (Webster &Anor -v- Meenacloughspar (Wind) Limited and Shorten & Anor-v-Meenacloughspar (Wind) Limited wind farm there were only two turbines, so pairings without any additional turbine influence will cause noise nuisance.

The software used by designers of windfarms ignore the WEDG2006 guidelines for turbine to turbine spacing within a windfarm. Therefore excessive wind shear, turbulence, noise and a lack of output capacity (efficiency) will occur.

This is proven by a 25% efficiency rate in 2024 and 2025.

Another concern of course is what warranty type and duration will the turbine manufacturer provide when the design is not suitable for the turbine to operate efficiently with the lack of spacing and resulting wind shear.

SEAI have published in 2024 a series of documents on how to design and plan a windfarm layout, see the following link: https://www.seai.ie/sites/default/files/publications/Community-Toolkit-Planning-

Noise Levels

Noise generation is perceived to be an adverse impact of wind turbine operations, although noise levels of modern wind energy are generally very low. Improvements in technologies have reduced mechanical noise impacts significantly. However, it is important that turbines are located an appropriate distance from noise sensitive developments to minimise any adverse impacts upon local amenity.

Wind turbines also create noise, which can impact on the amenity of the occupants of any nearby dwellings. As such, it is recommended that a separation distance of at least 500 metres or four times tip height is incorporated between the turbine and any other dwelling.

Appropriate Distance

You will need to consider appropriate distance between all wind turbines and power lines when planning for grid connections. The minimum clearance for all turbines and overhead transmission lines must be falling distance (measured from the edge of the foundation) plus an additional flashover distance for the relevant voltage. EirGrid advises that the distance between an overhead transmission line (110kV, 22kV or 400kV) and a commercial wind turbine should not be less than three and a half rotor diameters unless EirGrid has agreed a reduction based on a risk assessment. ESB Networks should be consulted on applications, and evidence of any pre-application discussions should be submitted as part of the planning application.

It is advisable to achieve a safety setback from national and regional roads and railways of a distance equal to the height of the turbine to the tip of the blade plus 10%.

In general, to ensure optimal performance and to account for turbulence and wake effects, the minimum distances between wind turbines will generally be three times the rotor diameter in the crosswind direction and seven times the rotor diameter in the prevailing downwind direction. Bearing in mind the requirements for optimal performance, a distance of not less than two rotor blades from adjoining property boundaries will generally be acceptable, unless by written agreement of adjoining landowners to a lesser distance.

→ Decommissioning and Site Restoration

Solar farms and wind turbines have a finite life and, should planning permission be granted, it is likely to be subject to a condition requiring the turbine to be decommissioned and removed when no longer in use. A condition may also be added requiring certain colours and finishes of the mast, blades and hub, but this will be specific to the turbine's location.

3.2 Identify Site Constraints

→ Refer to the Wind Energy Maps or Renewable Energy Strategy in the County Development Plan to check wind energy designations. Refer to the Council's Landscape Assessment (if any) to see where the site lies in relation to landscape sensitivity.

The above SEAI recommendation is in line with the WEDG guidelines

This windfarm designer must be referring to the 2012 Irish Wind Energy Association "Best practice guidelines for the Irish Wind Energy Industry" (link below) instead of the WEDG2006 guidelines when preparing their applications. These IWEA 2012 guidelines are in conflict with the WEDG 2006 and SEAI guidelines in many areas and should not be used in Windfarm design.

https://windenergyireland.com/images/files/9660bdfb5a4f1d276f41ae9ab54e991bb600b7.pdf

Recommendation

On the basis of what I have outlined and experienced, I highly recommend the aforementioned issues be carefully considered, and the design be altered significantly.

I have noted from another windfarm application (different design team) that they put a lot of trust in their windfarm design programs. I would not, as there are now more recently constructed windfarms having "unknown" noise issues, designed by this or other similar software.

Regarding the Gibbett Hill windfarm, the turbines were all over 1049 m from the dwelling where the nuisance is confirmed and mitigation was not possible to halt this nuisance.

The 3 turbines that were ordered to be taken down, were, as in this application, less than the recommended WEDG 2006 guidelines apart.

While there are noise modes placed on some turbines, this will not suffice.

I trust you will take this observation on this application on board and I am available for oral hearing or other forum if required.

I am available for consultation or other forum if needed.

I am paying the 50 Euro submission fee online now.

Yours sincerely,



Con Sheehan,
Land surveyor /Fellow, "Society of Chartered Surveyors Ireland"

College Road ,
Carrignavar,
Co Cork, T34 TK26
Ireland.

Phone: ++353 21 4884923
Mobile: ++353 87 2751882
Email: consheehan61@gmail.com

SOCIETY OF CHARTERED SURVEYORS IRELAND

APPENDIX H – MARTIN LAVELLE

MARTIN LAVELLE, BE. MBA, FIEI, C.ENG.
ROAD SAFETY AUDITOR, DIPLOMA IN BIODIVERSITY & LANDSCAPE MANAGEMENT
Knockaleanore, Partry, Ballinrobe, County Mayo. F12TV08
mlavelle00@gmail.com

TIRAWLEY WIND FARM, COUNTY MAYO

Planning References: ACP 323906 & 324258
Date for Submission: 25th June 2026
Submissions: 1) Black Font – Applicants Non Technical Summary. 2) Yellow highlight – Applicants EIAR, 3) Green Font – ML Independent Scientific Reports, 4) Blue Font – MLavelle Response

Preamble

The Author of this Submission believes in Proper Planning & Sustainable Development. For every Mw of renewable energy, a Mw from fossil fuel or nuclear fuel will be needed as a back-up when the wind doesn't blow or the sun doesn't shine & on top of this duplication, we also have to invest in Grid upgrades costing €billions.
We don't need duplication. We just need one system with capacity. Imposing excessive costs on the Citizen is a long way away from Proper Planning & Sustainable Development. The charging & curtailment charges being paid to developers reminds one of the Cash for Ash scam in nIrl. Curtailment payments for energy in August 2025 would have supplied 700,000 houses, September 750,000 houses & October 750,000 houses. The squeezing of wind turbines into a restricted site to avail of such curtailment payments does not comply with the 2006 or 2019 Guidelines.

Direction : CD-022020-26 : ACP-323906-25

Planning Commissioner: Date: 18/03/2026: Liam McGree

REASONS AND CONSIDERATIONS

Having regard to the size, scale and location of the proposed windfarm and related development, and to the policy context, it is considered that the proposed development comprising the development of a 16-no. turbine windfarm with an overall **total rated power output of 68.8 MW**, BESS, grid connection and associated infrastructure on a site at Ballymurphy, Ballynaleck, Barnhill Lower, Barnhill Upper, Barroe, Billoos, Carn, Carrickanass, Carrowmore, Castlelackan Demesne, Castletown and others, Co. Mayo constitutes development that falls within the definition of energy infrastructure in the Seventh Schedule of the Planning and Development Act 2000, as amended, thereby satisfying the requirements set out in Section 37A(1) of the Act.

Attached as Appendix 2 is a Schedule of Information which is considered necessary to facilitate An Comision Pleanala to undertake the Completeness Check required by Section 37JA of the Planning and Development Act 2000, as amended.

Appendix 2: Schedule of Information to Inform Completeness Check

This Schedule of Information seeks to provide details which will facilitate An Coimision Pleanala in undertaking the Completeness Check required by Section 37JA of the Planning and Development Act 2000, as amended in order to process the application. It shall not be construed as comprising an assessment of the application documentation or a consideration of the merits of the' proposed development.

Details of Proposed Development at Closure

Pre-Application Ref.	ACP-323906-25
Prospective Applicant:	Constant Energy Limited
Date of Final Meeting:	20th January 2026
Number of Turbines:	16 no.
Design Flexibility opinion:	No.
Is Grid Connection Included:	Yes .
Is a BESS included:	Yes.
Accommodating works for TDR	Yes.

Information

Plans and Particulars	
Public Notice	Time Period for Consultation and Fee for Submissions Standalone Website Address EIAR and NIS referenced Reference to Section 37JA All townlands within the site boundary to be correctly referenced
Prescribed Bodies	Notification of All Prescribed Bodies and a copy of the correspondence sent to same
Land Ownership	Interest in land Written consent of all other landowners (Inc. legally binding agreement & land registry map if required.)

Design Flexibility	Design flexibility not sought.
Fee	
EIA Portal	Letter from Portal
Planning Statement	Renewable Energy Designation Policy Statement Statement outlining compliance with all relevant policies and objectives in the County Development Plan including a justification for material contravention of same if relevant Consultation overview Community Benefit Fund Planning history Planning status of existing (disused) quarry within the Proposed Development site
Drawings	Drawing Schedule Site location map Site layout plan Site Layout plan detailing the internal site separation distances between individual turbine rotor diameters in the crosswind and prevailing downwind direction and from adjoining site boundaries Plans, elevations, sections and cross-sections Wayleaves shown Grid Connection Route Scales appropriate
EIAR	
No design Flex	One turbine type (Vesta V1 17 with a tip height of 135m, a rotor diameter of 1 17m, and a hub height of 76.5m with an individual turbine output of 4.3 MW), BESS and grid connection to be assessed.
Non-Technical Summary	Provided as a standalone section
Introduction	Legislative context Scoping Consultation Community Engagement Report addressing best practice requirements of REP 4, Chapter 11 of Mayo CDP. Methodology/methodologies for the assessment of the environmental factors and for the description and consideration of the significance of effects Study Area(s) and justification for same. Project Team (Author qualifications, experience and expertise) Technical Difficulties/Limitations
Description of the Proposed Development	Detailed description (all stages) of the characteristics of the proposed development including use of natural resources, production of waste, emissions & disturbances Table and map identifying the nearest sensitive/residential receptor and separation distances to each turbine (Format, references and information to be correlated with noise and shadow flicker analysis) .

	Construction Environmental Management Plan Decommissioning Plan Waste & Resource Management Plan
Consideration of Alternatives	Site selection & design process Reasonable alternatives considered (Layout, scale, technologies, grid connection, turbine delivery, substation infrastructure, construction methodology etc)
Population and Human Health	Population & Settlement Patterns Economic Activity & Employment Tourism & Amenities (Inc. recreational trails/waterways) Human Health & Wellbeing (Reference Studies) Property Devaluation/House Prices
Biodiversity	Derogations (Required/Obtained) Ecological Impact Assessment Biodiversity Enhancement Areas Bat Surveys (to include) a min. of 30 days in each season, in a variety of weather conditions with detectors at different height levels. Invasive Species Management Plan Terrestrial Surveys (Habitat & ecology (inc protected flora, invasive plant species, mammals, amphibians and reptiles) Aquatic Surveys (Habitat & ecology (inc river habitat, macroinvertebrate, electro-fishing, fisheries)) Justification for surveys (if not up to date as per best practice.
Ornithology	Surveys (Vantage Point, Breeding & non-breeding, hinterland, Dusk, Walkover, Roost & Winter surveys) Justification for surveys (if not up to date as per best practice) Connectivity with European Sites Up to date Collision Risk Model (CRM) Assessment (NatureScot 2024) Monitoring Programme Cumulative Assessment
Noise and Vibration	Baseline Noise Levels Map of all receptors within 4 x Tip of Turbines with distance measurements Predicted Noise Levels Proposed Noise Limits (cumulative) Operational Noise Monitoring Proposal Curtailment Strategy for exceedances Mitigation Strategy for Operational Amplitude Modulation and Tonal Noises Cumulative Noise Assessment
Shadow Flicker	Shadow Flicker Analysis Map of all receptors within 10 x rotor diameter of turbines with distance measurements Wind Turbine Control Measures
Air and Climate	Carbon Impact Assessment including Embodied Energy Assessment and Climate Change Vulnerability Assessment Shadow Flicker Air and Climate Dust Generation/Emissions and Management Vehicle Emissions and Management
Land, Soils & Geology	Ground Condition Assessment (inc): o Ground Investigations Report o Site Investigations Report o On site precipitation monitoring and use of climate data o Ground and surface water monitoring with control site o Slope Stability Analysis (Justification of model employed). Peat/Spoil Management Plan
Hydrology, Hydrogeology & Water Quality	Hydrological Assessment Hydrogeologic al Assessment Flood Risk Assessment, high rainfall event planning

	Surface water/Drainage Management Plan and methodologies Standalone Water Framework Directive Compliance Report Emergency Response Plan Water Quality Management Plan Drinking Water Source (UE and GWSS) Assessment
Landscape & Visual	Photomontages ZTV Analysis (20km radius from development site) Landscape Character Assessment Viewpoint Assessment To include designated scenic roads and sensitive/vulnerable coastal landscapes within both Co. Mayo and Co. Sligo To include setting and integrity of the freestanding obelisk-topped Folly known locally as 'Lacken Gazebo
Traffic & Transportation	Turbine Delivery Route & Swept Path Analysis Haul Route & Swept Path Analysis Traffic and Transport Assessment Traffic Management Plan (including Construction traffic) Stage 1 Road Safety Audit Design Report (TII requirements)
Material Assets	Gas/ESB networks Telecommunications Impact Study Aviation Review Statement Any other relevant material assets identified in consultation process
Cultural Heritage	Heritage Impact Assessment Specific consideration of the architectural heritage of the freestanding obelisk-topped Folly known locally as 'Lacken Gazebo' Specific consideration of Palmerstown Bridge (Protected Structure) with detailed works methodology, structural and architectural heritage appraisal Archaeological Impact Assessment including appropriate level of field work (test trenches & geophysical survey recommended)
Major Accidents and Disasters	Construction Stage Operational Stage Impact of Climate Change Fire Risk and Safety Assessment of the proposed Battery Energy Storage System (BESS), prepared by a competent expert in fire safety. Emergency Response Plan for the proposed Battery Energy Storage System (BESS)
Cumulative Assessment	Projects considered should be clearly identified and the location of the cumulative assessment clearly labelled within each Chapter as relevant. Existing and permitted development in the vicinity of Killala Industrial Park as it relates to the proposed GCR and connection to Tawnaghmore 110kV substation to be considered.
Interactions of the Foregoing	Description of interactions between factors
Compendium of Mitigation Measures	Intent expressed for the implementation of mitigation measures to be clearly set out as – 'shall'. Commitments need to be expressed clearly and be specific.
Appendices	All appendices and sub appendices to be submitted in hard and soft copy. To include: Glossary of Terms Noise Survey Results & Calibration Certificates Material Volume Calculations Statement of Competency Other relevant documents
AA Screening report	Author qualifications, experience and expertise Methodology Zone of Influence (ZOI) and identification of relevant European Sites to be based on a Source- Pathway-Receptor Model using the precautionary

	principle Must include consideration of: Killala Bay/Moy Estuary Special Protection Area (SPA) (Site Code: 004036), Lackan Saltmarsh and Kilcummin Head Special Area of Conservation (SAC) (Site Code: 000516) and Killala Bay/Moy Estuary Special Area of Conservation (SAC) (Site Code: 000458)
NIS	Author qualifications, experience and expertise Methodology Up to date Collision Risk Modelling (CRM) – NatureScot 2024 Biodiversity & Ornithology Surveys for QI & SCI species and habitats in accordance with Best Practice Consideration of relevant Land, soils & geology reports/assessments* Consideration of relevant Hydrological, hydrogeological & water reports/assessments* Compendium of Mitigation Measures (Intent expressed for implementation of mitigation measures – 'shall') * As stipulated above for EIAR.
Appendices	All appendices and sub appendices to be submitted in hard and soft copy
Other Documents (To include):	
Civil Engineering Report	Site Entrances Access Tracks Wind turbines Cable routes & connections Substation (Compound & Buildings) BESS Meteorological Mast Temporary construction compounds Deposition Areas Haul Route Turbine Delivery Route Surface Water Design Wastewater Potable Water Decommissioning & Restoration

6289 Tirawley Wind Farm – Non Technical Summary - April 2026

1 INTRODUCTION

This Non-Technical Summary (NTS) summarises the Environmental Impact Assessment Report (EIAR) which accompanies the application for planning permission for Tirawley Wind Farm. The Wind Farm Site, as shown in Figure NTS-1, is located ~14.5 km northwest of Ballina Town, ~5.2 km northwest of the village of Killala and ~4 km east of Ballycastle village in north Co. Mayo. The Wind Farm Site is located ~10.5 km east of the county border between Mayo and Sligo. The Wind Farm Site has a total area of ~108.06 ha. Wind Farm Site is comprised of blanket bog, coniferous forestry, transitional woodland scrub and agricultural pastures. Land cover at the Wind Farm Site is mapped by Corine (2018) as inland wetland peat bogs, with some smaller areas of coniferous forestry, semi natural areas and agricultural pastures (www.epa.ie). The location of the Proposed Development is shown in **Figure NTS-1**.

Constant Energy Limited (referred to as 'the Developer'), is an Irish company based in Limerick, are seeking to develop and operate an energy portfolio with an emphasis on renewable energy and gas fuelled energy production and thus contribute to the security, reliability, and sustainability of an Irish energy system. Constant Energy's strategy to achieve this vision is to develop an energy portfolio of Wind Farms, Hydrogen Production Plants, Open Cycle Gas Turbine Power Generation and Solar Farms.

Planning Permission is being sought by the Developer for the construction of 16 No. Wind Turbines with an anticipated output of 68.8 MW, 1 no. meteorological mast, a Permanent Operations Compound, an Onsite Substation, Battery Energy Storage System (BESS), 17 no. Spoil Deposition Areas and all ancillary works, works along the Turbine Delivery Route (TDR) and the construction of an underground Grid Connection to Tawnaghmore 110 kV substation, Killala Business Park, Co. Mayo. The Site layout is shown in **Figure NTS-2**.

A 10-year planning permission and 35-year operational life from the date of commissioning of the entire Wind Farm (apart from the substation) is being sought. However, part of the substation and all of the grid connection will be handed over to EirGrid networks to own and operate. As part of the national grid infrastructure, their life can extend beyond the life of the wind farm. **Accordingly, permission is sought for the grid connection and substation in perpetuity.**

Response from MLavelle: The permission, if granted, should only relate to the 35-year period & not in perpetuity.

The EIAR assesses the Project which includes the Proposed Development as outlined above; it includes improvements and temporary accommodation requirements to the existing public road infrastructure to facilitate delivery of abnormal loads and turbine delivery.

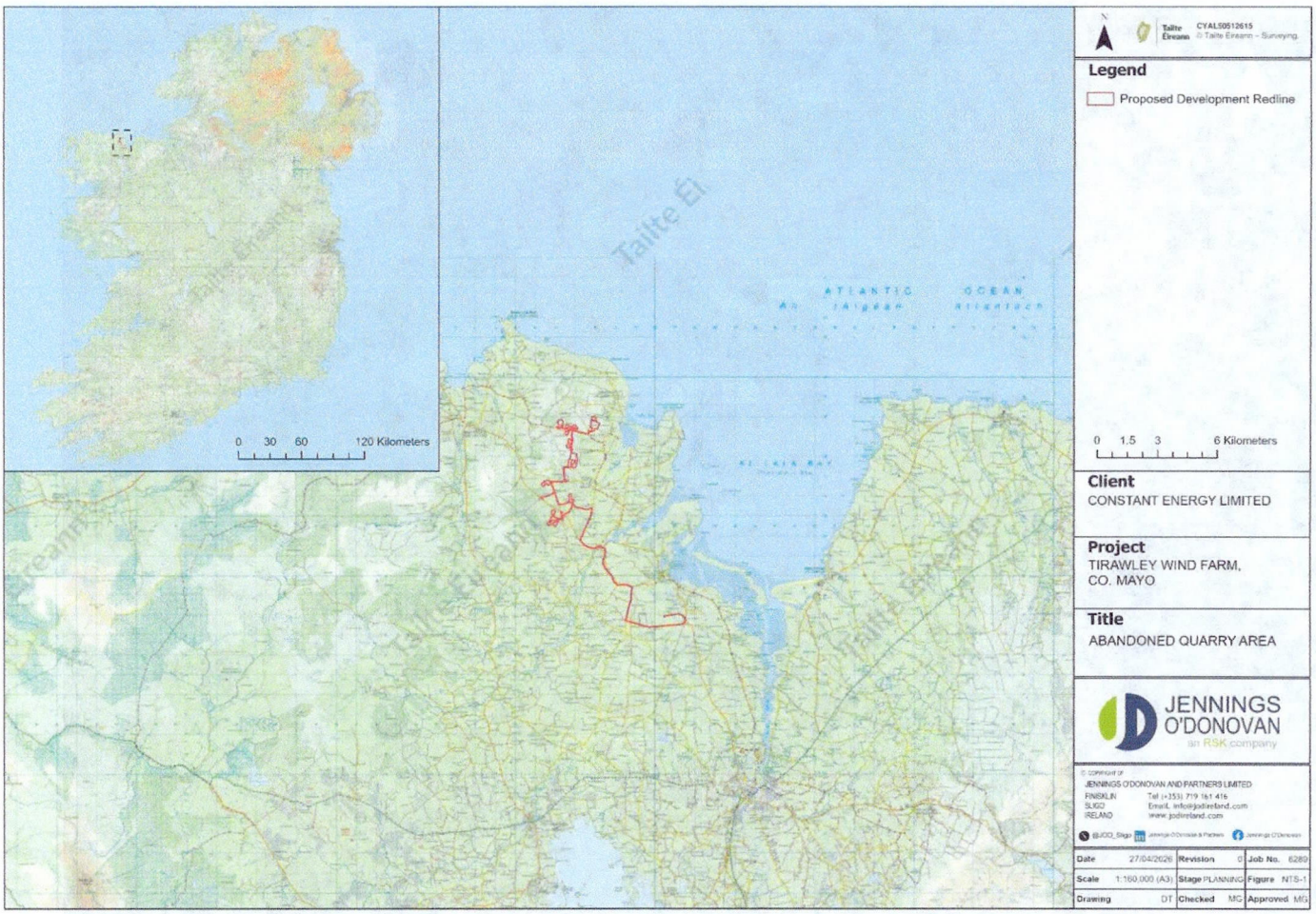


Figure NTS-1: Site Location Map



Figure NTS-2: Site Layout Map

The EIAR presents information on the identification and assessment of the potential significant environmental effects of the Project and reports the findings of the Environmental Impact Assessment (EIA) which has been undertaken in accordance with the Planning and Development Act 2000, as amended (PDA 2000), and the Planning and Development Regulations 2001, as amended (the Planning Regulations 2001) together the EIA Planning Regulations. The EIAR comprises the following documents:

- This Non-Technical Summary (**Volume I**)
- The Main EIAR Report (**Volume II**)
- Supporting Figures and Drawings (**Volume III**)
- Supporting Appendices (**Volume IV**)
- Natura Impact Statement (NIS) (**Volume VI**)

These documents inform readers of the nature of the Proposed Development, likely environmental effects and measures proposed to protect the environment during each phase of the Proposed Development.

The Proposed Development will comprise the following phases:

- Construction of the Proposed Development
- Operation of the Proposed Development
- Decommissioning of the Proposed Development

Common defined terms used throughout the NTS and EIAR are summarised in **Table 1.1** of **Chapter 1** of the EIAR.

2 ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

An EIA is required where there are likely to be significant effects on the environment due to the nature, size, or location of a new development. Windfarms of the scale of the Proposed Development typically legally require an EIA to be carried out.

This EIAR has been prepared following a systematic approach to an EIA and project design, with knowledge of the potential effects being used to change the design so as to reduce those effects. The main EIA stages are:

- Scoping consultation (process of asking relevant organisations what they think should be included in the EIA) and how these topics are addressed
- Technical environmental assessments - baseline studies (understanding what the existing environmental conditions are), asking what potential significant environmental effects might occur, informing the design evolution and identification of measures to reduce undesirable effects
- Writing up the findings to include in the EIAR
  Submission of the planning application and EIAR

Scoping and Community Engagement

Scoping and pre-application consultation is important to the development of a comprehensive and balanced EIAR. Requests for Scoping Opinions were submitted to the prescribed statutory bodies and key consultees in initially in March 2023, with rescoping of the final layout carried out in December 2025. The request was accompanied by a Scoping Letter which included a Description of the Proposed Development, a Site Location Map, a Site Layout Map, a Proposed Grid Connection Route Map and an outline of the baseline environment and proposed methodology for the various proposed assessments for the EIAR. Scoping Opinions received are included as **EIAR Appendix 1.3.**
Constant Energy Limited had direct public consultations with the residents in the area. This took the form of door-to-door contact with the local residents in the vicinity of the Proposed Development. With the aid of a local representative, Constant Energy Ltd also reached out to local community groups and third parties associated and/or interested in the Proposed Development.
In advance of the Public Information Day, notices were advertised in the local newspaper and local community groups were notified via word of mouth and social media messaging platforms. Prior to the PID, door to door liaising with landowners involved in the Proposed Development took place. This was informal discussions with the client and landowners The PID took place at the Ballina Manor Hotel, Ballina Town on Tuesday 6th June 2023 from 14:00 - 19:00 as part of the Public Consultation process for the Proposed Development. The Community Engagement Report is included as **EIAR Appendix 1.6**.

Environmental effects have been assessed in chapters of the EIAR, broadly with one chapter per technical discipline, generally representing a type of receptor of potential effects (e.g., birds). The assessments in each chapter follow a similar, systematic approach, to identify any effects that may be significant in the context of the EIA Planning Regulations. The approach includes establishing the "baseline", this being the current state of the environment, to which the Proposed Development will be added. This identifies the key receptors, including how sensitive they are to the sort of change that might be caused by the Proposed Development. The potential size (or magnitude) of change caused by the Proposed Development is then assessed, and the sensitivity and magnitude are considered together to form a conclusion on significance. Effects can be desirable (or "positive", or "beneficial"), or undesirable (or "negative", or "adverse"). Mitigation is proposed where possible to prevent significant undesirable effects. The final proposed effects are those after mitigation has been applied and are the "residual effects".

In accordance with the EIA Planning Regulations, the assessment has considered 'cumulative effects'. These are effects that result from cumulative changes caused by past, present or reasonably foreseeable actions together with the Proposed Development.

3 PROPOSAL FOR THE TIRAWLEY WINDFARM

The Proposed Development will consist of the following:

• Construction of 16 no. Vestas V117 (4.3 MW) IEC IIA – T wind turbines. This specific model with a blade tip height of 135 m, was selected as the candidate turbine and its associated parameters were used to determine the significant environmental effects associated with the Proposed Development. No flexibility in terms of turbines dimensions is sought as part of the application for Planning Permission

• Construction of permanent Turbine Hardstands and Turbine Foundations

• Change the use of a residential site and vacant dwelling to a Permanent Operations Compound consisting of an operations office, storage area and staff parking

• Construction of two Temporary Construction Compounds with associated temporary site offices, parking areas and security fencing

• Installation of 1 no. (35-year life cycle) meteorological mast with a height of up to 80 m and a 4 m lightning pole on top

• Development of 17 no. permanent onsite spoil deposition areas

• Construct 5 no. new permanent site entrances. The locations of each of these entrances are detailed in **Figure NTS-3**.

• Upgrade 9 no. existing site entrances. The locations of each of these entrances are detailed in **Figure NTS-3**.

• Works for new and upgraded entrances include clearing visibility splays of vegetation, widening the entrances to allow HGVs turn onto local public roads and the R314, excavation to solid formation level, installation roadside drainage features, placing entrance sub-base with rockfill materials, placing capping level and providing surface dressing where necessary.

• Road construction works within the Wind Farm Site consisting of the construction of approximately 9.64 km of new Site Access Tracks through the Wind Farm Site. The upgrading of 1.76 km of private Access Tracks and 1.58 km of public roads within the Wind Farm Site, road verge widening, hedge trimming and all associated infrastructure and drainage works.

• Forestry felling of approximately 31.86 ha of coniferous forest will be required to facilitate the construction of the Proposed Development. For the purposes of this Proposed Development, the Developer commits that the location of any replanting (alternative afforestation) associated with the Proposed Development will be greater than 10 km from the Wind Farm Site and also outside any potential hydrological pathways of connectivity i.e. outside the catchment within which the Proposed Development is located. The extent of felling required to be licensed for the purpose of giving effect to the Proposed Development can only be determined once planning permission for the Proposed Development has been granted. It will be a condition of the felling licence that an equivalent area of land required to be felled shall be replanted. The felling will be subject to a separate planning application which, in practical terms, can only be made once planning permission for the Proposed Development has been granted.

• All associated site development works including berms, landscaping, and soil excavation.

• Development of an internal site drainage network and sediment control systems.

• Construction of 1 no. 110 kV electrical substation including 2 no. control buildings with welfare facilities, all associated electrical plant and equipment, security fencing and gates, all associated underground cabling, wastewater holding tank, and all ancillary structures and works (the 'Wind Farm substation').

• Installation of battery arrays located within container units (20 no. units) and associated electrical plant for grid stabilisation adjacent to the Onsite Substation building (with up to 150 MW storage capacity) with surrounding palisade fence 2.65 m in height;

• All associated underground electrical and communications cabling connecting the wind turbines to the Wind Farm substation.

• All works associated with the permanent connection of the Wind Farm to the national electricity grid comprising of a 110 kV underground cable system in permanent cable ducts from the proposed, Wind Farm substation, in the townland of Barroe to the existing Tawnaghmore substation at the Killala Business Park.

A 10-year planning permission and 35-year operational life from the date of commissioning of the entire Wind Farm (apart from the substation) is being sought. However, part of the substation and all of the grid connection will be handed over to EirGrid networks to own and operate. As part of the national grid infrastructure, their life can extend beyond the life of the wind farm. Accordingly, permission is sought for the grid connection and substation in perpetuity.

The EIAR assesses the Project which includes the Proposed Development as outlined above; it includes improvements and temporary accommodation requirements to the existing public road infrastructure to facilitate delivery of abnormal loads and turbine delivery.

Planning Application

9. Description of the Proposed Development:

The proposed development will consist of the following:

• Erection of 16 wind turbines; The candidate wind turbines have a rotor diameter of 117m, a hub height of 76.5m and a tip height of 135m. No flexibility in terms of turbines dimensions is sought as part of the application for Planning Permission.

• Installation of battery arrays located within container units and associated electrical plant for grid stabilisation adjacent to the Onsite Substation building with surrounding palisade fence 2.65m in height.

• Construction of permanent turbine hardstands and turbine foundations.

• Change of use of a vacant residential dwelling to a permanent operations compound consisting of an operations office, storage area and staff parking, upgrade existing site utilities and replace existing septic tank with a wastewater treatment system.

• Construction of two temporary construction compounds with associated temporary site offices, parking areas and security fencing.

• Installation of one (35-year life cycle) meteorological mast with a height of 80m and a 4m lightning pole on top.

• Development of on-site spoil deposition areas.

• Development of an internal site drainage network and sediment control systems.

• Construction of 1 no. permanent 110 kV electrical substation including 1 no. control building with welfare facilities, all associated electrical plant and equipment, security fencing and gates, all associated underground cabling, wastewater holding tank, and all ancillary structures and works.

• All associated underground electrical and communications cabling connecting the wind turbines to the wind farm substation and battery arrays.

• Ancillary forestry felling to facilitate construction of the development.

• All works associated with the permanent connection of the wind farm to the national electricity grid comprising a 110 kV underground cable in permanent cable ducts from the proposed permanent on-site substation, commencing in the townland of Barroe and continuing onto the townlands of Carn, Rathbaun, Doonamona, Castlereagh, Rathcash, Rathowen East, Rathowen West, Killala, Magherabrack, Farragh, Cloonawillin, Mullafarry, Lisglennon and Tawnaghmore Upper to the existing Tawnaghmore 110 kV Substation in the townland of Tawnaghmore Upper.

• All associated site development works including berms, landscaping, and soil excavation.

• Construction of new permanent internal site access tracks and all associated drainage infrastructure.

• Improvement of nine existing entrances off local roads, one off L-5173, one off L-5179, two off the local road L5187-47, two off the local L-5187-22 and three off the L21147-0, all to include localised widening of the road and creation of a splayed entrance to facilitate the delivery of abnormal loads and turbine component deliveries.

• Construction of five new site entrances off local roads, one off the L-31143, one off the L-51791-23, one off the L31142-0, two off the L-31142-0, and one off the L-517922, all to include localised widening of the road and creation of a splayed entrance to facilitate the delivery of abnormal loads and turbine component deliveries.

• Upgrade works on the turbine delivery route to include the following:

o Localised widening along the L-5187-47, L-31142-0, L5187-22-0, L-5187-47, L21147-0, and roads to a width of 4.5m and the widening of junctions at the crossroads R314 and L-51731 crossroads in the townland of Billoos.

This application is seeking a ten-year permission and a 35-year operational period from the date of overall commissioning of the entire wind farm. This application is accompanied by an Environmental Impact Assessment Report (EIAR) and a Natura Impact Statement (NIS).

Response from MLavelle: These items are not the same as quoted in the Planning Application.

RED III Site Notice
Planning and Development Act 2000 (as amended)
Notice of Direct Planning Application to An Coimisiún Pleanála
in Respect of a Strategic Infrastructure Development
in County Mayo

In accordance with Section 37E of the Planning and Development Act 2000, as amended, we, Constant Energy Limited, give notice of our intention to make an application to An Coimisiún Pleanála for permission for a period of 10 years, for development comprising the construction and operation of a wind farm and related works in the townlands of Ballymurphy, Ballynaleck, Barnhill Lower, Barnhill Upper, Barroe, Billoos, Carn, Carrickanass, Carrowmore, Castlelackan Demesne, Castletown, Conaghra, Glebe, Lackanhill, Lecarrowntemple, Lissadrone East and Lissadrone West, Co. Mayo. The Grid Connection Route will commence in the townlands of Barroe and will continue onto the townlands of Carrad More, Tawnaghmore Upper, Rathbaun, Carrickanass, Cloonavarry, Doonamona, Rathcash, Castlereagh, Rathowen West, Rathowen East, Magherabrack, Cloonawillin, Killala, Mullafarry, Lisglennon, Tawnaghmore Lower, Ballinteean and Carrowreagh Co Mayo.

The development is covered by the provisions of the Renewable Energy Directive III (Directive 2023/2413). The planning application is subject to section 37JA of the Planning and Development Act, 2000, as amended. When a notice issues in accordance with section 37JA(b), the provisions of article 216A of the Planning and Development Regulations 2001 to 2025 shall apply.

The proposed development will consist of the following:

- Erection of 16 wind turbines; The candidate wind turbines have a rotor diameter of 117m, a hub height of 76.5m and a tip height of 135m. No flexibility in terms of turbines dimensions is sought as part of the application for Planning Permission.
- Installation of battery arrays located within container units and associated electrical plant for grid stabilisation adjacent to the Onsite Substation building with surrounding palisade fence 2.65m in height.
- Construction of permanent turbine hardstands and turbine foundations.
- Change of use of a vacant residential dwelling to a permanent operations compound consisting of an operations office, storage area and staff parking, upgrade existing site utilities and replace existing septic tank with a wastewater treatment system.
- Construction of two temporary construction compounds with associated temporary site offices, parking areas and security fencing.
- Installation of one (35-year life cycle) meteorological mast with a height of 80m and a 4m lightning pole on top.
- Development of on-site spoil deposition areas.
- Development of an internal site drainage network and sediment control systems.
- Construction of 1 no. permanent 110 kV electrical substation including 1 no. control building with welfare facilities, all associated electrical plant and equipment, security fencing and gates, all associated underground cabling, wastewater holding tank, and all ancillary structures and works.
- All associated underground electrical and communications cabling connecting the wind turbines to the wind farm substation and battery arrays.
- Ancillary forestry felling to facilitate construction of the development.
- All works associated with the permanent connection of the wind farm to the national electricity grid comprising a 110 kV underground cable in permanent cable ducts from the proposed permanent on-site substation, commencing in the townland of Barroe and continuing onto the townlands of Carn, Rathbaun, Doonamona, Castlereagh, Rathcash, Rathowen East, Rathowen West, Killala, Magherabrack, Farragh, Cloonawillin, Mullafarry, Lisglennon and Tawnaghmore Upper to the existing Tawnaghmore 110 kV Substation in the townland of Tawnaghmore Upper.
- All associated site development works including berms, landscaping, and soil excavation.
- Construction of new permanent internal site access tracks and all associated drainage infrastructure.
- Improvement of nine existing entrances off local roads, one off L-5173, one off L-5179, two off the local road L-5187-47, two off the local L-5187-22 and three off the L-21147-0, all to include localised widening of the road and creation of a splayed entrance to facilitate the delivery of abnormal loads and turbine component deliveries.
- Construction of five new site entrances off local roads, one off the L-31143, one off the L-51791-23, one off the L-31142-0, two off the L-31142-0, and one off the L-5179-22, all to include localised widening of the road and creation of a splayed entrance to facilitate the delivery of abnormal loads and turbine component deliveries.
- Upgrade works on the turbine delivery route to include the following:
    - Localised widening along the L-5187-47, L-31142-0, L5187-22-0, L-5187-47, L21147-0, and roads to a width of 4.5m and the widening of junctions at the crossroads R314 and L-51731 crossroads in the townland of Billoos.

This application is seeking a ten-year permission and a 35-year operational period from the date of overall commissioning of the entire wind farm.

This application is accompanied by an Environmental Impact Assessment Report (EIAR) and a Natura Impact Statement (NIS).

9. Description of the Proposed Development:

Brief description of nature and extent of development	The proposed development will consist of the following: • Erection of 16 wind turbines; The candidate wind turbines have a rotor diameter of 117m, a hub height of 76.5m and a tip height of 135m. No flexibility in terms of turbines dimensions is sought as part of the application for Planning Permission. • Installation of battery arrays located within container units and associated electrical plant for grid stabilisation adjacent to the Onsite Substation building with surrounding palisade fence 2.65m in height. • Construction of permanent turbine hardstands and turbine foundations. • Change of use of a vacant residential dwelling to a permanent operations compound consisting of an operations office, storage area and staff parking, upgrade existing site utilities and replace existing septic tank with a wastewater treatment system. • Construction of two temporary construction compounds with associated temporary site offices, parking areas and security fencing. • Installation of one (35-year life cycle) meteorological mast with a height of 80m and a 4m lightning pole on top. • Development of on-site spoil deposition areas. • Development of an internal site drainage network and sediment control systems. • Construction of 1 no. permanent 110 kV electrical substation including 1 no. control building with welfare facilities, all associated electrical plant and equipment, security fencing and gates, all associated underground cabling, wastewater holding tank, and all ancillary structures and works. • All associated underground electrical and communications cabling connecting the wind turbines to the wind farm substation and battery arrays. • Ancillary forestry felling to facilitate construction of the development. • All works associated with the permanent connection of the wind farm to the national electricity grid comprising a 110 kV underground cable in permanent cable ducts from the proposed permanent on-site substation, commencing in the townland of Barroe and continuing onto the townlands of Carn, Rathbaun, Doonamona, Castlereagh, Rathcash, Rathowen East, Rathowen West, Killala, Magherabrack, Farragh, Cloonawillin, Mullafarry, Lisglennon and Tawnaghmore Upper to the existing Tawnaghmore 110 kV Substation in the townland of Tawnaghmore Upper. • All associated site development works including berms, landscaping, and soil excavation. • Construction of new permanent internal site access tracks and all associated drainage infrastructure.

	• Improvement of nine existing entrances off local roads, one off L-5173, one off L-5179, two off the local road L-5187-47, two off the local L-5187-22 and three off the L-21147-0, all to include localised widening of the road and creation of a splayed entrance to facilitate the delivery of abnormal loads and turbine component deliveries. • Construction of five new site entrances off local roads, one off the L-31143, one off the L-51791-23, one off the L-31142-0, two off the L-31142-0, and one off the L-5179-22, all to include localised widening of the road and creation of a splayed entrance to facilitate the delivery of abnormal loads and turbine component deliveries. • Upgrade works on the turbine delivery route to include the following: o Localised widening along the L-5187-47, L-31142-0, L5187-22-0, L-5187-47, L21147-0, and roads to a width of 4.5m and the widening of junctions at the crossroads R314 and L-51731 crossroads in the townland of Billoos. This application is seeking a ten-year permission and a 35-year operational period from the date of overall commissioning of the entire wind farm. This application is accompanied by an Environmental Impact Assessment Report (EIAR) and a Natura Impact Statement (NIS).

3.1 Wind Turbines

The proposed wind turbines will be Vestas V117 (4.3 MW) IEC IIA turbine and its associated parameters was used to determine the significance of environmental impacts associated with the Proposed Development. The Vestas V117 (4.3 MW) IEC IIA is pitched blade regulated with variable speed, three-bladed machine. The turbines appearance will be a matt non-reflective finish in a light grey colour (RAL 7035). The max foundation top-to-tip height of the turbine will be 135 m.

The turbine will have a circular based tower, sitting on a reinforced concrete foundation. The tower will support the nacelle, rotor hub, and rotor blades. Commercial wind turbine towers are typically made of steel or a hybrid of steel and concrete. The nacelle is mainly metal (steel, copper, aluminium, etc.) with a metal/plastic/glass-reinforced plastic (GRP) body, while the blades can be made of a matrix of glass-fibre reinforced polyester or wood-epoxy or similar composite materials. The turbine parameters can be seen in **Table 3.1**.

Table 3.1: Turbine Parameters

Turbine Parameter	**Assessment Envelope**
Turbine Blade Tip Height	135 m
Rotor Diameter	117 m
Hub Height	76.5 m

The turbine will be equipped with Serrated Trailing Edge (STE) technology as standard. This design feature mitigates noise emissions by effectively breaking up turbulence into smaller eddies, reducing the intensity of pressure fluctuations and lowering noise emissions by approximately 2.5 dBA without reducing energy output. Additionally, the turbines have software incorporated so that sound power levels can be reduced, allowing for operation in Sound Optimized Modes (SO1 and SO2) to ensure strict compliance with established noise limits under specific wind conditions.

3.2 Site Access and Turbine Delivery Route (TDR)

There is a total of 14 proposed site entrances associated with the Proposed Development: consisting of **5 no. new site entrances opening out onto public roads and the upgrading of 9 existing entrances and the widening of 1 no.**

junction located on the R314. Works will include the removal of existing vegetation for visibility splays and widening to facilitate the use of each entrance for the delivery of construction materials and turbines to the Wind Farm Site.

The locations of each of these entrances are detailed in **Figure NTS-3**.

The Turbine Delivery Route and the Construction Haul Routes will utilise Site Entrance 1-14, refer to **Figure NTS-3**.

The site entrances are shown on **Figure NTS-3.**

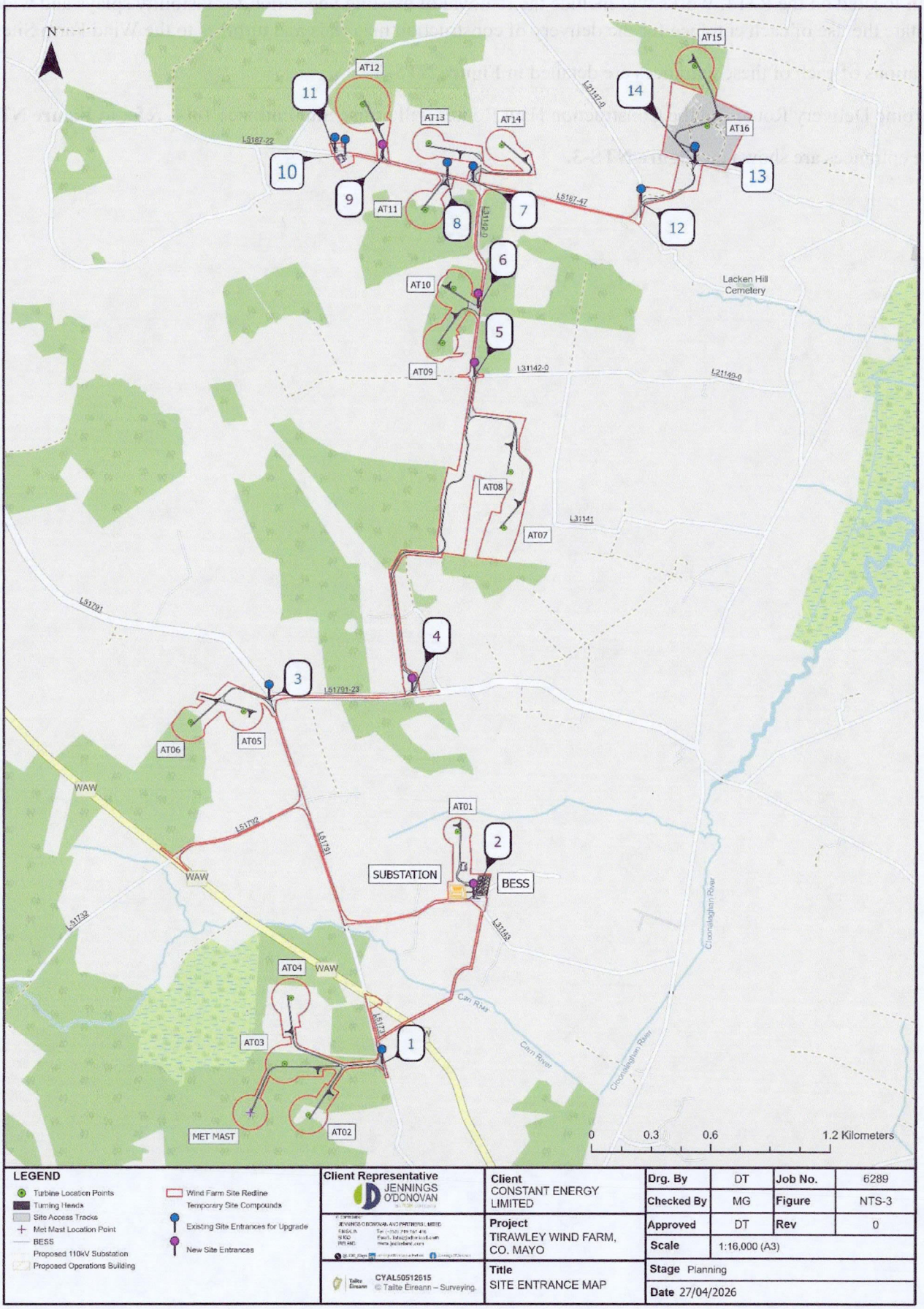


Figure NTS-3: New and Existing Site Entrances

Response from MLavelle: This Figure NTS-3 is not sufficient to analyse the existing or proposed entrances.

It is proposed that the turbine components including rotor blades, towers, nacelles, hubs and drivetrains will be landed by ship and stored for transportation at the final chosen port/harbour. The EIAR has considered three possible TDRs:

Option 1: It is proposed that turbine nacelles, tower hubs and rotor blades will be landed in Killybegs Port (Donegal). From there, they will be transported to the Wind Farm Site via the R263, N56, N15, N4, N59, L-1141, R294, L-1119, N59, L-1108, R315, L-51722, L-51732 and the R314 as shown on **Figure NTS-4.**

Option 2: It is proposed that turbine nacelles, tower hubs and rotor blades will be landed in Galway Port (Galway). From there, they will be transported to the Wind Farm Site via the R339, R336, N83, N17, N5, L-1331, N5, N58, N26, N59, L-1108, R315, L-51722, L-51732 and the R314 on **Figure NTS-5.**

Option 3: It is proposed that turbine nacelles, tower hubs and rotor blades will be landed in Foynes Port (Limerick). From there, they will be transported to the Wind Farm Site via the N67, N69, N18, M18, M17, N17, N5, L-1331, N5, N58, N26, R294, N59, L-1108, R315, L-51722, L-51732 and the R314 as shown on **Figure NTS-6.**

Delivery of turbines to the Wind Farm Site will require co-ordination with a number of statutory bodies including Transport Infrastructure Ireland (TII) Mayo County Council, and An Garda Síochána.

The EIAR has assessed the above three options with a particular focus on the final leg of the TDR between the Wind Farm Site and the Northern part of Ballina town Co. Mayo.

Figure NTS-4 to NTS-6: Proposed Turbine Delivery Haul Route Options

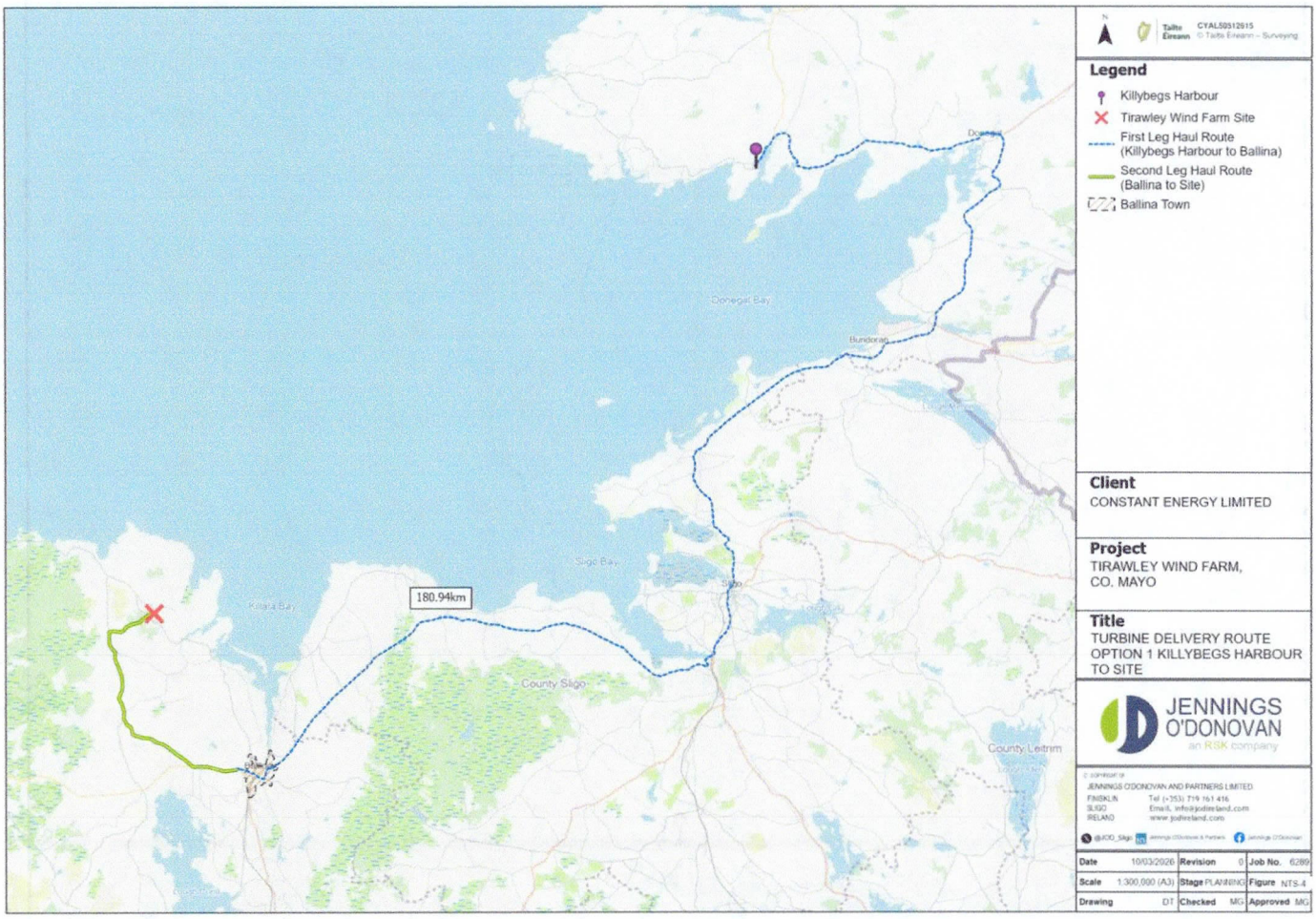
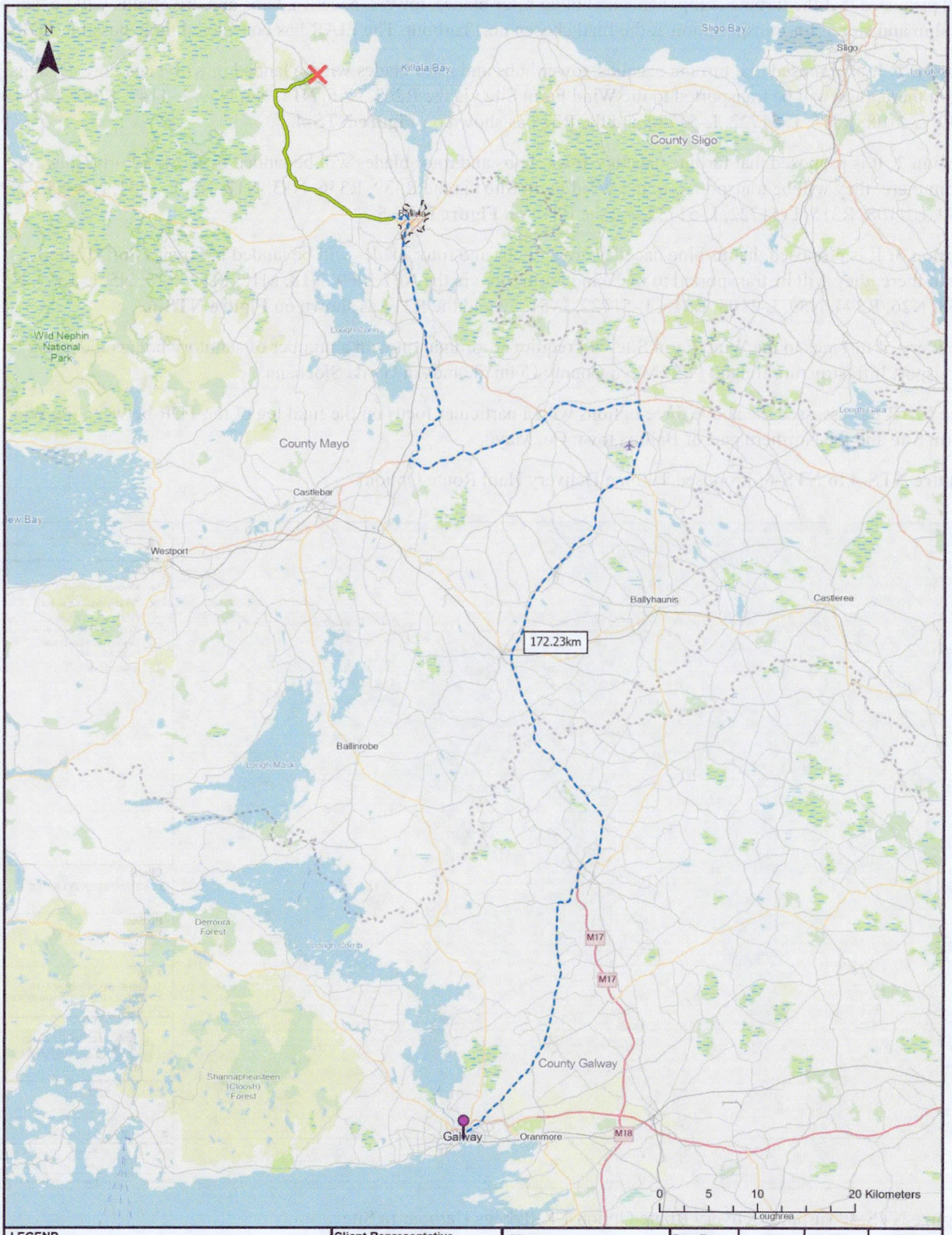


Figure NTS-4: Turbine Delivery Route Option 1 Killybegs Harbour to Site



LEGEND

- Galway Port
- Tirawley Wind Farm Site
- Haul Route Option 2 (Galway Port)
- Second Leg Haul Route (Ballina to Site)
- Ballina Town

Client Representative
JENNINGS O'DONOVAN

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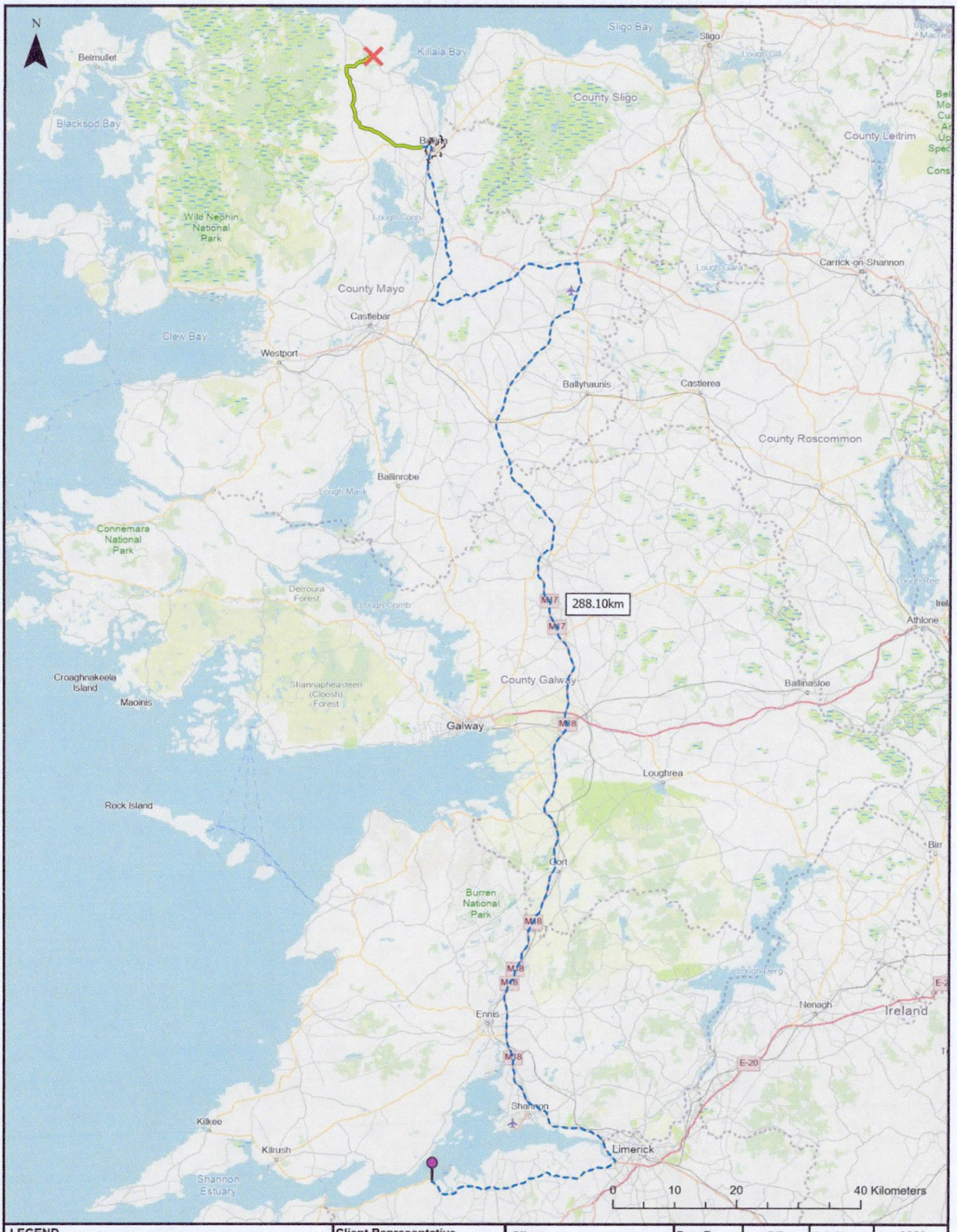
Client CONSTANT ENERGY LIMITED.	**Drg. By**	DT	**Job No.** 6289
	Checked By	MG	**Figure** NTS-5
Project TIRAWLEY WIND FARM, CO. MAYO	**Approved**	DT	**Rev** 0
	Scale	1:340,000 (A3)	
Title TURBINE DELIVERY ROUTE OPTION 2 GALWAY PORT TO SITE	**Stage** Planning		
	Date 10/03/2026		



LEGEND

- Foynes Port
- Tirawley Wind Farm Site
- Haul Route Option 3 (Foynes Port)
- Second Leg Haul Route (Ballina to Site)
- Ballina Town

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Project
TIRAWLEY WIND FARM, CO. MAYO

Title
TURBINE DELIVERY ROUTE OPTION 3 FOYNES PORT TO SITE

Drg. By	DT	**Job No.**	6289
Checked By	MG	**Figure**	NTS-6
Approved	DT	**Rev**	0
Scale	1:540,000 (A3)		
Stage	Planning		
Date	10/03/2026		

Figure NTS 6: Turbine Delivery Route Option 3 Foynes Port to Site

3.3 Grid Connection Route (GCR)

Connection will be sought from the grid system operators by application to EirGrid. The substation will connect via underground 110 kV cable at the existing Tawnaghmore 110 kV substation. The cable will connect into existing infrastructure within the confines of the substation and its compound.

The overall length of the grid connection between the Wind Farm substation and the existing Tawnaghmore 110 kV substation is 13.55 km, of which 12.43 km is located along the public road corridor and 1.12 km is located within the Killala Business Park grounds. The route of the above Grid Connection is provided in **Figure NTS-7.**



LEGEND

- Met Mast Location Point
- Turbine Location Points
- Tawnaghmore 110kV Substation
- Proposed 110kV Grid Route
- BESS
- Proposed 110kV Substation
- Proposed Development Redline

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Project
TIRAWLEY WIND FARM, CO. MAYO

Title
PROPOSED GRID CONNECTION ROUTE

Drg. By	DT	**Job No.**	6289
Checked By	MG	**Figure**	NTS-7
Approved	DT	**Rev**	0
Scale	1:30,000 (A3)		
Stage	Planning		
Date	10/03/2026		

Figure NTS-7: Proposed Grid Connection Route

3.4 Construction Phase

The first phase of the Proposed Development will comprise the construction phase. This phase will begin with site preparation works and will be complete when the turbines are built and ready for commissioning, and when all wastes have been removed from the Wind Farm Site. For this Proposed Development, it is envisaged that the construction phase will last approximately 21 months. An indicated construction program is set out at **Table 3.2**.

Table 3.2: Indicative Construction Programme

Activity	Month														
	0-7					7-14					14-21				
Site Establishment/ Felling and Fencing	X	X													
Internal Site Access Track Construction		X	X	X	X										
Substation & Compound Construction				X	X	X	X								
Substation Electrical Works									X	X	X	X	X	X	
Substation Commissioning										X					
Excavation & Construction of Turbine Foundations & Hardstands		X	X	X	X	X	X	X	X						
Internal Cabling Installation								X	X	X					
Turbine Delivery and Erection										X	X				
Grid Connection									X	X	X	X	X		
Energisation														X	
Turbine Commissioning														X	X
Site Restoration														X	X

It should be noted that, during the Wind Turbine erection phase, operations will need to take place outside those hours to facilitate Turbine Foundation construction and so that lifting operations are completed safely. Hours of working for Turbine Foundation construction will be agreed with Mayo County Council prior to the commencement of Turbine Foundation construction.

The Developer will appoint a civil contractor who will have overall responsibility for management, including environmental management on the construction site. The civil contractor will ensure that construction activities are carried out in accordance with the mitigation measures outlined in the EIAR and as required by the planning permission, such as the Construction Environmental Management Plan (CEMP) included in **EIAR Appendix 2.1.** The services of specialist advisors will be retained as appropriate, such as an archaeologist and ecologist, to be called on as required to advise on specific environmental issues. An estimated 45 to 63 jobs will be created through the construction phase of the Project.

3.5 Site Restoration

The Biodiversity and Enhancement Management Plan (BEMP) is presented in **EIAR Appendix 6.4**. The primary objective of the Plan is to preserve and enhance an area of blanket bog habitat (3.94 ha) to offset the loss of similar

habitat (0.68 ha) at the wind turbine AT13 location. The BEMP will also provide mitigation for loss and disturbance to other habitats and species as a result of the Proposed Development.

The Plan area comprises the entire of an abandoned commercial quarry at Castlelackan Demesne other than the ground required to facilitate the AT16 turbine and the Site Access Track. The disused quarry, which is within the north-eastern sector of the Proposed Development site, supports relatively intact blanket bog, as well as tall willow scrub, ponds and various recolonising habitats since the quarrying activities. While a sector of the quarry will be used for peat and soil deposition derived from the Wind Farm construction works, these areas will later be incorporated into the Plan area as meadow grassland and native woodland. Overall, it is anticipated that over time the biodiversity value of the site will increase substantially for habitats and associated flora and fauna species.

The Plan is underwritten by a detailed monitoring programme, which will allow modifications to ensure that the objectives are being achieved.

3.6 Operational Phase

The operational lifespan for the Proposed Development is 35-years. During the operational phase, Wind Turbine and infrastructure maintenance will be ongoing and regular. The Proposed Development will create approximately between one and two full-time jobs during the operational phase. In addition to these jobs, various personnel will be required for the successful and continued operation of the Wind Farm Site. During the operational phase of the Proposed Development, the operation and reliability, maintenance (Wind Turbines, civil works and electrical infrastructure) finance, ongoing compliance with permissions and permits, safety, security, community relations and benefits and land-owner agreements must be continually managed. These requirements are widely distributed over various employment sectors and are an integral part of the ongoing operation of the Proposed Development and will provide continuous employment for the lifetime of the Wind Farm Site.

4 SITE SELECTION AND DESIGN

The process of identifying a suitable area for a wind farm is influenced by a number of factors. The key policy, planning and environmental considerations for the selection of a potential Wind Farm Site included:

- Site location relative to Mayo County Council's ('the Council') Renewable Energy Strategy (RES) classification of areas considered suitable for wind farm development;
- Low population density;
- Consistent wind speeds;
- Protection of visual amenity;
- Low potential for impact on designated National and European sites;
- Located outside areas designated for protection of ecological species and habitats;
- Access to the national electricity grid possible within a viable distance; and
- Sufficient area of unconstrained land that could potentially accommodate wind farm development and turbine spacing requirements.

5 LEGAL AND POLICY FRAMEWORK

The Proposed Development has had regard to The National Planning Framework, The Regional Spatial and Economic Strategy (RSES) for The Northern and Western Regional Assembly Area and the Mayo County Development Plan 2022-2028. These documents are relevant to the determination of the planning application by An Coimisiún Pleanála (the Commission). **Chapter 4: Planning Policy** of the EIAR sets out the relevant planning policy and legislative background to the planning application.

In order to facilitate the accelerated deployment of renewable electricity infrastructure and to achieve the national targets outlined in the Climate Action Plan 2025, the National Planning Framework (NPF) 2025 establishes regional renewable energy capacity allocations. These allocations are to be embedded within the Regional Spatial and Economic Strategies (RSES) and the corresponding Regional Renewable Energy Strategies, and subsequently disaggregated into county-level targets to inform the preparation of city and county development plans. The additional renewable power capacity allocation for onshore wind for the Northern and Western Region is 1,389 MW.

Lands classified under the Council's RES's tiered strategic wind energy strategy are considered 'the most appropriate for renewable energy developments'. The definitions of the on-shore wind energy classifications, as per the Mayo Renewable Energy Strategy 2011 – 2022 are outlined below –

- **Priorities Areas** are areas which have secured planning permission and where on-shore wind farms can be developed immediately.

- **Tier 1 – Preferred (Large Wind Farms)** are areas in which the potential for large wind farms is the greatest.

- **Tier 1 – Preferred (Cluster of Turbines)** are areas identified as being most suitable for smaller clusters of wind turbines (clusters of up to three to five turbines depending on site conditions and visual amenities.

- **Tier 2 – Open for Consideration identifies** areas which may be considered for wind farms or small clusters of wind turbines but where the visual impact on sensitive or vulnerable landscapes, listed highly scenic routes, scenic routes, scenic viewing points and scenic routes will be the principal considerations. The Tier 2 classification will be reviewed by the Council following a determination by EirGrid of grid infrastructure for the County.

The final Wind Farm Site layout comprises of a mix of areas classed as Tier 1, Tier 2 and non-designated area. Of the 16 no. turbines, 3 no. turbines are in a 'Tier 1 Preferred Large Windfarms' area, 8 no. turbines are within an area 'Open for Consideration' and **5 no. turbines are on a non-designated area. However, these 5 no. turbines are within 820 m of a designated area.**

The Mayo Renewable Energy Strategy (RES) allows for renewable developments on unclassified lands, stating they will be assessed on their individual merits under the principles of proper planning and sustainable development.

The EU produced the Renewable Energy Directive (REDI) 2009/28/EC, to make the EU a global leader in renewable energy and ensure that the target of the final energy consumption being at least 16% renewables by 2020 and 27% renewables are met by 2030. In 2015, the EU set itself a long-term goal of reducing greenhouse gas emissions by 80-95%, when compared to 1990 levels, by 2050. Under the 2009 Renewable Energy Directive (REDI), Ireland committed to produce at least 16% of all energy consumed by 2020 from renewable sources. Ireland did not meet its 2020 target for overall Renewable Energy Share resulting in Ireland being obligated to acquire statistical transfers of 3.3 TWh of renewable energy from other Member States to compensate for this shortfall.

In 2023, the European Union (EU) adopted an amendment of the Renewable Energy Directive, which is referred to as "RED III". RED III obliges Member States to collectively ensure the share of renewable energy in the European Union's gross final energy consumption is at least 42.5% by 2030, with an additional 2.5% indicative top-up to allow the target of 45% to be achieved.

RED III also places the presumption of imperative reasons of overriding public interest (IROPI) for renewable energy projects on a permanent footing. Article 16f states that Member States must ensure that in the permit-granting procedure, the planning, construction and operation of renewable energy plants, their connection to the grid, the grid itself and storage assets are assumed to be IROPI.

[2026] IEHC 65 [H.JR.2025.0001283] JUDGMENT of Humphreys J. delivered on Tuesday the 10th day of February 2026

SHEILA HOCTOR, PATRICK CARNEY, JOHN DOOLEY, MICHAEL MAHON AND REGINA HOCTOR APPLICANTS AND AN COIMISIÚN PLEANÁLA RESPONDENT AND CARRIG RENEWABLE ENERGY LIMITED

"The assessment of public safety is a matter for the statutory decision - takers."

SAFETY, HEALTH AND WELFARE AT WORK ACT 2005 Number 10 of 2005

Liability of directors and officers of undertakings.

80.—*(1) Where an offence under any of the relevant statutory provisions has been committed by an undertaking and the doing of the acts that constituted the offence has been authorised, or consented to by, or is attributable to connivance or neglect on the part of, a person, being a director, manager or other similar officer of the undertaking, or a person who purports to act in any such capacity, that person as well as the undertaking shall be guilty of an offence and shall be liable to be proceeded against and punished as if he or she were guilty of the first-mentioned offence.*

Response from MLavelle: The Carrig Hill HC Decision determines that Public Safety is the responsibility of the decision-taker. The HSE, the competent Authority on health in Ireland determines that there are health issues in relation to windfarms. Thus, any decision is subject to the Precautionary Principle & should be refused. The alternative places the ACP Inspector at risk of prosecution for negligence. Such a prosecution is under the criminal code & ACP insurance doesn't cover such a conviction. A criminal conviction has repercussions for future travel to many countries.

Reference 2025: C3S/ECMWF and WMO, 2026: C3S-WMO European State of the Climate 2025, climate.copernicus.eu/ESOTC/2025, doi.org/10.24381/zy93-sb27

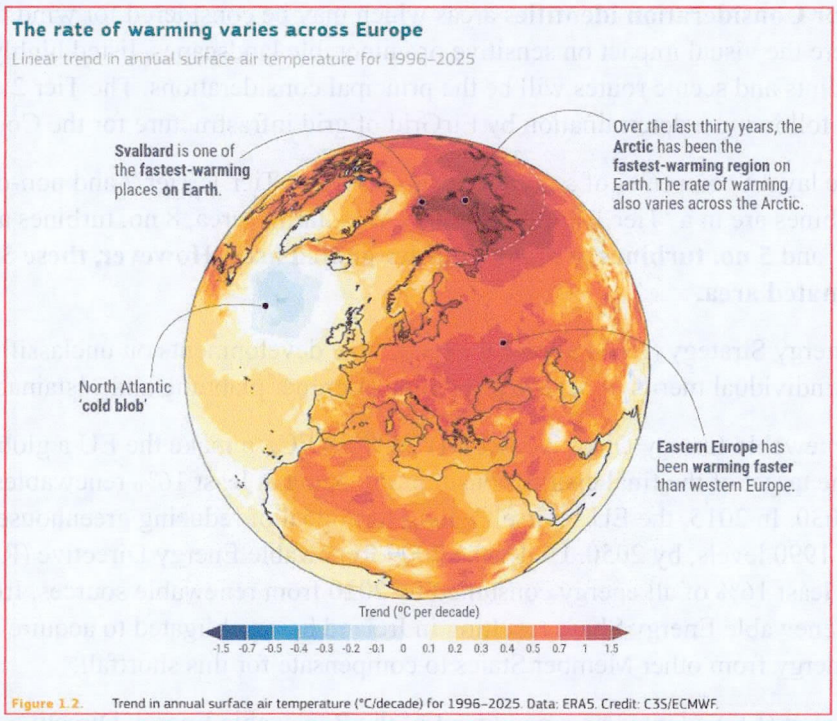


Figure 1.2. Trend in annual surface air temperature (°C/decade) for 1996–2025. Data: ERA5. Credit: C3S/ECMWF.

Note that Ireland has not experienced an increase in surface air temperature 1996 – 2025. Note that Ireland was classified as "Hibernia" [Always Winter & hibernation refer] by the Romans almost 2,000 years ago. We basically have always been cold as a result of being beside the North Atlantic Cold Blob. Adopting Policies that are based on other country issues is not democratic.



National temperature statistics and rankings for 2025 across WMO RA VI (Europe)

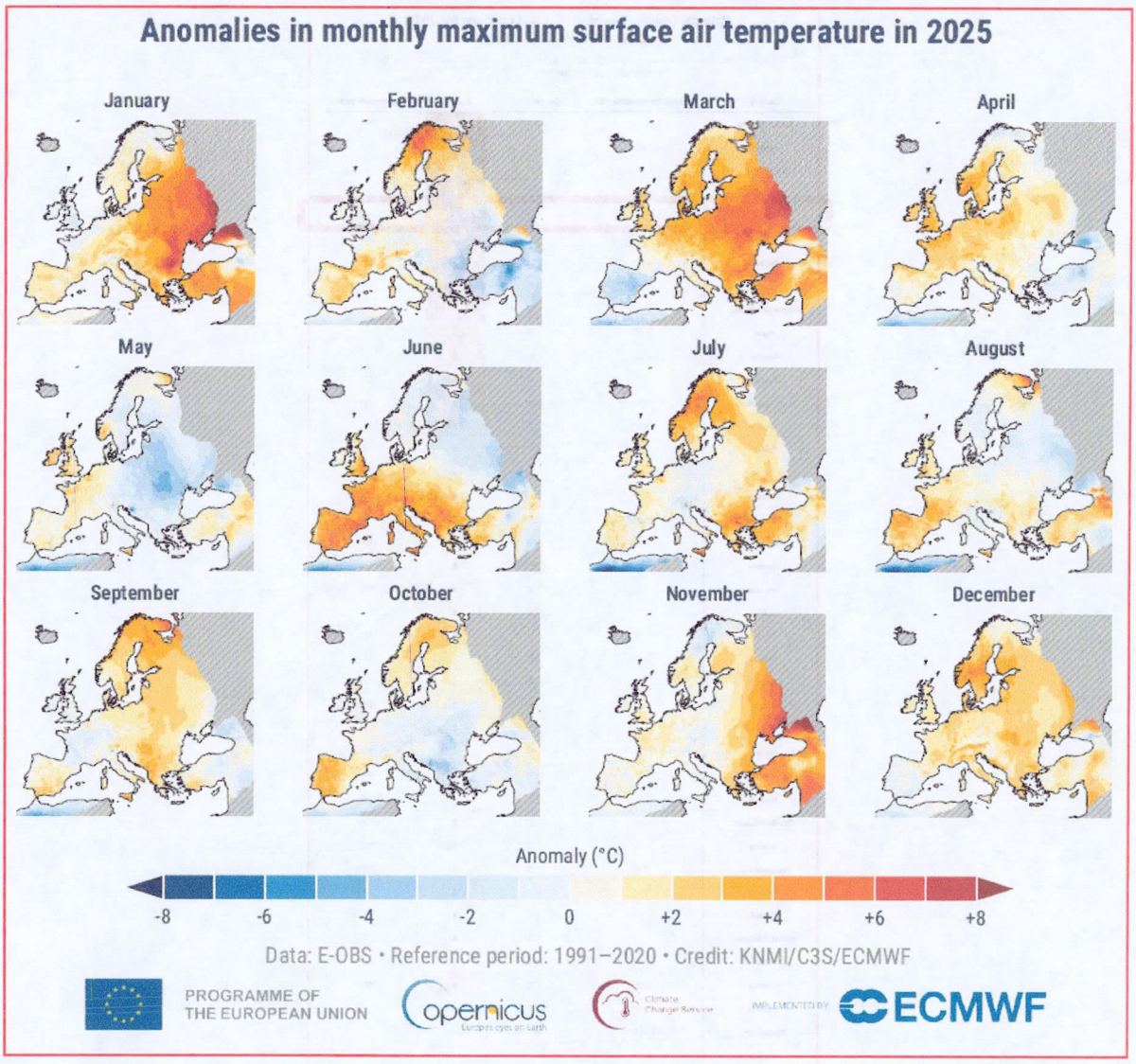
Countries are ordered by the ranking for 2025. Click on a column to sort by a different variable, or use the search bar to find a specific country's statistics.

Country	Average temperature (°C)	Anomaly (°C)	Ranking	Year records began
United Kingdom	10.00	0.95	1	1884
Norway	3.40	1.50	1	1901
Kazakhstan	8.80	2.57	1	1941
Iceland	5.20	1.10	1	1874
Ireland	11.14	0.97	2	1900
Sweden	6.52	1.46	2	1860
Finland	4.50	1.60	2	1900
Cyprus	20.00	1.90	2	2000
Austria (Mountains)	-	1.30	2	1768
Spain	15.00	1.10	3	1961
Estonia	6.00	1.60	3	1922
Bulgaria	-	1.20	3	1930
North Macedonia	12.50	0.80	3	1981
Croatia	14.50	1.1	3	1961
France	14.00	1.05	4	1900
Latvia	6.00	1.20	4	1924
Denmark	9.60	1.00	4	1874
Belgium	12.00	1.00	4	1833
Switzerland	-	1.20	4	1864
Slovenia		1.10	4	1950
Romania	11.95	1.22	4	1901
Andorra	11.90	1.30	4	1951
Italy	14.21	1.03	4	1961
Portugal	16.47	0.81	5	1931
Lithuania	-	1.00	5	1961
Israel		1.10	5	1950
Türkiye	15.10	1.00	5	1971
Syria	19.40	1.30	5	1996
Belarus	8.50	1.30	6	1881
Armenia	7.20	1.00	6	1935
The Netherlands	11.40	0.90	7	1900
Hungary	11.78	1.05	7	1901
Luxembourg	10.50	0.70	8	1947
Germany	10.10	0.80	8	1881
Slovakia	-	0.90	8	-
Austria (Lowlands)		0.80	8	
Poland	9.5	0.8	9	1951
Czechia	14.3	0.50	3	1961
Moldova	10.50–12.50	1.60–2.90	-	-
Montenegro	7.70–19.00	1.00–2.20	-	-
Ukraine	10.40	1.40	-	-
Russia (Europe)	-	1.70	-	1999

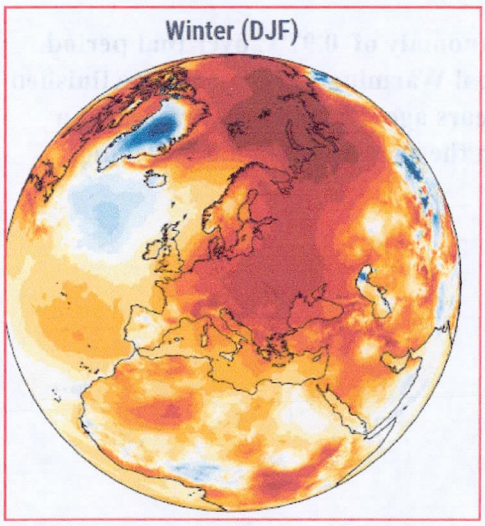
Ranges indicate the stations with the lowest and highest temperature/anomaly.

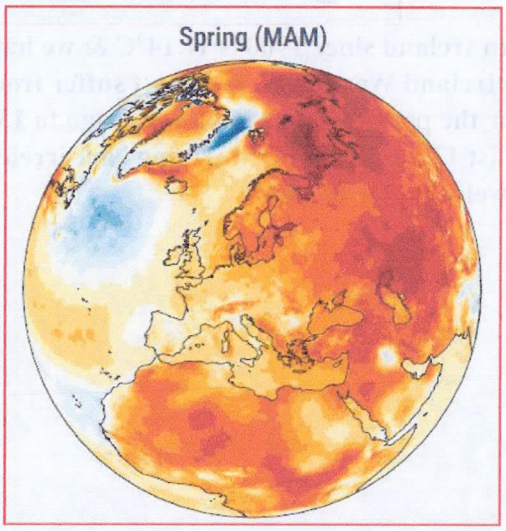
Data: Statistics reported by the national meteorological and hydrological services to the World Meteorological Organization • Reference period: 1991–2020 • Credit: NMHSs/WMO/C3S/ECMWF

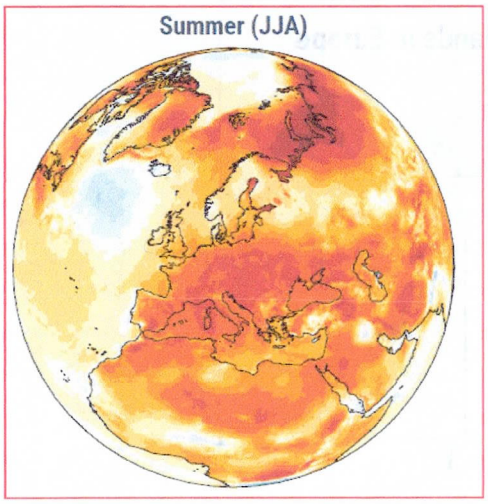
The average temperature in Ireland since 1900 is 11.14^{0}C & we have an anomaly of 0.97^{0}C over that period. We could do with a bit of "Ireland Warming". We don't suffer from Global Warming. Our last ice age finished about 13,000 years ago. For the period from 27,000 years ago to 13,000 years ago, Ireland was covered by a 1km high ice glacier. The last 13,000 years of "warming" are irrelevant in the context of Global Warming. Climate change would be welcome for Ireland.

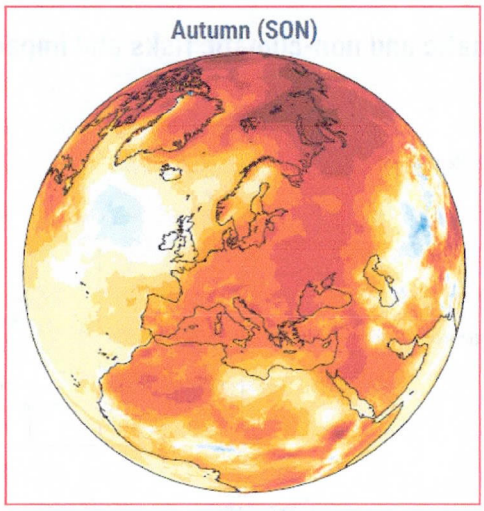


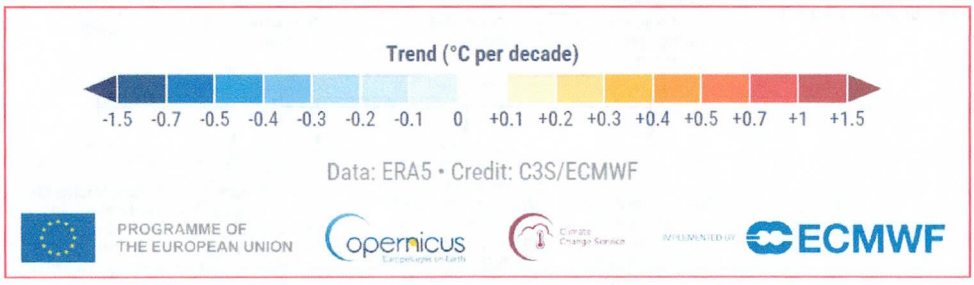
Linear trend in surface air temperature during 1996–2025.

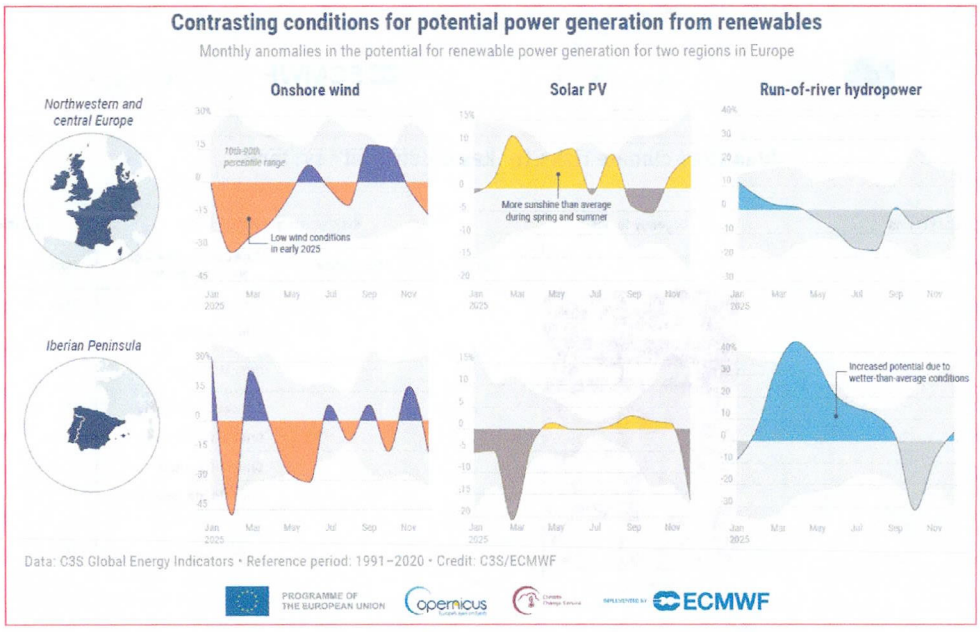












Note the low wind onshore wind in early 2025.

Climatic and non-climatic risks and impacts on peatlands in Europe

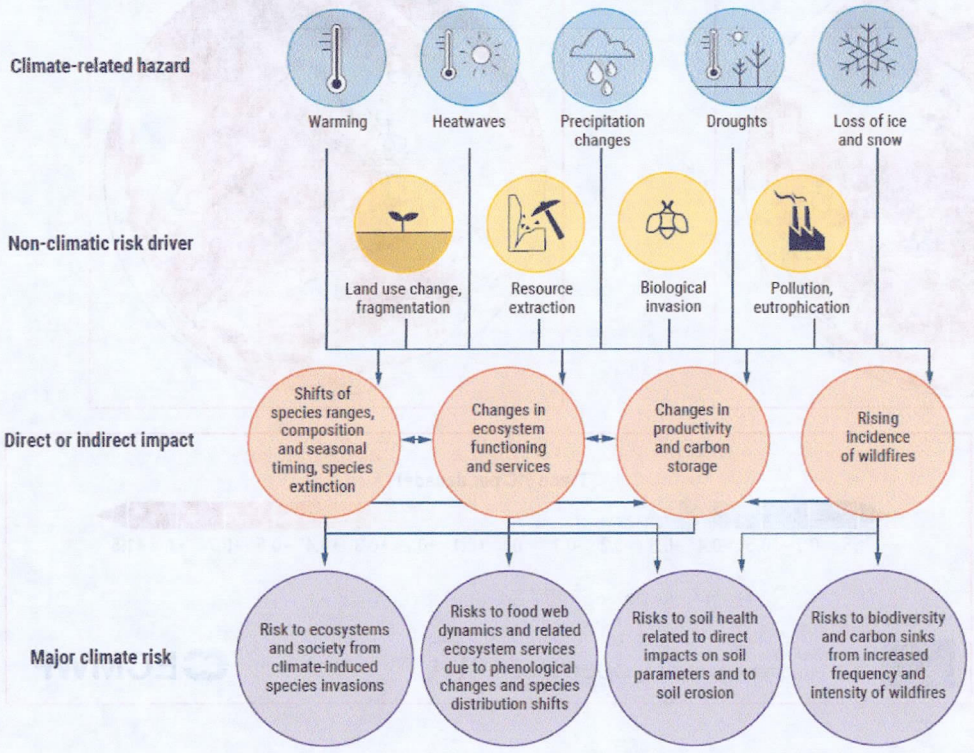


Figure adapted from EEA 'Annual European Union greenhouse gas inventory 1990–2021 and inventory report 2023'.

Identified climate risks for key biodiversity systems

Climate risks for ecosystems	Urgency to act	Risk severity			Policies	
		Current	*Mid-century*	*Late century (low/high warming scenario)*	*Horizon*	*Readiness*
Coastal ecosystems	Urgent action needed	Critical •••	Critical •••	Critical/Catastrophic •••	Medium	Medium
Marine ecosystems	Urgent action needed	Critical •••	Critical •••	Critical/Catastrophic ••	Medium	Medium
Biodiversity/carbon sinks due to wildfires (hotspot region: southern Europe)	Urgent action needed	Critical •••	Critical ••	Critical/Catastrophic ••	Medium	Medium
Biodiversity/carbon sinks due to wildfires	More action needed	Substantial •••	Critical ••	Critical/Catastrophic ••	Medium	Medium
Biodiversity/carbon sinks due to droughts and pests	More action needed	Substantial •••	Critical ••	Critical/Catastrophic ••	Long	Medium
Species distribution shifts	More action needed	Substantial •••	Critical ••	Critical/Catastrophic ••	Medium	Medium
Ecosystems/society due to invasive species	More action needed	Substantial •••	Critical ••	Critical/Catastrophic ••	Medium	Medium
Aquatic and wetland ecosystems	More action needed	Substantial •••	Critical ••	Critical ••	Medium	Medium
Soil health	More action needed	Substantial •••	Substantial ••	Substantial/Critical ••	Medium	Medium
Cascading impacts from forest disturbances	Further investigation	Substantial •	Critical •	Critical •	Long	Medium

Low confidence (•) Medium confidence (••) High confidence (•••)

Data: EUCRA • Credit: EEA/C3S/ECMWF

6 POPULATION AND HUMAN HEALTH

Chapter 5: Population and Human Health following desk-based collection of data and consultation with local stakeholders. Four geographical Study Areas were outlined for this assessment, namely:

- Study Area 1: The Wind Farm Site and Environs – Electoral Divisions (EDs) Ballycastle, Killala, Lackan North and Lackan South (160.09 km2)
- Study Area 2: Mayo County (5,587 km2)
- Study Area 3: Northern and Western Region Assembly: Cavan, Donegal, Leitrim, Galway, Mayo, Monaghan, Roscommon and Sligo (25,800 km2)
- Study Area 4: The Republic of Ireland (70,273 km2)

Population and Settlement Patterns: The Proposed Development does not contain a housing or services element and is not considered to have any direct positive or negative effect on the local or regional population levels. There is, however, a benefit to the region in terms of the ability to provide a high-quality supply of electricity to industry and business, which may increase employment opportunities and attract companies to County Mayo. While construction workers who are not based locally may temporarily relocate to the region during the initial construction and decommissioning phases, this effect on local population dynamics is considered to be imperceptible. The predicted effect on immediate settlement and social patterns is also slight to non-existent.

During the construction phase, there is potential for short-term, limited effects on residential amenity, primarily relating to an increase in construction traffic, noise, and dust. These effects are defined as slight negative in the construction and decommissioning phases and imperceptible in the operational phase. Overall, the construction phase is predicted to be slight positive and short-term in nature should workers relocate to the area. For the operational phase, the effect is predicted to be slight positive at the local level in terms of settlement patterns where increased business is attracted to the area. No likely adverse significant effects are predicted on population and/or settlement patterns.

Economic activity: The construction phase of the Proposed Development will generate economic effects through expenditure on site preparation, access tracks, and the purchase of materials and equipment. A peak workforce of approximately 45-63 workers is expected, with labor and materials, such as concrete and stone, sourced from the local area where possible. Employment will be created and maintained across local, regional, and international levels throughout the project's lifetime. Additionally, employees during both the construction and operational phases are likely to use local shops, restaurants, and accommodation, resulting in a slight positive effect on employment in the study areas.

The Proposed Development has the potential to bring significant positive benefits to local communities by supporting sustainable employment and contributing annual rates between €770,560 and €908,160 to the local authority. Furthermore, a community benefit fund will be established under the RESS programme, estimated to provide an average of €341,121 per annum to the local community for 15 years. The overall economic effect is predicted to be moderate, positive, and short-term during construction, and moderate, positive, and long-term during the operational phase. No likely adverse significant effects are predicted on economic activity.

There are 266 properties within 2 km of the proposed turbines. The closest inhabited dwelling to a V117 turbine not associated with the Proposed Development (H3) is located 554 m from the nearest turbine (AT08). The V117 turbine with a 135 m blade tip height (4 x 135 m = 540 m) maintains 540 m housing buffer.

Response from MLavelle: The issue of "not associated with the proposed development" is irrelevant. Who will pay for the medical bills into the future? This is untrue. AT01 – H2 = 322m: AT01 – H6 = 567m: AT01 – H5 =559m: AT05 – H4 = 555m: AT06 – H4 = 558m: AT08 – H3 = 555m: AT11 – H1 =541m: AT12 – H1 = 265m: AT13 – H1 = 465m.

Houses H1 from Turbine 13, H2 from Turbine 2 are separated by less than 540m. House H1 is affected by Turbines 11, 12 & 13. House H4 is affected by Turbine 5 & 6. Having turbines making noise from different directions reminds on of Phil Spector's "Wall of Sound". The resultant noise will be continuous. The wake effects will be exacerbated by this. Birds & Bats will be affected by this wall of noise.

The Wind Farm Site covers an area of c. 108.06 ha. Topography across the Wind Farm Site is variable, ranging from ~20 to 155 mOD (meters above Ordnance Datum). The north and center of the Wind Farm Site are located on elevated ground. The greatest elevations are found in the north of the Wind Farm Site, which is situated on the southeastern slopes of Knockboha Hill, which stands at an elevation of ~186 mOD. There are also several other local high points further to the south which range in elevation from ~108 to 137 mOD. Meanwhile, the southern section of the Wind Farm Site is located on lower ground with topography sloping gently to the southeast towards Cloonaghmore Estuary and Killala Bay.

Response from MLavelle: Folio MY40485F indicates an area of 195.38ha, which includes 5 Turbines. These 5 turbines occupy far more than 108.06ha. No other Folio maps are shown with turbine locations. These areas are not coloured blue. Are the planning fees based on site area? And should this site area refer to the area coloured blue, which is excluded?

The Wind Farm is comprised of blanket bog, coniferous forestry, transitional woodland scrub and agricultural pastures.

5.3.5 Tourism and Amenities

5.3.5.1 Tourist Attractions

Study Area 1: Development Site and Environs (10 km)

The scenic route of the Wild Atlantic Way runs proximate to the Proposed Development. Discovery Points along the route and in the vicinity of the Proposed Development are Downpatrick Head to the north, Céide Fields to the northwest, Lackan Strand to the east and further south Killala Quay.

The Study Area does contain a number of other key attractions also (**Table 5.7**).

Table 5.7: Selected Tourist Attractions Within the Study Area (10 km)

Tourist attraction	Location Description	Distance (km)
The Western Way	Section Through the Wind Farm Site	0
Eurovelo Atlantic's Coast Route	Throughout Ireland	1.5
Lackan Strand	South of Rathlackan	1.1
Rathfran Abbey	North of Killala	3.1
Downpatrick Head	North of Ballycastle	4.2
Ballycastle Beach	North of Ballycastle	4.5
Killala Round Tower	Killala	5.6
Ross Beach, Killala	North-east of Killala	5.7
Moyne Abbey	Southeast of Killala	8.6
Blanemore Forest Walk	East of Garranard	8.7
Céide Fields	West of Ballycastle	9.5

Several key tourism and recreational receptors are located within the vicinity of the Proposed Development. There are five attractions within 5 km of the Proposed Development.

The Western Way is a regionally significant long-distance trail of over 200 km extending from Oughterard to the Sligo border. The Proposed Development intersects only a small, localised section of the 32 km Ballycastle to Ballina

segment, which is a critical component of the emerging 'Céide Coast' experience. This coastal stretch utilises quiet country roads to link world-class heritage sites, including the Céide Fields and Downpatrick Head, with cultural landmarks such as the Killala Round Tower and the 1798 French route, Bothar Na Sop. By providing access to unique geological features and a vast Neolithic archaeological landscape, this section serves as a vital asset for public health through outdoor recreation and underpins the local economy via international tourism26. Other walking trails include the Kilcummin Loop Walks, the Ballycastle Loop Walk, the Moygownagh Loop Walk and the Belleek Nature Trail.

Historical and religious heritage sites also form a significant part of the regional tourism offering. The remnants of Rathfran Abbey (founded 1274) are located approximately 3.08 km east of the nearest turbine. Additionally, the Monasteries of the Moy Greenway facilitates access to other notable features such as Moyne Abbey and Rosserk Friary, which contribute to the area's recreational infrastructure and cultural identity.

North of the Wind Farm Site (approx. 4.2 km) is Downpatrick Head, a Signature Discovery Point on the Wild Atlantic Way. This site is of high visual and ecological value, featuring the *Dún Briste* sea stack and a unique vantage point over the Stags of Broadhaven.

The Eurovelo Atlantic's Coast Route is an 11,000 km long cycling trail that traverses the coastline of several countries along the western coast of Europe, including Ireland. The Celtic Coast section of this route follows a similar route to the Wild Atlantic Way within the study area, passing less than 1.5 km northeast of the nearest turbine.

The settlement of Killala, located 5.6 km south, functions as a picturesque tourism hub. Renowned for its intact Round Tower and its historical significance regarding the 1798 rebellion and General Humbert's landing at Kilcummin Pier, the village is a focal point for heritage-based tourism and local social interaction.

The Céide Fields and Visitor Centre are another discovery point located along the route of the Wild Atlantic Way, approximately 9.5 km northwest of the Proposed Development. The fields are the oldest known field system in the world, covered by a natural blanket bog with its own vegetation and wildlife. The opening of the new immersive visitor centre in 2022 was predicted to attract over 7,500 additional visitors by year 5 (2026) resulting in a total yearly figure of 38,000. The visitor centre is located off the R314 and features a viewing platform over the Atlantic Ocean.

The strategic importance of this coastline is further underscored by the 'Céide Coast experience' initiative. Supported by Fáilte Ireland and having secured Part 8 planning approval, this development is a key driver for raising the profile of North Mayo in international markets. The project will formalise public access to a series of high-value geological and heritage receptors, including the Glenurla Valley Waterfall, Polladarky Blow Hole, Léam Giant Stepping Stones, Doonfeeney Sea Arch, and Ballynacashlan Castle. The realisation of this trail represents a significant shift in the local socio-economic baseline, transitioning the area into a primary destination for national and international tourism. Consequently, the protection of the recreational amenity and the 'sense of place' associated with these specific sites is a key consideration for the long-term economic and social health of the local population.

Tourism is important to the local economy and tourism expenditure will help support local enterprises such as hotels, B&B, camping and caravan parks, shops, restaurants, public houses, golf clubs, and the visitor attractions themselves. Mayo, as a county, is a very popular destination for international and Irish tourists alike. Many areas that are important to the tourist industry of County Mayo owe their attraction to the abundance of natural resources, pristine environment and scenic landscape as well as renowned destinations such as Céide fields, Wild Nephin Ballycroy National Park, Croagh Patrick, Downpatrick Head, Knock Shrine, Westport/Clew Bay and Achill27.

The branding of Ireland's Atlantic coastline as the 'Wild Atlantic Way', provides an exceptional opportunity for the county to showcase its many attractions and activities along the county's Atlantic coast.

Tourism has been identified as a key economic sector for county Mayo. Alongside its existing tourist attractions, Mayo offers great opportunities for further development with the potential for significant job creation. The Mayo Tourism Strategy 'Destination Mayo 2016-2021' was developed to "*ensure a wider distribution of tourists to a range of tourist options that the County has to offer*", once successfully implemented. This would not only help to extend the tourism season, but also reduce pressure on established, more traditional tourist destinations and their infrastructure.

There are a number of policies and objectives, including development options, outlined in the Mayo CDP (2022-2028) which seek to promote tourism in the county. The CDP (2022) states, that three key tourism pillars were identified; "Firstly, the continued development and enhancement of our tourism product and the various categories of tourism

that bring visitors to Mayo. Secondly, ensuring that high quality services and accommodation are accessible and available for our visitors and thirdly, the identification of priority infrastructure designed to provide new and innovative activities and flagship products".

Also, Infrastructure and Visitor Services Policies TRP 23 states, "to support and promote sustainable tourism, accessible to all throughout County Mayo, and to work in partnership with tourism organisations and adjoining local authorities, where necessary, in securing the development of tourism enterprises and infrastructure, subject to suitable locations, where it can be demonstrated that the development will not have significant adverse effects on the environment, including the integrity of the Natura 2000 network, residential amenity or visual amenity".

5.3.5.2 Tourism: Numbers and Revenue

At the time of writing there is no available data providing a tourism breakdown for Study Area 1 or Study Area 2 from 2018 to date. Regional tourism performance figures for 2019 for the Northern and Western Region are provided below.

The Western Region includes the counties of Galway, Mayo and Roscommon. The region has a wealth of natural, cultural and heritage assets of national importance and is a significant tourist destination. Regional tourism performance figures for 2019 for the West Region records that overseas tourist numbers totalled 1,943,000 visitors in 2019 and tourism revenue (2019) accounted for €653,000,000 in the region from overseas tourists. Domestic visitors from Ireland and Northern Ireland accounted for 1,961,000 visits to the region in 2019, with €418,000,000 in revenue generated from Northern Ireland and domestic visitors28.

County Mayo's coast is also included in the '*Wild Atlantic Way*" which is one of the longest defined costal routes in the world. It was devised as a new '*experience*' and '*destination*' by Fáilte Ireland to present the west coast of Ireland as a compelling international tourism product. It has become an over-arching brand which individual destinations and businesses can trade collectively under with much greater potential visibility and clarity of message in the international marketplace29.

5.3.5.3 Tourist Attitudes to Windfarms

The first wind farm in Ireland was completed in 1992 at Bellacorrick, County Mayo and since then wind farms have elicited a range of reactions from Irish people (Failte Ireland, 2012). In 2012, 91% of overseas holidaymakers to Ireland rated scenery as an important part of a destination with natural/unspoilt environment also rated highly at 91%. The future sustainability of Ireland's tourism industry is therefore inextricably linked to the maintenance of the character and scenic qualities of the Irish landscape.31 Furthermore, Fáilte Ireland carried out research on Overseas Holidaymakers Attitudes to Ireland in 2018. Responses showed that holiday makers choice is based largely on '*beautiful scenery* (93%), followed closely by *plenty to do and see* (91%) and *friendly people* and *natural attractions* (88%)'32.

Fáilte Ireland Surveys 2007 and 2012

A study carried out by Fáilte Ireland, in association with the Northern Ireland Tourist Board (NITB), in 2007 surveyed both domestic and overseas holidaymakers to Ireland to determine their attitudes to wind farms33. In 2007, there were 67 wind farms connected to the national grid. The survey drew on many aspects of an earlier SEAI survey (carried out in 2002) including the photomontages of wind farms, and in particular, the landscape types that were used to elicit a reaction from respondents. The purpose of the survey was to assess whether or not the development of wind farms would impact on the visitors' enjoyment of Irish scenery. In 2012, this research was updated by Millward Browne Landsdowne on behalf of Fáilte Ireland to determine if there was any change in visitor attitudes during this period34.

The 2012 research carried out on behalf of Failte Ireland to update/ compared to the findings of the 2007 research,35 indicated that 47% of visitors felt an increased positive impact on landscape, compared to 32% in 2007. Negative responses also increased, showing 30% in 2012 against 17% in 2007. However, 49% of visitors felt that wind farms had no impact on the landscape in 2007 in comparison to 23% in 2012. It was notable that those interviewed who did not see a wind farm during their trip held more negative perceptions and opinions on wind farms to those that did. Of the wind farms viewed, the majority (59%) contained less than ten turbines in 2012, which was quite similar to 2007 (63%). Despite the fact that there has been an increase in the number of visitors who have seen at least one wind farm on their holiday, there was also a slight increase (from 45% in 2007 to 48%) in the number of visitors who felt that this had no impact on their sight-seeing experience. Importantly, and as has been seen in the previous research, the type of

landscape in which a wind farm is sited can have a significant impact on attitudes. Although 21% feel that wind farms have a fairly or very negative impact on sight-seeing, this figure increases substantially for wind farms in coastal areas (36%).

In this study, visitors were again asked to rate the beauty of five different yet typical Irish landscapes: coastal, mountain, farmland, bogland and urban industrial land, and then rate the scenic beauty of each landscape and the potential impact of siting a wind farm in each landscape. As in 2007, the results indicate that each potential wind farm and site must be assessed on its own merits, due to the scenic value placed on certain landscapes by the visitor and the preferred scale/ number of wind turbines within a wind farm. Looking across all landscapes, wind farms are seen to have an enhancing effect on the landscapes seen as less beautiful, particularly urban/ industrial and bogland.

Coastal areas (91%) followed by mountain moorland (83%) and fertile farmland (81%) continue to be rated as the most scenic, and unsurprisingly resistance is greatest to wind farms in these areas. For instance, there was a greater relative negativity expressed about potential wind farms on coastal landscapes (40%), followed by fertile farmland (37%) and mountain moorland (35%). On the other hand, less than one in four were negatively disposed to the construction on bogland (24%) or urban industrial land (21%). The majority of visitors also still favour large turbines (47%) over small turbines (28%), and in smaller numbers, with the option of five turbines proving the most popular, followed by two clusters of ten and finally wind farms of 25 turbines.

Seven out of ten (or 71%) visitors claim that potentially greater numbers of wind farms in Ireland over the next few years would have either no impact or a positive impact on their likelihood to visit Ireland (**Graph 5.1**). Of those who feel that the potentially greater number of wind farms would impact positively on future visits, the key driver is support for renewable energy, followed by potential decreased carbon emissions. Given the scenario where more wind farms will be built in Ireland in the future, the most widely held view is that this will not impact their likelihood to visit the area again, with a slightly greater majority saying that this would have a positive rather than a negative impact.

Wind Farms & Tourism Trends

In 2021, BiGGAR Economics published research findings, on research carried out in Scotland on 44 wind farms and tourism trends38. This research also re-examined 28 wind farms constructed between 2009 and 2015 that had been analysed in a previous study by BiGGAR Economics published in 2017, finding that the localities in which they were based had outperformed Scotland and their local authority areas in the majority of cases. This research has analysed trends in tourism employment in the localities of the 44 wind farms developed in recent years, providing a substantial evidence base. The study found no relationship between tourism employment and wind farm development, at the level of the Scottish economy, across local authority areas nor in the locality of wind farm sites.

5.5.6 Tourism

The Proposed Development includes both embedded design features and specific measures to safeguard the tourism and recreational amenity of the North Mayo region:

- **Western Way Diversions:** During the construction and decommissioning phases, clearly marked temporary diversions will be implemented where the trail intersects the Wind Farm Site. This ensures hiker safety and the continuity of the trail without significant interruption to the recreational experience.

- **Infrastructural Enhancements:** The upgrading of existing public roads within the Wind Farm Site as part of the Project's infrastructure will provide improved, more durable surfaces and enhanced drainage. These upgrades will remain in place during the operational phase, providing a localised long-term benefit for the Western Way and other recreational users.

- **Signage and Communication:** Advance warning signage and project information will be provided at key entry points to inform visitors of temporary works, ensuring that the wider "Céide Coast" and "Wild Atlantic Way" experiences are not negatively impacted.

- **Embedded Design:** Significant separation distances have been maintained between turbines and core tourism hubs, such as Downpatrick Head and Céide Fields, to ensure the integrity of the regional tourism brand.

Based on the landscape, visual and cumulative assessment (**Chapter 12: Landscape and Visual Amenity**) and the implementation of the mitigation measures outlined above, it is considered that there will not be any significant effects from the proposed Tirawley Wind Farm. Overall effects of the Proposed Development with regards to tourism are considered to be slight, negative during the construction, operational and decommissioning phases.

Response from MLavelle:

Reference 2020 : The impacts of onshore-windfarms on a UK rural tourism landscape: objective evidence, local opposition, and national politics Tom Mordue, Oliver Moss & Lorraine Johnston. Journal of Sustainable Tourism, 28:11, 1882-1904, DOI: 10.1080/09669582.2020.1769110.

Landscape: the heart of the issue

Terkenli (2014, p. 282) tells us that landscape is "a highly complex, synthetic, and controversial concept" which carries significant social resonance regarding place and identity, and is deserving of deeper understanding in the tourism literature, particularly from perspectives emphasising relationality. This means examining how landscapes, places, and spaces are made by relations within and between physical, biological, social, and cultural processes (cf. Murdoch, 2006).

Similarly, Carneiro et al. (2015, p. 1219) argue that relationality is under-researched in the tourism literature, particularly in relation to how landscape is made up of a diversity of complex values generating strong emotions that confer certain places with aesthetic privileges. Landscape, then, has a multiplicity of meanings which are simultaneously framed by sight and site in that it is an envisioning specific to particular places with physical attributes and boundaries that distinguish one place from others (see Daniels & Cosgrove, 1989, 2006; Wylie, 2007). This is not only about the local or touristic view of a particular landscape and place, it is a characteristically modern means of encountering and representing the external world in ways that connect the pictorial with territory and the individual onlooker with community. For Cosgrove (1984), landscape is an idea and within the "landscape idea", as he terms it, a moral authority emerges which "either denies collective experience….or mystifies it in an appeal to transcendental qualities of a particular area or region" (Cosgrove, 1984, p. 262). Williams (1973, p. 124) also alludes to this when he says: "It is into this complex of territorial establishment that we must re-insert the self-conscious development of landscape and what is called 'the invention of scenery'". Landscape is thus an impression, a powerful element integral to the social construction of place; and a visual signifier of what is "authentic" to a particular place or region (Carneiro et al., 2015). Because of this, siting onshore-windfarms always has implications for what is appropriate to a given landscape, especially in relation to who and what that landscape represents, what it should contain and consist of, and where its physical, social, and aesthetic boundaries lie.

By including the physical in this relational configuration we see landscape as being more than socially and aesthetically constructed, it is a "material-semiotic" assemblage of discourses and things (cf. Law, 2009). Thus, any landscape is a socio-natural–material integration of unique characteristics that create its place in the world (Gailing & Leibenath, 2015, p. 132). Furthermore, while landscapes are physically already there, they are personally and collectively embodied, and brought into being by people variously engaging in things like working on the land, everyday local life, "gazing" (Foucault, 1973; Urry, 1990), walking, mountain-biking, fishing, sailing, fell-running, and so on (see, Gailing & Leibenath, 2015; Ingold, 1993).

Critically, whomever has the power to speak for a landscape authors its content, its (re)presentation, and its boundaries within society (cf. Daniels & Cosgrove, 1989; Murdoch, 2006; Williams, 1973). These are key political as well as socially tangled relations, and if certain meanings of landscape can be stabilized for a period of time an exclusionary politics can be built that translates into the ordering and bordering of rural space (Mason & Milbourne, 2014), including rural tourist space. Which is an unstable process because, as already mooted, people–place attachments can vary within as well as across places. Meaning that local acceptance of energy installations can and do vary within and between places too (see Bailey et al., 2016; Devine- Wright & Howes, 2010; McLachlan, 2009). Landscape protection thus requires significant maintenance and vigilance on behalf of protagonists, which typically involves constructing a discursive "frontier between inside and outside" (Gailing & Leibenath, 2015, p. 127) where envisionings of the local past are invoked in order to safeguard a prescribed vision of the local future (Mason & Milbourne, 2014). By contrast, and by way of opposition, the environment and the environmental lobby, are not so easily envisioned, made concrete and tangible. They are more abstract, consisting of concepts that speak to the intellect more than the emotions and the embodied experience of everyday life. In short, regardless of how localities collectively make up the global network of places, landscape is relationally close while environment is relationally distant (Macnaghten & Urry, 1998).

Like Murdoch (2006), then, we see the local not only as a distinct place with unique landscape characteristics, but also a multi-dimensional staging post in a network of socio-spatial relations and interconnections that cross and pass

through local, regional, national, international boundaries, and cross-currents (cf. Casey, 2007; Layne, 2018). Any locality is more-or-less bound to other localities, spatial practices and scales of power in long or short, strong, or weak, network connections.

Which is not to suggest the local is merely an illustration of global forces, rather that it is an "important site unto itself" (Armstrong, 2014, p. 540) which is always evolving while always connected to other places and spaces. Defending the local landscape against the global in the onshore-windfarm/tourism issue is therefore not a simple binary opposition. It is more of an issue of bonding and dispersal in which successful resistance by one locality has implications for others, both in terms of siting onshore-windfarms elsewhere and pollution costs of not siting onshore-windfarms anywhere. Indeed, and as alluded to, a focus on such contested spatialities and nuances has received too scant attention in the literature generally (Brace & Geoghegan, 2011; Simcock, 2016; Walker et al., 2014), but more so with regard to the way in which wind energy, tourism, and local interests interact and/or conflict (Gaspar de Sousa & Kastenholz, 2015; Rudolph, 2014; Terkenli, 2014). This is where our analysis is positioned as we consult the various discourses and evidences derived from and through the research we conducted on behalf of NCC.

Table 3. Illustrative quotations regarding negative impacts of onshore-windfarms.

- Visitors do not like wind-turbines in such an area of outstanding beauty they are noisy and ugly to look at
- Visitors do not want to come to Northumberland because of Wind-turbines blighting the previous beautiful landscape and the noise
- Tourists come to Northumberland for beautiful unspoilt countryside, not to see huge wind-turbines in every direction

People's perception of Northumberland is of a wild and beautiful place and the wind-turbines have immediately destroyed this perception and are an ugly intrusion into the loneliness of the last wildernesses in England

- This county's assets – namely tranquillity/peace/landscapes is blighted by more than [its] fair share of windfarms. Def a turn off for visitors
- Regular guests have said they won't return because of the number of wind-turbines has spoiled the landscape
- People say they don't like them and we are ruining the countryside. They can't believe it
- Most people we meet hate turbines
- Potential visitors are put off because the inland areas they visit have been blighted by wind-turbines
- Many [visitor] comments are along the lines of an amazement that we do not appreciate the amazing landscape that we have and seem prepared to intrude turbines into many of the most iconic views
- Repeat business customers now going elsewhere, and new business customers have heard about the impact of OWTs on Northumberland.

Table 4. Illustrative quotations on whether onshore-windfarms will affect business investment decisions.

- I will not invest in something where visitors do not want to come because of the presence of wind-turbines
- It they continue, we will consider selling and moving to another part of the UK
- If tourists don't like them and numbers decrease why invest? I would rather invest in a Gite business in France!
- No point investing in our property if values will be affected
- My guests come here for its peace, tranquillity, silence and fantastic vistas. Ugly, useless turbines spoiling that will not help to attract business
- Will direct investment to other parts of the country
- People come to Northumberland top see the fabulous undeveloped countryside not look at vulgar man made monstrosities
- We have reached a stage where the turbines are affecting the landscape, more will make this a less desirable destination not worth investing in!
- Onshore windfarms are ruining the natural beauty of Northumberland, our guests will go elsewhere for a proper rural escape
- They are an eyesore as we live in the country at the moment we have fabulous views. If a windfarm was to set up. We would close our wedding business, sell up and 22 jobs would be lost. This would be because no one would want to get married with a view to those ugly things. You would kill our business off, devalue our property and ensure that jobs are lost in an area where there are few jobs to begin with
- We would consider buying property elsewhere to develop as tourism accommodation but not in any area where there is a windfarm

- Windfarms will be impossible to avoid and are an anachronism to those coming to enjoy big skies and landscapes
- If there will be more onshore wind-turbines planned in this area, we do not know if we want to stay here anymore/move the business elsewhere
- There's absolutely no point in putting money into a holiday property indeed into our own home as we'll never get the value back when we sell if an array of turbines are built as proposed near our village
- North Northumberland no longer offers the OWT free landscape required by many visitors.

Reference : The impacts of onshore-windfarms on a UK rural tourism landscape: objective evidence, local opposition, and national politics. Tom Mordue, Oliver Moss & Lorraine Johnston. Journal of Sustainable Tourism, 28:11, 1882-1904, DOI: 10.1080/09669582.2020.1769110.

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TOURISTS come to Northumberland for beautiful unspoilt countryside, not to see huge wind-turbines in every direction
People's perception of Northumberland is of a wild and beautiful place and the wind-turbines have immediately destroyed this perception and are an ugly intrusion into the loneliness of the last wildernesses in England
This county's assets – namely tranquillity/peace/landscapes is blighted by more than [its] fair share of windfarms. Def a turn off for visitors
Regular guests have said they won't return because of the number of wind-turbines has spoiled the landscape
People say they don't like them and we are ruining the countryside. They can't believe it
Most people we meet hate turbines
Potential visitors are put off because the inland areas they visit have been blighted by wind-turbines
Many [visitor] comments are along the lines of an amazement that we do not appreciate the amazing landscape that we have and seem prepared to intrude turbines into many of the most iconic views
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There's absolutely no point in putting money into a holiday property indeed into our own home as we'll never get the value back when we sell if an array of turbines are built as proposed near our village
North Northumberland no longer offers the OWT free landscape required by many visitors

5.3.6 Human Health

Common concerns around wind farms in terms of human health are generally associated with issues such as electromagnetic fields, shadow flicker and noise. These topics are considered in this EIAR in addition to air quality and water contamination in **Chapters 9: Hydrology and Hydrogeology, Chapter 11: Noise** and **Chapter 15: Shadow Flicker.**

5.5.7 Human Health

5.3.6.2 Health Effect Studies

While there are anecdotal reports of negative health effects on people who live near wind farms, there is no peer reviewed scientific research in support of these views. Several peer reviewed scientific research publications are outlined below.

The National Health and Medical Research Council (NHMRC), Australia's leading medical research body, have concluded that there is no reliable or consistent evidence that wind farms directly cause human health problems as part of their Systematic Review of the Human Health Effects of Wind Farms published in December **2013**. The review was commissioned to determine whether there is a direct association between exposure to wind farms and negative effects on human health or whether the association is casual, by chance or bias.

Objectors to wind farms often refer to 'Wind Turbine Syndrome' as a condition that can be caused by living in close proximity to wind farms. The symptoms allegedly include sleep deprivation, anxiety, nausea and vertigo. It has been rejected by the wind industry and is further refuted by a review carried out by the NHMRC that wind turbines cause this sort of symptoms. The review began in late **2012** and included a literature and background review of all available evidence on the exposure to the physical emissions produced by wind turbines. These emissions were noise, shadow flicker and electromagnetic radiation produced by wind turbines. The review concludes that the evidence considered does not support any direct association between wind farms and human health problems and that bias and confounding could be possible explanations for any reported association.

The international scientific journal "*Frontiers in Public Health*" published a study44 in **2014** on the subject of wind turbines and human health. This review completed a bibliographic-like summary and analysis of the science around this issue, specifically in terms of noise (including audible noise, low-frequency noise, and infrasound), EMF, and shadow flicker.

The study concluded as follows:

"The available scientific evidence suggests that EMF, shadow flicker, low-frequency noise, and infrasound from wind turbines are not likely to affect human health; some studies have found that audible noise from wind turbines can be annoying to some. ***Annoyance may be associated with some self-reported health effects (e.g., sleep disturbance) especially at sound pressure levels >40 dB(A).*** *Because environmental noise above certain levels is a recognized factor in a number of health issues, siting restrictions have been implemented in many jurisdictions to limit noise exposure. These setbacks should help alleviate annoyance from noise. Subjective variables (attitudes and expectations) are also linked to annoyance and have the potential to facilitate other health complaints via the nocebo effect. Therefore, it is possible that a segment of the population may remain annoyed (or report other health impacts) even when noise limits are enforced." Based on the findings and scientific merit of the research conducted to date, it is our opinion that the weight of evidence suggests that when sited properly, wind turbines are not related to adverse health effects. This claim is supported (and made) by findings from a number of government health and medical agencies and legal decisions".*

In general, there are no specific health and safety considerations in relation to the operation of a wind turbine. The area surrounding the turbine base will still be available for use.

Response from MLavelle: This statement is untrue.There are many published studies in relation to specific health & safety considerations in the operation of wind turbines.

Reference 2018 : Are There Harmful Effects Caused by the Silent Noise of Infrasound Produced by Windparks? An Experimental Approach Vahlg, Christian-Friedrich; Ghazy, Ahmed; and Chaban, Ryan | Germany, Health, Noise. The Thoracic and Cardiovascular Surgeon. 2018; 66(S 01). DOI:10.1055/s-0038-1628066. Tuesday, February 20, 2018, 47th Annual Meeting of the German Society for Thoracic and Cardiovascular Surgery, Leipzig

Introduction: The increased number of wind parks raised the question, whether infrasound waves produced by wind turbines are harmful on human-beings, or not. Infrasound is a low frequency sound (< 20 Hz), undetectable with human ears. However, some people live near windparks describe unspecific symptoms i.e., palpitations, dizziness, headache, etc. This study analyses the infrasound effects on isolated atrial human myocardium and measures the contractile performance in human trabeculae using different frequencies and amplitudes of infrasound generated by a loudspeaker.

Methods: Human atrial trabeculae were resected from 8 patients undergoing aorto coronary bypass surgery, then demembranized using Triton X 100 and small fibers were generated with diameter < 0.3 mm and length 4–6 mm. The fibers were attached between force transducer and loudspeaker while activated at optimal length and room temperature in an organ bath using supramaximal calcium concentrations. Then infrasound was imposed using frequencies of 10 Hz or 20 Hz. Sound amplitudes (SA) were either 5% or 10% of tissue length (TL). Sound was applied for 1 minute. Force was measured before and after 1 minute of infrasound.

Results: Imposed infrasound on isolated human myocardium caused a direct force inhibition of the completely activated myocardial preparation. At 10 Hz and 5% TL (SA) force inhibition was 18.8+2% while at 10% TL (SA) up to 23.3+2% ($p < 0.05$). At 20 Hz; force inhibition was 23+2% at 5% TL and 32+4% at 10% TL ($p < 0.01$). After stopping infrasound; force was recovered but not to the initial value. No sound was heard during the experiments. Passive resting force was minimally affected (n.s.).

Conclusion: Infrasound can induce direct effects on human myocardium in the given experimental setting. Although mono-frequency sounds are not present in nature, our experimental data indicates, that direct effects on myocardial tissue are present. The infrasound influence on human tissue requires further investigation because the increasing number of a) wind turbines and b) human beings exposed by the neighborhood of windparks. Humans have no chance to protect themselves from the silent noise of infrasound, as long as no scientific data presents.

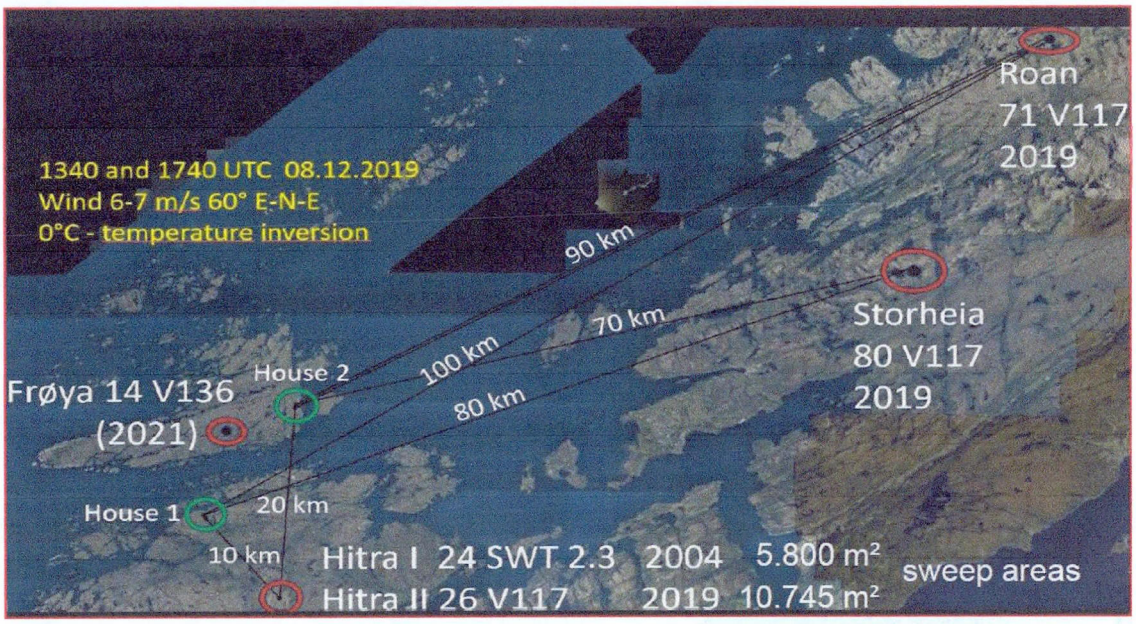
Reference 2026 : Wind Turbine Infrasound Propagation Over Long Distance. Evidence from Norwegian Communities & A Call for Precaution. Steven Crozier, MD, Specialist in Family Medicine, Retired Chief Medical Officer–Frøya, Norway, Member of the Public Health Committee -Motvind Norge. Kybernetisk kvarter, NTNU. June1st, 2026

MOTIVATION: Infrasound & Ill Health:

THE SPARK: A DOCTOR'S JOURNEY: From Skeptic to Investigator: A Local Doctor's Duty
- *Frøya Island Braces: New WTF, Rising Concerns*
- *The Quest for Answers: Procuring Tools, Seeking Truth*

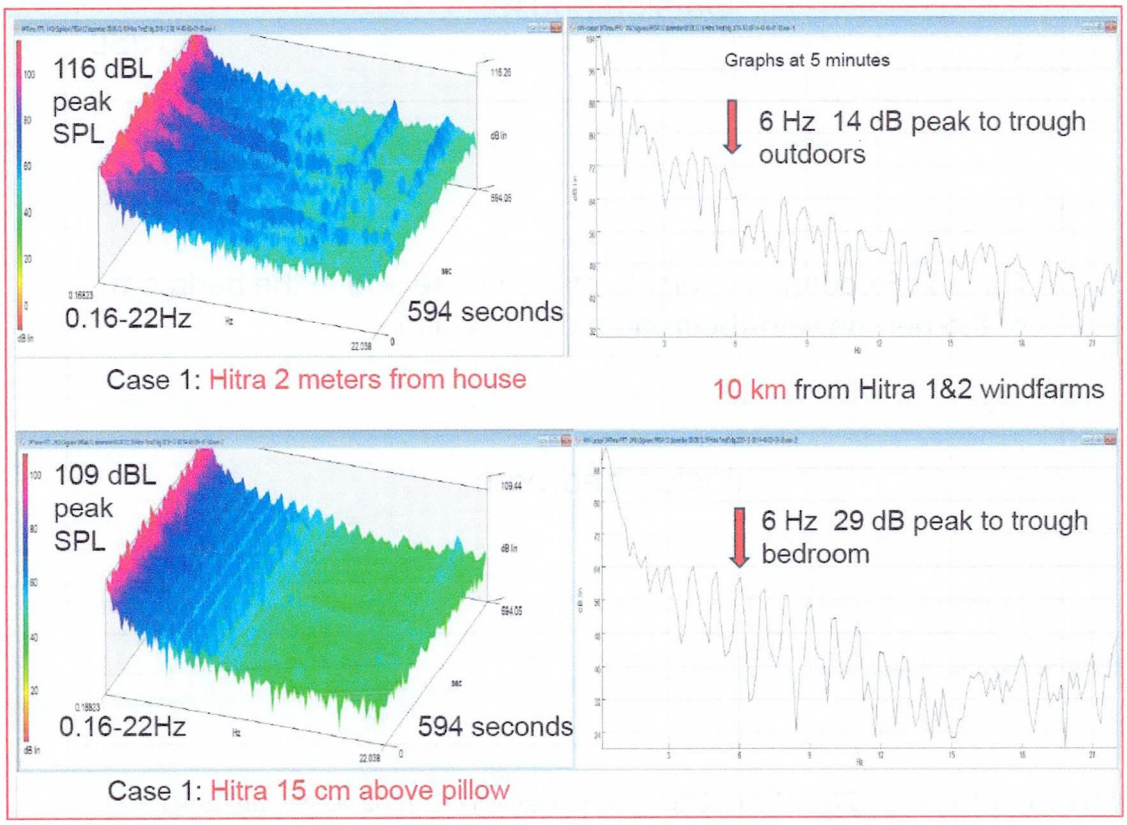
*THE INVESTIGATION: **LISTENING IN ON HITRA** : Scientific Ears: - Bedroom & Outdoor Recordings vs. Frøya - Control Location.*

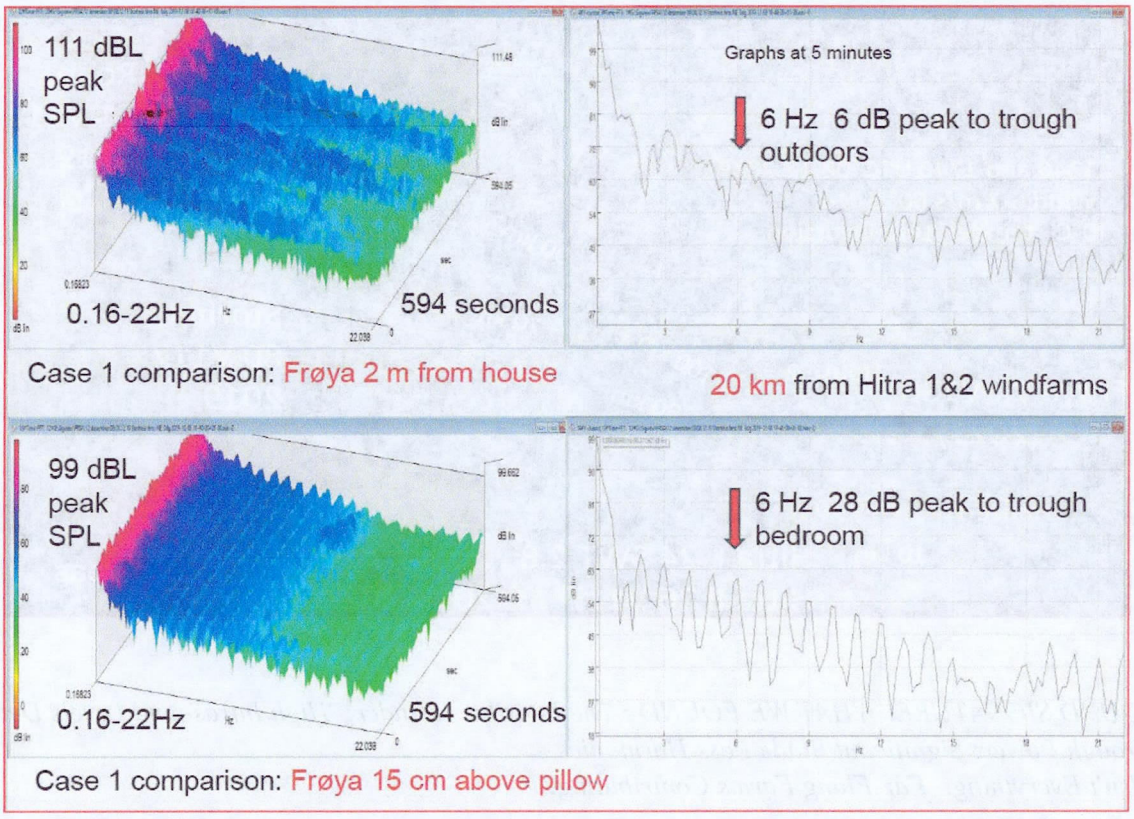
THE PROBLEM: NEW TURBINES, NEW TROUBLES : Hitra Island: A Tale of Two Turbine Eras
- *The Alarm Bells: 'Rumbling & Booming' Homes*
- *Focus: Are bigger turbines, bigger problems?*

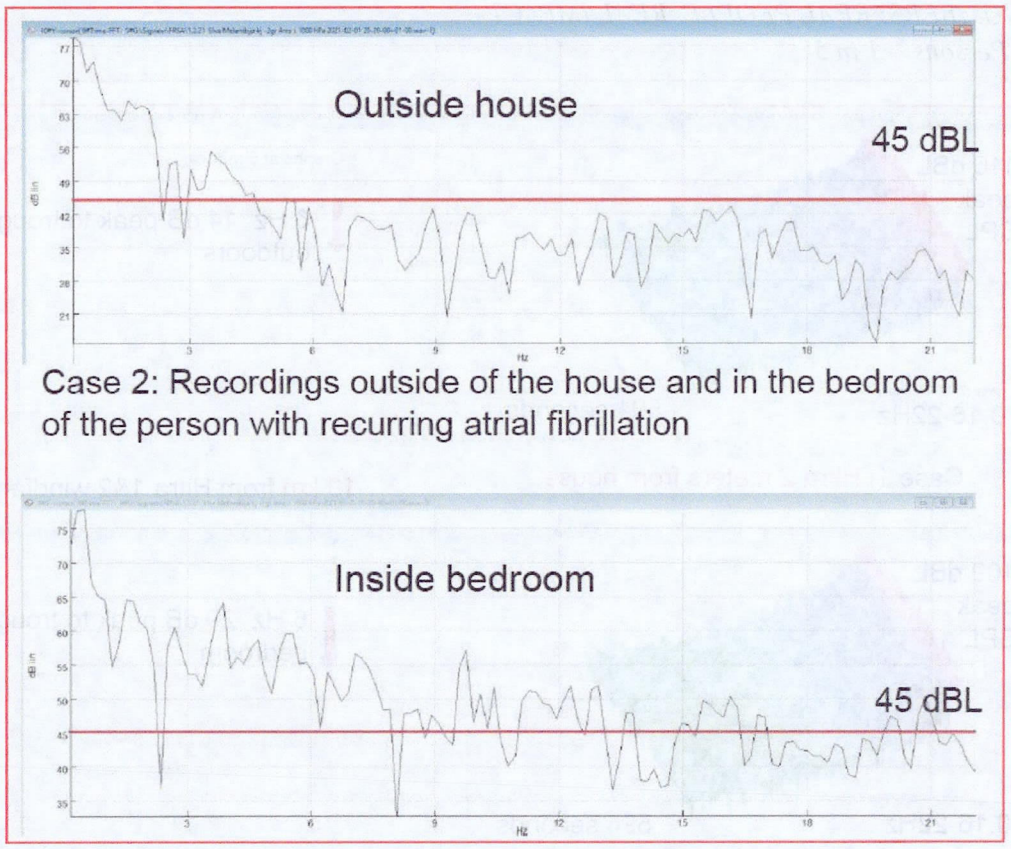


HITRA'S SOUND SIGNATURE: WHAT WE FOUND : The Invisible Intruder: High Infrasound Levels Detected
Peak-to-Trough Power: Significant Blade Pass Harmonics
• Distance Isn't Everything: Far-Flung Farms Contributing?

BEYOND THE NUMBERS: REAL PEOPLE, REAL IMPACT
Highly Sensitive Persons - 1 in 5







CORROBORATING EVIDENCE: THE TYSVÆRSURVEY: TysværWTF (2021): Averages - 41% vs. 24/21%,disturbances 89% vs 63/51% 53% participation rate,17% in favor, 63% not

DEBUNKING DISMISSALS: A CRITICAL LOOK
The 'Infrasound Doesn't Explain Symptoms' Study (VTT 2020)
• The Flaw: 10-min exposure to low-level, compiled sound

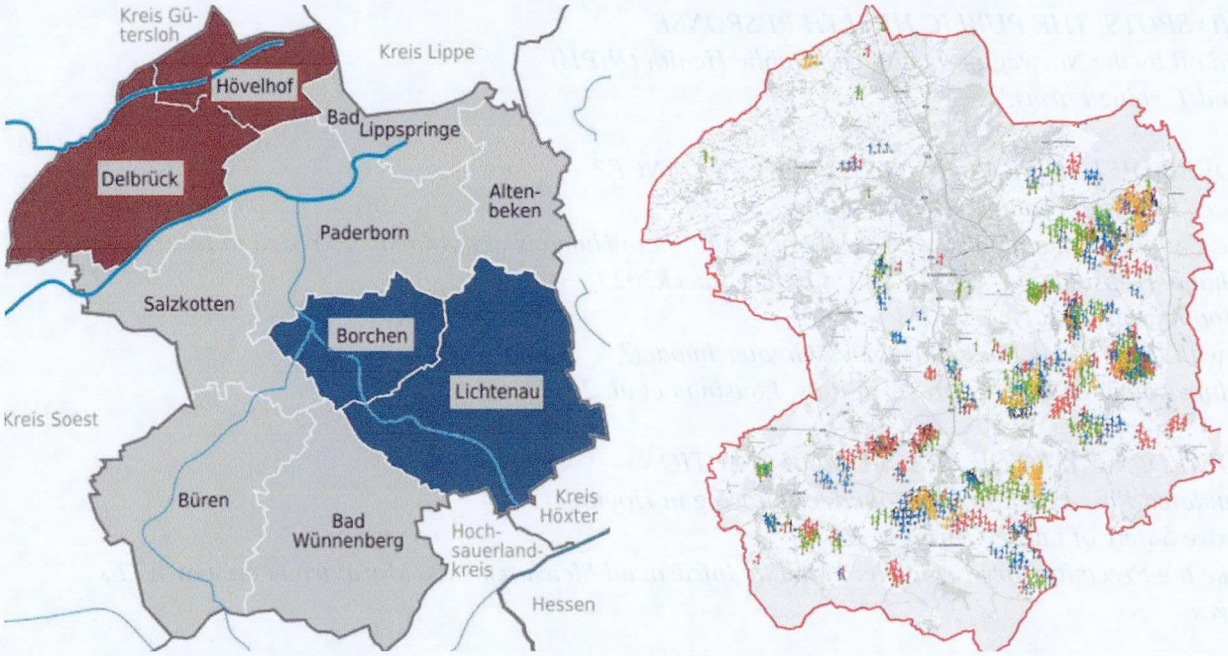
SYSTEMIC BLIND SPOTS: THE PUBLIC HEALTH RESPONSE
Concerns brushed off by the Norwegian Institute of Public Health (NIPH)
• NIPH Stance: ind Turbine Farms.'

THE SCIENCE DEEP DIVE: INFRASOUND'S CELLULAR DANCE?
Beyond Annoyance: Potential Biological Mechanisms
Impairment of the Endothelium and Disorder of Microcirculation in Humans and Animals Exposed to Infrasound due to Irregular Mechano-Transduction"Ursula Maria Bellut-Staeck2023
The Hysteresis Hpoththesis: H.R.Noori 2014
Rhythmic pulses with large Blade Pass Harmonics-Greater Impact?
Animal Models: Infrasound & Atrial Fibrosis in Rats. Lousinha et al. 2021

THE PATH FORWARD: A CALL FOR PRECAUTION & ACTION
The Gap: No Mandated Post-Erection Infrasound Monitoring in Homes
Industry Must Prove Safety of Larger Turbines
• Our Plea: Invoke the Precautionary Principle. Mandate Infrasound Measurements. Moratorium on new WTFs within 10kilometres

Reference 2026: Significantly increased incidence of heart failure and rhythm disorders in communities with substantial expansion of wind energy Christian-Friedrich Vahl and Oliver Dietz, Infrasound Research Group, University Medical Center, Johannes Gutenberg University, Mainz, Germany (Arbeitsgruppe Infraschall, Unimedizin Mainz).Poster Nr. P-15-07, Abstract ID: 85384. 132. Kongress der Deutschen Gesellschaft für Innere Medizin (132nd Congress of the German Society for Internal Medicine) April 18 to 21, 2026, Wiesbaden

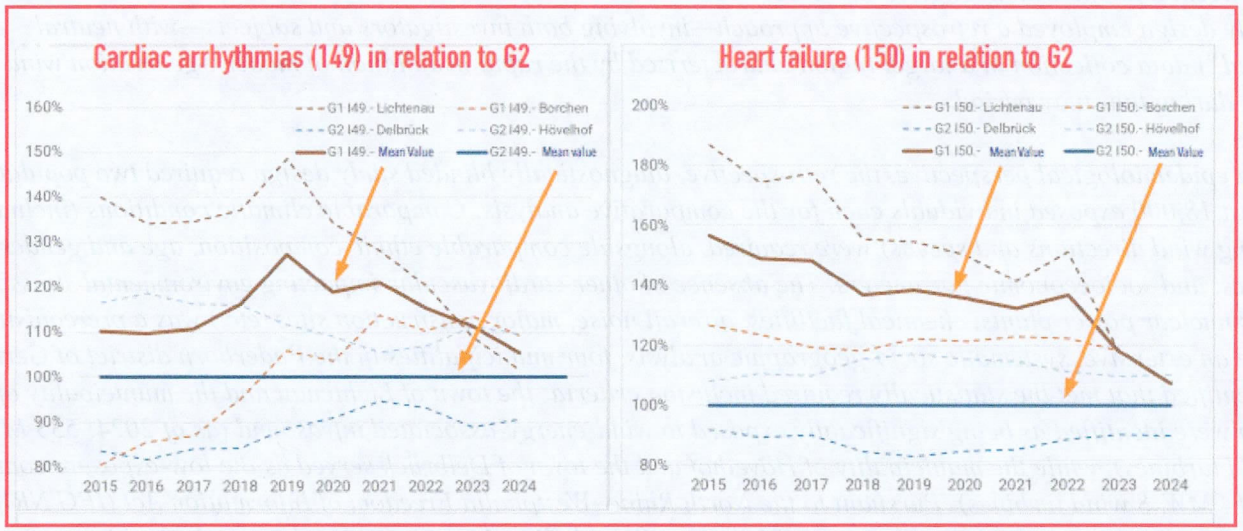
Background
Experimental studies on isolated human myocardium have demonstrated reduced contractility and rhythm-relevant alterations in intracellular calcium metabolism following infrasound exposure. The aim of the current epidemiological study was to determine whether changes in myocardial health associated with low-frequency sound (including infrasound) could be detected under "real-life" conditions. The study compared the incidence of the target outcomes—heart failure and cardiac arrhythmias—between two populations: one with high exposure to the potential harmful agent and one with negligible exposure.
The study design employed a retrospective approach—involving both investigators and subjects—with neutral ("blinded") data collection in a target region characterized by the rapid installation of modern-generation wind turbines during the study period.
Methods
From an epidemiological perspective, the retrospective, diagnostically blinded study design required two populations of at least 18,000 exposed individuals each for the comparative analysis. Comparable climatic conditions (including prevailing wind directions and speeds) were required, alongside comparable ethnic composition, age and gender structures, and socioeconomic parameters. The absence of other cardiovascular-impacting environmental stressors (such as nuclear power plants, chemical facilities, aircraft noise, major construction sites, etc.) was a prerequisite. Through an extensive, systematic socio-geographic analysis, four municipalities in the Paderborn district of Germany were identified that met the statistically required inclusion criteria: the town of Lichtenau and the municipality of Borchen were identified as being significantly exposed to wind-energy-associated infrasound (as of 2024: 533 MW, 224 wind turbines), while the municipality of Hövelhof and the town of Delbrück served as the low-exposure control group (14 MW, 8 wind turbines). Pursuant to the North Rhine–Westphalia Freedom of Information Act (IFG NRW), the Association of Statutory Health Insurance Physicians Westphalia—Lippe provided data on the incidence of new cardiovascular cases for the aforementioned municipalities in the Paderborn district (in electronic form, in accordance with Section 5, Paragraph 1, Sentence 5 of the IFG NRW).

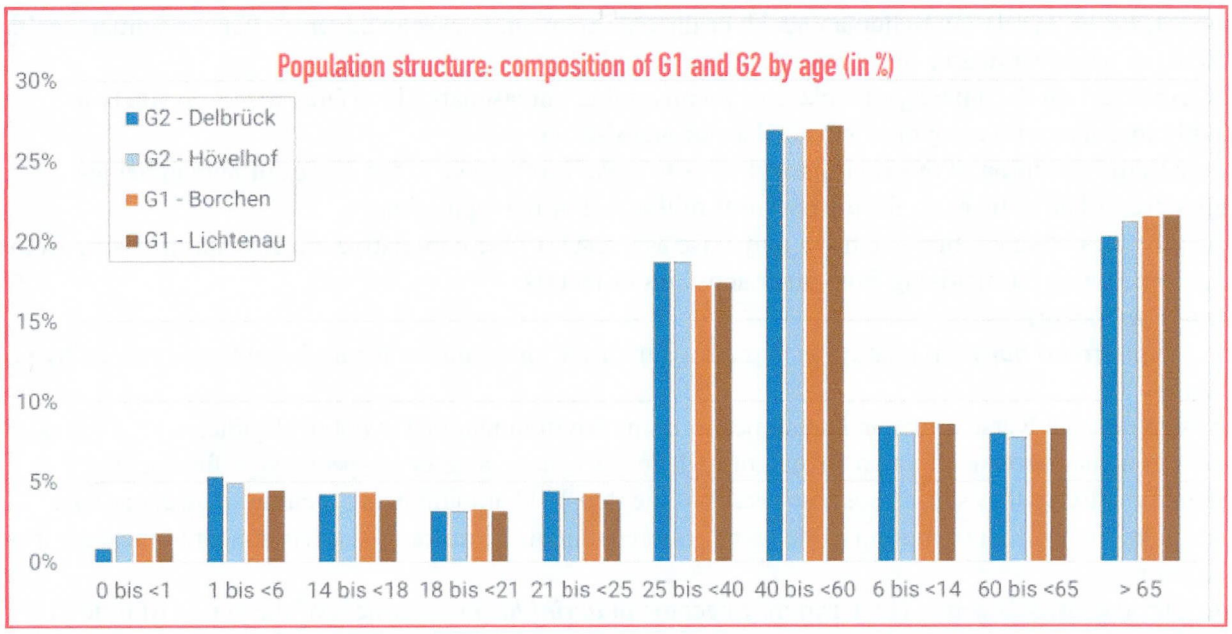


Red: Control: Delbrück and Hövelhof (inhabitants, n=49,700)
Blue: Test population: Borchen and Lichtenau (inhabitants, n=25,550)

Results

Exposed residents (E, minimum number during the study period): City of Lichtenau (E min: n=11,900), Municipality of Borchen (E min: n=13,650), Municipality of Hövelhof (E min: n=17,000), City of Delbrück (E min: n=32,700) (calendar years: 2015–2024). ICD codes I49 (cardiac arrhythmia (life- threatening)) and I50 & I50.1 (heart failure) were reported. Compared to Delbrück, a significant increase in the incidence of newly diagnosed heart failure was observed in Borchen ($p<0.0001$) and likewise in Lichtenau ($p<0.0001$). Based on the annual average, the increase in Borchen ranged from 21% to 51% during the 2021–2024 period, and from 20% to 68% in Lichtenau. Regarding "life-threatening arrhythmias," the incidence in the exposed group was markedly elevated (significance level $p<0.0001$). The figures below illustrate the study results by showing the incidence of new diagnoses in the regions without wind turbines (Delbrück, Hövelhof) as a 100% reference.





Incidence of newly diagnosed heart failure (ICD-10 code I50) and life-threatening cardiac arrhythmias (I49) alongside the expansion of wind energy. Source: Original data from the Association of Statutory Health Insurance Physicians of Westphalia—Lippe; retrospective, "blinded" data collection covering the period (2015–2024) marked by a significant increase in wind turbines. For illustrative purposes, the mean value for the municipalities of Delbrück (33129) and Hövelhof (33161)—which lack infrasound exposure—was used as the 100% reference in the figures. Bottom: Age structure of the study populations in 2024.

Conclusion

Data from the Paderborn region indicate a significantly elevated risk of new-onset cardiovascular disease in municipalities with extensive wind energy expansion. Consequently, appropriate measures must be taken immediately to systematically inform the exposed population about the risk of cardiac arrhythmias and heart failure, thereby enabling the timely implementation of suitable therapeutic interventions. Research funding should be allocated for detailed studies to precisely define the threshold values for infrasound exposure that necessitate public information.

Reference 2021 : Landscape In Pain: Shetland's Industrial Scale Wind Farm And Solastalgia. Professor *Roxane Permar. Technical Aesthetics and Design Research. 2021. 3(4). DOI: 10.34031/2687-0878-2021-3-4-14-21*

Research suggests that potential carbon losses resulting from wind farm construction within a natural peat bog mean that there may be no net carbon benefit from the windfarm. Sustainable Shetland estimates that it could take 67 years to pay back the carbon loss during the construction of the windfarm.

Pollution caused by microplastics from the erosion of turbine blades is a subject of ongoing public debate in Shetland. Research carried out at Strathclyde University in Glasgow has been applied by a group of Norwegians to examine the erosion of turbine blades on the west coast of Norway, a similar harsh environment to that of Shetland.
Bisphenol – A, (BPA) released through rotor blade erosion, is harmful to marine life and humans. Research indicates exposure to BPA can have possible adverse health effects on humans, including reproductive and developmental effects, metabolic disease, and other health effects. Rochester J.R. Bisphenol A and human health: a review of the literature. ReprodToxicol. 2013. 42. 132–155. doi: 10.1016/j.reprotox.2013.08.008

A huge concern in relation to industrial scale windfarms is the impact from noise and infrasound….. There is much research that suggests that adverse effects of noise and infrasound are observed at distances even beyond 1km. Further research is needed to determine at what distances risks become negligible, as well as to better estimate the portion of the population suffering from adverse effects at a given distance.
In addition to the negative health impact on people from noise, infrasound, vibration and pollution, the impact of the devastation being created on emotional and mental health also needs serious consideration as research indicates it is real.

Reference 2017 : State of Victoria. Australia: Environment Protection Act 2017 No. 51 of 2017
What is *harm*?

(1) In this Act, ***harm***, in relation to human health or the environment, means an adverse effect on human health or the environment (of whatever degree or duration) and includes—
(a) an adverse effect on the amenity of a place or premises that unreasonably interferes with or is likely to unreasonably interfere with enjoyment of the place or premises; or
(b) a change to the condition of the environment so as to make it offensive to the senses of human beings; or
(c) anything prescribed to be harm for the purposes of this Act or the regulations.
(2) For the purposes of subsection (1), harm may arise as a result of the cumulative effect of harm arising from an activity combined with harm arising from other activities or factors.

What is *material harm*?

(1) In this Act, ***material harm***, in relation to human health or the environment means harm that is caused by pollution or waste that—
(a) involves an actual adverse effect on human health or the environment that is not negligible; or
(b) involves an actual adverse effect on an area of high conservation value or of special significance; or
(c) results in, or is likely to result in, costs in excess of the threshold amount being incurred in order to take appropriate action to prevent or minimise the harm or to rehabilitate or restore the environment to the state it was in before the harm.
(2) For the purposes of subsection (1), harm may become ***material harm*** regardless of the period of time in which the harm occurs and as a result of—
(a) a single occurrence of harm arising from an activity; or
(b) multiple occurrences of harm arising from the same activity; or
(c) the cumulative effect of harm arising from an activity combined with harm arising from other activities or factors.
(3) In this section, ***threshold amount*** means $10 000 or a higher amount prescribed by the regulations.

The concept of minimising risks of harm to human health and the environment

(1) A duty imposed on a person under this Act to minimise, so far as reasonably practicable, risks of harm to human health and the environment requires the person—
(a) to eliminate risks of harm to human health and the environment so far as reasonably practicable; and
(b) if it is not reasonably practicable to eliminate risks of harm to human health and the environment, to reduce those risks so far as reasonably practicable.
(2) To determine what is (or was at a particular time) reasonably practicable in relation to the minimisation of risks of harm to human health and the environment, regard must be had to the following matters—
(a) the likelihood of those risks eventuating;
(b) the degree of harm that would result if those risks eventuated;
(c) what the person concerned knows, or ought reasonably to know, about the harm or risks of harm and any ways of eliminating or reducing those risks;
(d) the availability and suitability of ways to eliminate or reduce those risks;
(e) the cost of eliminating or reducing those risks.

Principles of environment protection

Principle of integration of environmental, social and economic considerations

Environmental, social and economic considerations should be effectively integrated.

Principle of proportionality

A decision, action or thing directed towards minimising harm or a risk of harm to human health or the environment should be proportionate to the harm or risk of harm that is being addressed.

Principle of primacy of prevention

Prevention of harm to human health and the environment is preferred to remedial or mitigation measures.

Principle of shared responsibility

Protection of human health and the environment is a responsibility shared by all levels of Government and industry, business, communities and the people of Victoria.

Principle of polluter pays

Persons who generate pollution and waste should bear the cost of containment, avoidance and abatement.

Principle of waste management hierarchy

Waste should be managed in accordance with the following order of preference, so far as reasonably practicable—
(a) avoidance;
(b) reuse;
(c) recycling;

(d) recovery of energy;
(e) containment;
(f) waste disposal.

Principle of evidence-based decision making

Actions or decisions under this Act should be based on the best available evidence in the circumstances that is relevant and reliable.

Precautionary principle

If there exist threats of serious or irreversible harm to human health or the environment, lack of full scientific certainty should not be used as a reason for postponing measures to prevent or minimise those threats.

Principle of equity

(1) All people are entitled to live in a safe and healthy environment irrespective of their personal attributes or location.
(2) People should not be disproportionately affected by harm or risks of harm to human health and the environment.
(3) The present generation should ensure the state of the environment is maintained or enhanced for the benefit of future generations.

Principle of accountability

Members of the public should—
(a) have access to reliable and relevant information in appropriate forms to facilitate a good understanding of issues of harm or risks of harm to human health and the environment and of how decisions are made under this Act; and
(b) be engaged and given opportunities to participate in decisions made under this Act, where appropriate to do so; and
(c) have their interests taken into account in decisions made under this Act.

Principle of conservation

Biological diversity and ecological integrity should be protected for purposes that include the protection of human health.

The following Response is from the Australian Parliament in a reference to Health issues from windfarms outlined by Chapman 2015.

Reference 2015 : Select Committee on Wind Turbines: Final report. August 2015. ISBN 978-1-76010-260-9

Wind turbines and ill-health

2.7 The committee has taken evidence from a number of people who reside in proximity to wind turbines who have complained of a range of adverse health impacts. These include tinnitus, raised blood pressure, heart palpitations, tachycardia, stress, anxiety, vertigo, dizziness, nausea, blurred vision, fatigue, cognitive dysfunction, headaches, nausea, ear pressure, exacerbated migraine disorders, motion sensitivity, inner ear damage and worst of all, sleep deprivation.

2.8 Dr Sarah Laurie told the committee:
The human cost of the failure to protect people from excessive noise pollution, especially at night, is terrible. I have personally helped to prevent a number of suicides of people who were utterly desperate because of the consequences of excessive noise pollution and who reached out for help.
From my experience there is a subset of people who are terribly impacted very early on. Those people are the ones who tend to present with acute vestibular disorder type of symptoms—dizziness and motion sickness, which can be accompanied by extreme anxiety. Those people often just cannot last very long, and they move if they can.

2.9 Ms Janet Hetherington, an adjacent landholder to the Macarthur wind farm in south-west Victoria, relayed her own experience:
At my farm, I experience severe adverse health effects such as vibration, heart palpitations, tinnitus, head pressure, headaches, sleep deprivation, anxiety, night sweats, nausea, itchy skin, cramps, and ear, nose and throat pain. Twice now I have experienced horrendous pain in my chest stabbing through to my backbone in between my shoulder blades. I contemplated calling an ambulance both times but could not move to do so because of the severity of the pain. Ten minutes later it had dissipated, leaving me with great stress and anxiety and feeling washed out. All these sensations leave me drained in the morning. I find it very hard to start work that day.

2.10 Ms Anne Gardner also attributed her and her husband's ill health to the nearby Macarthur wind farm. She described the following symptoms:
My husband experienced bolts of pressure which tallied up with pressure peaks measured by Les Houston (sic) 86 per cent of the time while my husband was blind to the acoustic measurements of the time. Refer to his recap statement. I suffer day and night from headaches, nose and ear pressure, nausea, heart palpitations and chest burning from vibrations through the floor, couch, chair and in bed all night.

2.11 Mr Clive Gare and his wife host 19 towers from the North Brown Hill wind farm located 17 kilometres from Jamestown in South Australia. Mr Gare told the committee:
After a short period of living with an operating wind farm, we had these products installed. I find that, because I work and reside in close proximity to the wind farm, I suffer sleep interruption, mild headaches, agitation and a general feeling of unease; however, this occurs only when the towers are turning, depending on the wind direction and wind strength. My occupation requires that I work amongst the wind towers during the day which means I suffer the full impacts of noise for days at a time without relief. The impacts are that we are not able to open our windows because of the noise at night and we are not able to entertain outside because of the noise.
In conclusion, if we did not have soundproof batts in VLam Hush windows [special window laminate designed to dampen noise], our house would not be habitable. In my opinion, towers should not be within five kilometres of residences, and I would personally not buy a house within 20 kilometres of a wind farm.

2.12 The committee notes that the Gares have received payment of $2 million over five years to host turbines and have reported serious adverse impacts. The committee notes, therefore, that their evidence is an 'admission against interest' and as such represents highly reliable evidence.

2.13 Mr John Pollard, a resident of Glenthompson near the Oaklands Hill wind farm in Victoria, told the committee:
The wind farm guidelines on health issues of this very serious problem have to be assessed. They will not acknowledge infrasound. I will relate one incident that happened in our home one night. My wife was sleeping in the chair beside me and I was watching television. This is after they had turned the turbines off. She was dead to the world and I was just watching the television. All of a sudden she woke up, completely startled and disorientated, and I was really worried about her because I thought she had had a stroke or something. Eventually she came to her senses and she said the turbines must be on. I said, 'No, they're not. It's 10.30. They turn off at nine o'clock.' I went outside and they were still running. So I thought that next day I would ring AGL. When I was about to ring, they rang me and said, 'I'm sorry, John. We forgot to turn the turbines off last night.'

2.14 Waubra resident Mr Donald Thomas identified hearing difficulties from the nearby Waubra wind farm turbines.9 He claimed that these difficulties disappeared when he left the area:
I went to the doctor with what I kept saying was a lot of ear pressure and earaches. I went to see a specialist, and my ears came back as being in good health and functioning pretty well, even though I have lost a lot of hearing. Basically, my left ear does not work too good… My ears—especially when I go to my Stud Farm Road property, I have ear pressure that can develop into a headache and rapid heartbeat. If I leave that area and go back to one of my other properties, that can settle back down.

2.15 Mr Peter Jelbart, a 25 year old who had lived with his family nearby the Macarthur wind farm in south-west Victoria, noted the difficulty of sleeping in the family home. He told the committee he had worked and slept unaffected in noisy environments outside of the family home in Victoria:
While I was working in Western Australia I used to do three weeks on, one week off and come home for a week. Over in Western Australia I was sleeping at times on the sides of busy highways and in the back of trucks with ice packs running… At home, I noticed pretty much from day one that there is a serious problem there. Something is completely different when sleeping. I would wake up after a couple of hours of sleep—at times, not even after a couple of hours—and have disrupted sleep that I have had nowhere else. There is a proper problem… Whether it is low-frequency noise and the infrasound combining with it, it seems worse when it is quiet. Around our house the yard is pretty well protected by trees. When it is relatively quiet around the house yard there is still a really soft drone that comes through and just gets into you. It is pretty hard to explain. There are probably a lot of people going through the same thing who will have the same trouble trying to explain it, especially to people who have not experienced it. The problem with it is, it also seems to affect different people over different periods of time.

2.16 The committee has had the opportunity to take evidence from researchers in the United States and Canada who expressed their concern with the health effects of turbines. Ms Lilli-Ann Green is the Chief Executive Officer of a healthcare consulting firm in the United States. In 2012, Ms Green and her husband conducted interviews with people living near wind turbines in 15 different countries. As she told the committee: We have interviewed people on three continents who live more than five miles from the nearest wind turbine and are sick since wind turbine wind turbines need to be sited from people in order to do no harm. People report to us that over time their symptoms become more severe. Many report not experiencing ill effects for some time following wind turbine construction, meanwhile their spouse became ill the day the wind turbines nearby became operational. They speak of thinking they were one of the lucky ones at first, but after a number of months or years they become as ill as their spouse. Not one person who stayed near wind turbines reported to us that they got used to it or got better; they all became more ill over time… I really believe that we just do not have enough information yet. But throughout the interviews, country by country, people described the same symptoms. Many times they used the same phrases to describe them and the same gestures—and they were not speaking English. There is a common thread here.

2.17 Dr Jay Tibbetts, a medical practitioner and vice chair of the Brown County Board of Health in Wisconsin, drew the committee's attention to the board's October 2013 finding that the Shirley wind farm was a 'human health hazard'. Dr Tibbetts described how the declaration came about:
The [Board of Health] has been studying adverse health effects for the past 4 ½ years in the Shirley Wind Project. We have reviewed many peer reviewed studies, at least 50 medical complaints including ear pain, pressure, headache, tinnitus, vertigo, nausea, chest pain, chest pressure, loss of concentration, sleep deprivation and more, as well as more than 80 other complaints from citizens of Shirley Wind. There have been 2 formal studies of infrasound/low frequency noise by acousticians in 2012 and 2014. The latter study revealed symptom generating [Infrasound/Low Frequency Noise] at a distance of 4 ½ [miles].

2.18 The committee also heard of detailed research by Professor Emeritus Robert McMurtry from Western University in Ontario, Canada. Professor McMurtry made a number of points to the committee:
• adverse health effects have been reported globally in the environs of wind turbines for more than 30 years with the old design of turbines and the new;
• the wind energy industry has denied adverse health effects, preferring to call it 'annoyance'. Annoyance is recognised and was treated by the World Health Organization as an adverse health effect, which is a risk factor for serious chronic disease including cardiovascular and cancer;
• the regulations surrounding noise exposure are based upon out-of-date standards ETSU-97, which fail to evaluate infrasound and low-frequency

Professor Chapman and his critics

2.19 Professor Simon Chapman AO, Professor of Public Health at the University of Sydney, has been an outspoken critic of those who suffer ill-effects from wind turbines. In both his written and oral submissions, Professor Chapman cited many of his own publications in support for his view that:
…the phenomenon of people claiming to be adversely affected by exposure to wind turbines is best understood as a communicated disease that exhibits many signs of the classic psychosocial and nocebo phenomenon where negative expectations can translate into symptoms of tension and anxiety.

2.20 Several highly qualified and very experienced professionals have challenged this argument. Dr Malcolm Swinbanks, an acoustical engineer based in the United Kingdom, reasoned:
The argument that adverse health reactions are the result of nocebo effects, ie a directly anticipated adverse reaction, completely fails to consider the many cases where communities have initially welcomed the introduction of wind turbines, believing them to represent a clean, benign form of low-cost energy generation. It is only after the wind-turbines are commissioned, that residents start to experience directly the adverse nature of the health problems that they can induce.

2.21 The committee highlights the fact that Professor Chapman is not a qualified, registered nor experienced medical practitioner, psychiatrist, psychologist, acoustician, audiologist, physicist or engineer. Accordingly:
• he has not medically assessed a single person suffering adverse health impacts from wind turbines;

• his research work has been mainly—and perhaps solely—from an academic perspective without field studies;
• his views have been heavily criticised by several independent medical and acoustic experts in the international community; and
• many of his assertions do not withstand fact check analyses.

2.22 Professor Chapman has made several claims which are contrary to the evidence gathered by this committee. First, he argues that the majority of Australia's wind turbines have never received a single complaint. There are various problems with this statement:
(i) wind turbines located significant distances from residents will not generate complaints;
(ii) many residents suffering adverse health effects were not aware of any nexus between their health and the impact of wind turbines in order to make a complaint;
(iii) just because residents do not lodge a formal complaint does not mean they are not suffering adverse health effects;
(iv) data obtained by Professor Chapman from wind farm operators of the numbers of complaints lodged cannot be relied upon; and
(v) the use of non-disclosure clauses and 'good neighbour agreements' legally restricts people from making adverse public statements or complaints.
2.23 Second, Professor Chapman has argued that complaints of adverse health effects from wind turbines tend to be limited to Anglophone nations. However, the committee has received written and oral evidence from several sources directly contradicting this view. The German Medical Assembly recently submitted a motion to the executive board of the German Medical Association calling for the German government to provide the necessary funding to research adverse health effects. This would not have happened in the absence of community concern. Moreover, Dr Bruce Rapley has argued that in terms of the limited number—and concentrated nature—of wind farm complaints:
It is the reporting which is largely at fault. The fact is that people are affected by this, and the numbers are in the thousands. I only have to look at the emails that cross my desk from all over the world. I get bombarded from the UK, Ireland, France, Canada, the United States, Australia, Germany. There are tonnes of these things out there but, because the system does not understand the problem, nor does it have a strategy, many of those complaints go unlisted.

2.24 Third, Professor Chapman has queried that if turbines are said to have acute, immediate effects on some people, why were there no such reports until recent years given that wind turbines have operated in different parts of the world for over 25 years. Several submissions to the committee have stated that adverse health effects from wind turbines do not necessarily have an acute immediate effect and can take time to manifest.

2.25 Fourth, Professor Chapman contests that people report symptoms from even micro-turbines. The committee heard evidence that once people are sensitised to low frequency infrasound, they can be affected by a range of noise sources, including large fans used in underground coal mines, coal fired power stations, gas fired power stations and even small wind turbines. As acoustician Dr Bob Thorne told the committee:
Low-frequency noise from large fans is a well-known and well-published issue, and wind turbines are simply large fans on top of a big pole; no more, no less. They have the same sort of physical characteristics; it is just that they have some fairly unique characteristics as well. But annoyance from low-frequency sound especially is very well known.

2.26 Fifth, Professor Chapman contends that there are apparently only two known examples anywhere in the world of wind turbine hosts complaining about the turbines on their land. However, there have been several Australian wind turbine hosts who have made submissions to this inquiry complaining of adverse health effects.
Paragraphs 2.11–2.12 (above) noted the example of Mr Clive Gare and his wife from Jamestown. Submitters have also directed attention to the international experience.
In Texas in 2014, twenty-three hosts sued two wind farm companies despite the fact that they stood to gain more than $50 million between them in revenue. The committee also makes the point that contractual non-disclosure clauses and 'good neighbour' agreements have significantly limited hosts from speaking out. This was a prominent theme of many submissions.

2.27 Sixth, Professor Chapman claims that there has been no case series or even single case studies of so-called wind turbine syndrome published in any reputable medical journal. But Professor Chapman does not define 'reputable medical journal' nor does he explain why the category of journals is limited to medical (as distinct, for assertion. However, the committee does note that a decision to publish—or not to publish—an article in a journal is ultimately a

business decision of the publisher: it does not necessarily reflect the quality of the article being submitted, nor an acknowledgment of the existence or otherwise of prevailing circumstances. The committee also notes that there exist considerable published and publicly available reports into adverse health effects from wind turbines.

2.28 The committee also notes that a peer reviewed case series crossover study involving 38 people was published in the form of a book by American paediatrician Dr Nina Pierpont, PhD, MD. Dr Pierpont's *Report for Clinicians* and the raw case data was submitted by her to a previous Australian Senate inquiry (2011) to which Dr Pierpont also provided oral testimony. Further, at a workshop conducted by the NHMRC in June 2011, acoustical consultant Dr Geoffrey Leventhall stated that the symptoms of 'wind turbine syndrome' (as identified by Dr Pierpont), and what he and other acousticians refer to as 'noise annoyance', were the same. Dr Leventhall has also acknowledged Dr Pierpont's peer reviewed work in identifying susceptibility or risk factors for developing wind turbine syndrome / 'noise annoyance'. Whilst Dr Leventhall is critical of some aspects of Dr Pierpont's research, he does state: Pierpont has made one genuine contribution to the science of environmental noise, by showing that a proportion of those affected have underlying medical conditions, which act to increase their susceptibility.

2.29 Seventh, Professor Chapman claims that no medical practitioner has come forward with a submission to any committee in Australia about having diagnosed disease caused by a wind farm. Again, Professor Chapman fails to define 'disease'. Nonetheless, both this committee, and inquiries undertaken by two Senate Standing Committees, have received oral and written evidence from medical practitioners contrary to Professor Chapman's claim.

2.30 Eighth, Professor Chapman claims that there is not a single example of an accredited acoustics, medical or environmental association which has given any credence to direct harmful effects of wind turbines. The committee notes that the semantic distinction between 'direct' and 'indirect' effects is not helpful. Dr Leventhall and the NHMRC describe stress, anxiety and sleep deprivation as 'indirect' effects, but these ailments nonetheless affect residents' health.

2.31 Finally, Professor Chapman queries why there has never been a complainant that has succeeded in a common-law suit for negligence against a wind farm operator.
This statement is simply incorrect. The committee is aware of court judgements against wind farm operators, operators making out of court settlements or withdrawing from proceedings, injunctions or shutdown orders being granted against operators, and properties adjacent to wind turbines being purchased by operators to avoid future conflict. The committee also reiterates its earlier point that contractual non-disclosure clauses have discouraged legal action by victims.

Reference 2017 : Does the presence of wind turbines have negative externalities for people in their surroundings? Evidence from well-being data. Christian Krekel , Alexander Zerrahn. Journal of Environmental Economics and Management. Volume 82, March 2017, Pages 221-238
Wind turbines, however, are not free of externalities themselves, particularly interference with landscape aesthetics. We quantify these negative externalities using the life satisfaction approach. To this end, we combine household data from the German Socio-Economic Panel Study (SOEP) with a novel panel dataset on over 20,000 installations. Based on geographical coordinates and construction dates, we establish causality in a difference-in-differences design. Matching techniques drawing on exogenous weather data and geographical locations of residence ensure common trend behaviour. We show that the construction of wind turbines close to households exerts significant negative external effects on residential well-being, although they seem both spatially and temporally limited, being restricted to about 4000 m around households and decaying after five years at the latest. Robustness checks, including view shed analyses based on digital terrain models and placebo regressions, confirm our results.
In fact, beyond unpleasant noise emissions (Bakker et al., 2012, McCunney et al., 2014) and impacts on wildlife (Pearce-Higgins et al., 2012, Schuster et al., 2015), most importantly, wind turbines have been found to have negative impacts on landscape aesthetics.
We investigate the effect of the presence of wind turbines on residential well-being and quantify their negative externalities using the so-called *life satisfaction approach*. To this end, we combine household data from the German Socio-Economic Panel Study (SOEP) with a novel panel dataset on more than 20,000 installations for the time period between 2000 and 2012. Trading off the decrease in life satisfaction caused by the presence of wind turbines against the increase caused by income, we value the negative externalities monetarily. As this approach has already been

applied to various other environmental externalities, including air pollution (Ambrey et al., 2014, Ferreira et al., 2013, Levinson, 2012), landscape amenities (Kopmann and Rehdanz, 2013), noise pollution (Rehdanz and Maddison, 2008, van Praag and Baarsma, 2005), or flood disasters (Luechinger and Raschky, 2009), we contribute to a steadily growing stream of literature.
To estimate the causal effect of the presence of wind turbines on residential well-being, we employ a difference-in-differences design that exploits variation in wind turbine construction across space and over time: residents are allocated to the treatment group if a wind turbine is constructed within a pre-defined radius around their households, and to the control group otherwise. To ensure comparability of the treatment and control group, we apply, first, propensity-score matching based on socio-demographic characteristics, macroeconomic conditions, and exogenous weather data; and second, spatial matching techniques based on geographical locations of residence.
We show that the construction of a wind turbine within a radius of 4000 m has a significant and sizeable negative effect on life satisfaction.

Reference 2022 : Acoustic Noise Emission in Wind Turbine: An Overview. Dr. G. Arivukkodi1, Dr. S. Kanmani. International Journal for Research in Applied Science & Engineering Technology (IJRASET). ***Volume 10 Issue IX Sep 2022. ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538***

Quality of life which describes an individual's state of dwelling , represents a cornerstone of human health. Noise induced environment means a significant degradation in the quality of life. This represents a degradation in human health according to WHO, health is defined as a state of complete physical, mental and social well- being and not merely the absence of infirmity (Shepherd et al.,2011, Pedersen, 2011). Since 19th century wind power has been harnessed as a source of power, debate is ongoing in terms of audible and inaudible noise with respect to relationship between wind turbines and reported health effects. Referring to wind turbines an Ontario environmental decision found that serious harm to human health includes indirect impacts such as anxiety or anger, this could eventually lead to adverse health effects. Many health effects of noise are psychologically mediated via the indirect pathway (Møller and Pedersen.,2011, Pedersen et al.,2009).
Noise annoyance is not related to wind turbine noise itself, but also biased to factors like attitude to visual impact, residence (urban ,sub urban, rural) and landscape (plain, complex) .The proportion who are fairly annoyed or very annoyed remains quite level through the 29-37 dB(A)range but tend to increase at noise levels above 37 dB(A) (Van den Berg.,2006). To date to collect noise impact data there have been two approaches namely epidemiological studies that rely on masked surveys and direct clinical case studies. These approaches typically focus on the emotional impacts of noise upon sleep disruption and degradation of well-being and increases in stress that arise from sleep disturbance and noise annoyance(Rand et al.,2011, Zwicker and Fastl.,1999,Van den Berg .,2003).
From psychological perspective, noise annoyance can express in through malaise, fear, threat, uncertainty, or defenselessness. On the basis of widespread complaints about wind turbine operation induced health effects, various authorities have recommended setbacks in the range 1.5 to 2km from home and other sensitive areas. There have been field studies conducted to analyze the annoyance in addition to one to one interactions. Perhaps the studies carried out by Pedersen, Van den berg, (2009) were based on the size of the samples , the experience of the investigators and the inter-comparison between the studies(Pedersen and Waye ,2004).
Van Den Berg et al.,2003 analysed the data-sets at two locations in Germany ranging from 400m to 1500m. He found that wind turbine noise was dominant in the environment 25% of the time and predominantly at night (72% of all 105 measurement hours) compared to daytime (4% of 191 measurement hours). Swedish studies reported by Pedersen 2004 and Persson Waye 2007 generated dose-response relationship between the prevalence of wind turbine and induced annoyance. They delivered questionnaires to 627 households in areas comprising 16 wind turbines. Approximately the response rate were similar and ranged from 60% (< 30 dB(A)) to 78% (>40dB(A)). The results revealed that the proportion of respondents who noticed wind turbine
noise increased sharply from 39% (n=27) at 30.0 -32.5 dB(A) to 85% (n=53) at 35.0 -37.52.5 dB(A). Pedersen and Persson Waye 2004 concluded that living in rural landscape in contrast with an urbanized area enhanced the risk of perceiving wind turbine noise, furthermore, the risk of annoyance. Other physical parameters linked with annoyance include the terrain complexity exhibiting various focusing and defocusing effects and great ground reflection. The New Zealand study compared health related quality of life in different proximities to a wind turbine facility between two communities around the radius 2 km and 8 km with similar demographic, socio-economic and geographic characteristics. The study revealed that wind turbine noise increased with A weighted sound pressure levels., further more annoyed when the noise level exceeded 35-40 dB(A)(Dickinson, 2009, Bowdler 2008). Wind turbine noise

(swishing or thumping) from single turbine elicits increased fluctuation of the sound up to 4 to6 dB in a stable atmosphere. Under acoustical perspective Individuals are highly sensitive to frequency modulation variations of approximately 4Hz or greater. Whereas, non-acoustical factors also determine the tolerance of annoyance towards the noise. In relation to wind farms, the following personal factors given in Table 4 appeared to increase the odds of being annoyed.

Table 4. Non-acoustical factors influencing wind turbine noise annoyance

Non-acoustical factors influencing wind turbine noise annoyance
• Being able to see wind turbines from home • Having negative opinion about wind turbines in general or a negative opinion about the visual impact of turbines on the landscape • Self-reported sensitivity to noise • Perceived predictability of the noise level changing • General attitudes, fear of accidents, and awareness of benefits • Noise sensitivity • Economic benefit (home ownership, compensation, personal benefits from noise source)

In the analysis of combined data, the researchers found that people who reported annoyance outdoors were more likely to report sleep interruption, feeling tense and stressed, and feeling irritable. The impact of noise on sleep interruption did not increase gradually with noise levels; instead, the rates of reported sleep interruption were stable at lower noise levels, and increased at 40 dB in the Swedish study and at 45 dB in the Dutch study (Burns and Robinson ,1970). To date researchers concluded that wind turbine noise is different, and possibly more annoying, than other sources of community noise at similar levels. They also elucidated the limitations on the research that there is no statistical association between annoyance (indoors or outdoors) and other self-reported health outcomes included in the study (including diabetes, high blood pressure, cardiovascular disease, tinnitus, and other outcomes). Further, the exposure response relationship described by the researchers were developed using data from a very small number of field studies.

Reference 2026 : Infrasound and Human Health: Mechanisms, Effects, and Applications Maryam Dastan, Ellen Dyminski Parente Ribeiro, Ursula Bellut-Staeck, Juan Zhou and Christian Lehmann. Appl. Sci. 2026, 16, 1553 https://doi.org/10.3390/app16031553

Infrasound, physically defined as sound at frequencies below 20 Hertz, can travel long distances with minimal attenuation and permeate biological tissues due to its marked particle displacement and deep penetration. Generated by both natural phenomena and humanmade systems, infrasound has drawn increasing scientific and public attention regarding its potential physiological and psychological effects. Experimental studies demonstrate that infrasound can modulate mechanosensitive structures at the cellular level, particularly pressure-sensitive ion channels such as PIEZO1 and TRPV4, leading to intracellular calcium influx, oxidative stress, altered intercellular communication, and in some settings, apoptosis. These responses vary according to sound pressure levels, frequencies, exposure duration, and tissue type. In the cardiovascular system, higher sound pressures have been associated with mitochondrial injury and fibrosis, whereas low sound pressures may exert context-dependent protective effects. In animal models, prolonged or intense exposure to infrasound has been shown to induce neuroinflammatory responses and memory impairment. Short-term studies in humans at moderate intensities have reported minimal physiological changes, with psychological and contextual factors influencing symptom perception. Occupational environments such as factories and agricultural settings may contain elevated levels of infrasound, underscoring the importance of systematic measurements and exposure assessments. At the same time, controlled infrasound stimulation has shown potential as an adjunct modality in bone repair and tissue regeneration, highlighting its dual capacity as both a biological stressor and a possible therapeutic tool. Overall, existing data indicate that infrasound may be harmful at chronic exposure depending on intensity and frequency, yet beneficial when precisely regulated. Future research should standardize exposure metrics, refine measurement technologies, and clarify dose–response relationships to better define the health risks and therapeutic applications of infrasound.

Infrasound is sound with frequencies below the range of human hearing. Complex acoustic and electromagnetic patterns can mediate information at the cellular level, even at very low intensity. Frequencies below 10 Hz are

considered to have particularly high information content. However, the information content of a spectrum depends on all characteristics, including, of course, the duration or time of occurrence. It can be generated from natural sources such as wind, volcanoes, avalanches, and earthquakes. It can also be generated by man-made sources, e.g., wind turbines, diesel engines, and ventilation systems. Among man-made sources, wind turbine-generated infrasound is distinctive for its rhythmic, repetitive pattern, setting it apart from most other environmental low-frequency sources and drawing particular attention in both public discourse and scientific investigation.

In biological tissues, infrasound propagates as longitudinal mechanical waves shaped by tissue density and elasticity. Because it undergoes minimal attenuation, infrasound can penetrate deeply and may produce resonance when its frequency aligns with that of specific organs or tissues. In resonance, the absolute strength of the stimulus is less important than the alignment of its frequency with the system's intrinsic vibrations. Even weak stimuli, when temporally and spatially synchronized, can significantly affect system stability. The human body, as an energetic organism, is comparable to an oscillator with a complex waveform, in which different organs have distinct resonance solutions.

Resonance can intensify mechanical strain, promoting tissue deformation, mechanotransduction, and, under sustained exposure, structural or functional damage. Modeling studies indicate that tissues with distinct acoustic impedances exhibit different resonance responses, with certain frequencies enhancing energy absorption and localized effects

Human Studies

Experiments in ex vivo human tissue extend these insights. Exposure of atrial appendage muscle samples obtained during cardiac surgery to infrasound > 100 dB (Z) for 1 h showed a graded reduction in myocardial contractility, averaging a 9% decline in force per 10 dB increase above 100 dB (Z). These results provide rare direct evidence that human myocardium is functionally sensitive to infrasound at supraphysiological intensities.

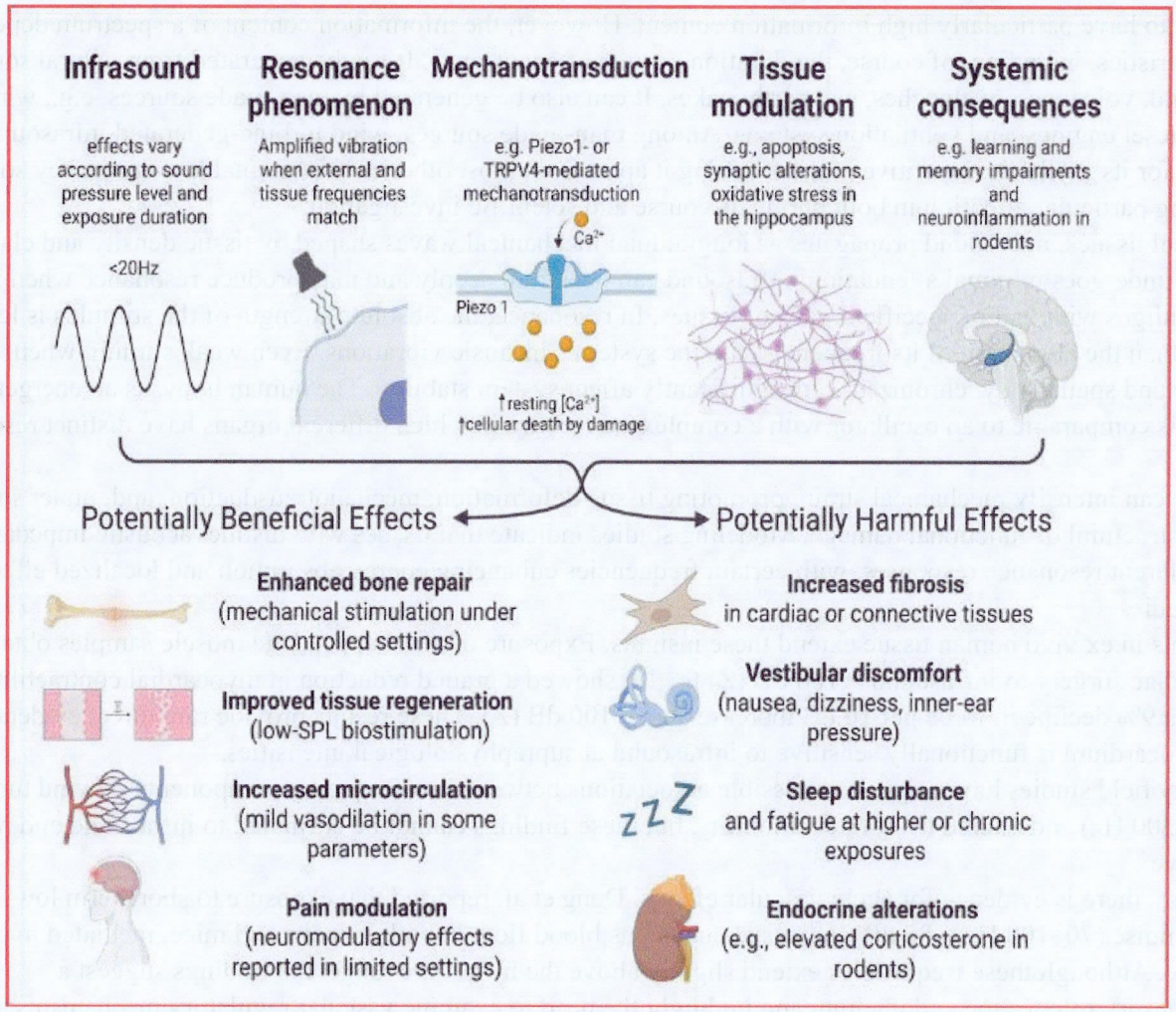
Exploratory field studies have suggested possible associations between low frequency components of wind turbine noise (20–200 Hz) and altered heart rate variability, but these findings cannot be attributed to infrasound and remain inconclusive.

Nonetheless, there is evidence for acute vascular effects. Deng et al. reported that exposure to short-term low-frequency noise (70–100 Hz ≤ 85 dB) increased cutaneous blood flow in both humans and mice, mediated in part by nitric oxide. Although these frequencies extend slightly above the infrasonic range, the findings suggest a mechanosensory role for the endothelium and highlight the need to examine vascular regulatory mechanisms at infrasonic frequencies.

Broader epidemiological surveys of low-frequency noise (including infrasound) have associated such exposures with annoyance, subjective ear pressure, and sleep disturbance, but consistent links to cognitive performance remain elusive. An earlier report noted that infrasound near the auditory threshold heightened pressure sensations and annoyance, but impaired performance only in one of nine tasks.

Low-frequency noise from environmental sources such as wind turbines, which often includes infrasound components, has been associated with disrupted sleep and reduced performance on higher-order cognitive tasks (e.g., logical reasoning, mathematical calculations). However, causality remains debated, with some reports emphasizing annoyance, restlessness, or emotional discomfort in the absence of consistent objective deficits.

The results of the Weichenberger study could provide an explanation, as could the fact that infrasound can temporarily increase alertness. It has been proven that infrasound activates three centers responsible for fear, flight, emotion, and central RR and pulse regulation. Importantly, because some of these centers are involved in attentional control and arousal, it has been suggested that activation of this pathway could, for example, wake people up at night, leaving them unable to pin down what actually caused them to waken.



***Reference 2018* : WHO 2018 Evidence base**

Based on the overall scope and key questions the current guidelines review the relevant literature in the area of environmental noise and health in order to incorporate significant research undertaken since the publication of previous guidelines. The process of evidence search and retrieval involved several steps. These include the identification, retrieval and synthesis of the evidence, followed by a systematic review and assessment (described in section 2.4). 2.3.1 Identification, retrieval and synthesis of evidence

As a first step, the GDG identified key health outcomes associated with environmental noise. Next, it rated the relevance of these health outcomes according to the following three categories:

- critical for assessing environmental noise issues
- important, but not critical for assessing environmental noise issues
- unimportant.

The GDG rated the relevance based on the seriousness and prevalence of the outcomes and the anticipated availability of evidence for an association with noise exposure. The following health outcomes were selected as either critical or important for developing recommendations on the health impacts of environmental noise.

Critical health outcome

Cardiovascular disease
Annoyance
Effects on sleep
Cognitive impairment
Hearing impairment and tinnitus

Important health outcome

Adverse birth outcomes
Quality of life, well-being and mental health
Metabolic outcomes

Reference 2025 : Maintenance of Wind Turbine Blades and Microplastic Emission: How to Mitigate Environmental Risks. Leon Mishnaevsky Jr. *Wind Energy*, 2025; 28:e70072. https://doi.org/10.1002/we.70072

Blade repair can be needed as early as 1–2 years after the wind turbine installation and can be required quite often, every 2 years. This repair frequency and high costs apparently mean that the technology should be drastically improved.
Maintenance and repair of wind turbine blades include typically the following steps: finding damage, assessing the degree and type of the damage, designing the repair scheme, removing the damaged region and surface preparation, fabricating repairing parts, and attaching it, inspection. The steps where any plastic particle emission can be expected are removal of the damaged region (typically, by griding), surface preparation (grinding), bonding, and finally surface polishing.
Different repair procedures are applied to wind turbine blades, depending on specific conditions and blade damage mechanisms. According to the estimations from [2], the most common blade damage mechanism is the leading edge erosion. While it is a minor damage of the blade and not so spectacular as blade collapses (which are widely reported in newspapers), erosion repair constitutes 90% of all blade damages requiring repair. The costs for repair of minor blade damage (erosion) are also 12 times higher than those of structural failure. Moreover, structural blade repair requires a blade replacement or factory repair, while the surface erosion can be repaired onsite, thus adding to the risk of onsite plastic emission.
Using the data of wind turbine service companies, it was determined that the volume of emitted particles due to erosion is about 75g per year per blade for onshore wind turbines.
Microplastic shedding from turbine blades, known as Leading Edge Erosion, is a great concern to manufacturers who are forced to repair the damage that occurs after only a couple of years. The particles eroded from blades include epoxy which is 40% Bisphenol-A (BPA), a frequently banned endocrine disruptor and neurotoxin. Academic research has shown the potential for 137 pounds of epoxy microparticles to be shed per turbine per year.
Recent reports from Germany and other countries have highlighted a disturbing issue: the degradation of wind turbine rotor blades. These blades, made from composite materials such as carbon-fibre-reinforced polymers (CFRP), are not only prone to breaking but also to releasing fine, respirable fibres—referred to as "nasty fibres"—into the air. According to experts, these fibres are as carcinogenic as asbestos.
Asbestos, once widely used in construction for its heat-resistant properties, was later discovered to cause serious respiratory illnesses, including lung cancer and mesothelioma. The material's dangers became so apparent that its use was eventually banned in many countries. Now, the similarities between asbestos and the fibres released from wind turbine blades are raising alarms. Like asbestos, these carbon fibres are chemically non-reactive and difficult to break down in the lungs, posing long-term health risks to those exposed.
The problem doesn't stop with human exposure. Animals and the broader environment are also at risk. In incidents where turbine blades have snapped or caught fire, fine fibres have been scattered across surrounding areas, contaminating soil and potentially entering the food chain. The long-term effects of this contamination are still unknown, but the potential for widespread ecological harm is significant.
What makes this situation even more concerning is the apparent lack of regulatory oversight. There are no strict guidelines in place to manage the risks associated with these fibres. In some cases, local fire brigades have been tasked with clearing debris from damaged turbines without proper protective gear or awareness of the hazards involved. This lack of preparedness is reminiscent of the early days of asbestos use when the dangers were either unknown or deliberately downplayed.
Moreover, the issue of recycling turbine blades adds another layer of complexity. Unlike other materials, CFRP is difficult to recycle, often ending up in landfills where it can continue to pose risks. The sheer volume of blades that will need disposal in the coming years is staggering, and without effective recycling solutions, we could be facing a significant environmental disaster.

Reference 2025 : Asbestos found in wind farm lift brake pads prompts safety response : Tamara Clark, ABC Wimmera · **20 Nov 2025 · abc.net.au** ~~
The discovery of asbestos-ridden lift brake pads has sparked an urgent safety response at wind farms across the country. WorkSafe Victoria and renewable energy company Goldwind Australia, a subsidiary of Chinese firm Goldwind Science and Technology Co. Ltd, said white asbestos was found in brake pads used in wind turbine lifts at its facilities.
The brake pads were supplied by 3S Industry, a major Chinese-based supplier to Australia. 3S Industry is one of a few brake pad suppliers to Australia, meaning a significant percentage of the country's wind turbines could be affected.
Interstate regulators have united to form a coordinated safety response. The importation of asbestos, or goods containing asbestos, has been illegal in Australia since 2003.

Reference 2024 : Microplastics Emission from Eroding Wind Turbine Blades: Preliminary Estimations of Volume Leon Mishnaevsky, Jr., Antonios Tempelis , Yauheni Belahurau and Nicolai Frost-Jensen Johansen. Energies 2024, 17, 6260. https:// doi.org/10.3390/en17246260

In this article, the volume of removed plastic due to the leading-edge erosion of wind turbine blades is evaluated using different approaches. A probabilistic model of material removal due to successive rain droplet impacts was developed and applied to the determination of the volume loss of blades due to erosion. As a result, it was shown that for the case of an average tip speed of 90 m/s, 1000 mm of rain annually, and a mean rain intensity of 1 mm/h, the volume loss is at the level of 15 mm3/cm2 per year. For the area 10 m×50mm(fullleading-edge surface), it leads to 75 cm3 or **75 g per blade per year.**

Reference 2024 : INQUIRY INTO INQUIRY INTO PFAS CONTAMINATION IN WATERWAYS AND DRINKING WATER SUPPLIES THROUGHOUT NEW SOUTH WALES Name: Date Received: Mr Ian McDonald 10 December 2024. Select Committee on PFAS Contamination in Waterways and Drinking Water Supplies Throughout New South Wales

All epoxy resins contain BPA or similar bisphenol components. Epoxy resins are used in almost every part of our daily life (BPA *in a confined state*) such as paints, plastic drink bottles, flooring etc and in the manufacture of wind turbine blades. Epoxy resins are also used in the manufacture of wind turbine blades. The blades, however, wear and then shed a fine dust of BPA throughout their life. This dust is spread wide and far by wind and if only one gram of it gets into dam or town storage waters, 10million litres of water is polluted and then rendered unusable. This dust (BPA *in an unconfined state*) from eroding blades has already covered large areas of our planet in proximity to wind farms and BPA is leaching into soils and waterways. Furthermore, the process is accelerated when the blades are cut up, dumped (on-site) and buried.

The wind industry openly admit that any wind turbine will emit in excess of 60kg of microplastics containing '*forever chemicals*' per year into the atmosphere which will find their way into soil profiles and waterways. That is the equivalent of about **50 tonne of pure unadulterated BPA pollutants over 20 years finding their way into water catchments from a typical 100 turbine wind farm.**

Reference: Select Committee on PFAS (per and polyfluoroalkyl substances) - Submission 105. Submission on PFAS: Environmental and Health Impacts in Renewable Energy Infrastructure. Submission to: Federal Senate Inquiry into PFAS Standards. Author: Dr Anne S. Smith, Rainforest Reserves Australia

This submission outlines the pervasive environmental and health challenges posed by per and polyfluoroalkyl substances (PFAS) within renewable energy infrastructure, such as solar panels, wind turbines, and batteries. PFAS, often termed "forever chemicals" due to their extreme resistance to environmental degradation, represent an escalating global crisis. These chemicals, essential for certain industrial applications, are increasingly recognized for their role in long-term environmental contamination, bioaccumulation, and biomagnification in food chains.

In renewable energy technologies, PFAS are used in coatings, composites, and cooling systems to enhance performance and durability. However, their persistence creates contamination risks during production, operation, and disposal. Evidence links PFAS exposure to serious human health impacts, including cancer, immune suppression, endocrine disruption, and neurodevelopmental issues. Furthermore, the contamination of ecosystems— affecting soil, water, and wildlife—has significant socio-economic repercussions.

Key Findings from International Research

International research has provided critical insights into PFAS contamination, its impacts, and strategies for mitigation. These findings can inform Australia's policy and regulatory responses.

1. Human Health Risks:

o **Cancer and Endocrine Disruption**: Studies by **Barry et al. (2013)** and **Blake et al. (2015)** have linked PFAS exposure to kidney and testicular cancer, as well as hormonal disruption affecting reproductive health.

o **Immune Suppression**: Research by **Grandjean & Clapp (2015)** indicates that PFAS exposure reduces vaccine efficacy, increases infection susceptibility, and compromises overall immune function.

2. Environmental Persistence:

o PFAS' extreme resistance to degradation, as documented by **Vierke et al. (2012)**, complicates cleanup efforts and ensures long-term environmental contamination.

o **Ahrens et al. (2015)** further highlight PFAS' ability to travel globally, contaminating even remote ecosystems.

3. Economic Impacts:

o Cleanup costs for PFAS-contaminated sites in the United States exceed $1 billion annually, according to the U.S. Environmental Protection Agency (EPA). The financial burden on industries, governments, and communities is substantial and underscores the importance of preventive measures.

Environmental Impacts

The environmental impacts of per- and polyfluoroalkyl substances (PFAS) are far-reaching, with significant consequences for soil, water, ecosystems, and biodiversity. The persistent and bio-accumulative nature of PFAS exacerbates their effects, making remediation efforts challenging and often cost-prohibitive.

Contamination of Soil and Water

PFAS contamination is a pressing concern for soil fertility and water quality. Due to their chemical stability and resistance to natural degradation, PFAS remain in the environment for decades, continually cycling between soil and water systems.

• Impact on Agriculture: PFAS contamination in soil alters its chemical composition, reducing fertility and crop yields. Banzhaf et al. (2017) documented how PFAS interfere with soil structure and nutrient availability, negatively impacting agricultural productivity. Farmers in contaminated regions often face reduced economic output and loss of livelihood due to restrictions on using contaminated land for cultivation.

• Threat to Aquifers: PFAS leach into groundwater systems, contaminating aquifers that serve as critical drinking water sources. Contaminated water supplies pose a direct risk to human health and the environment. Aquifers with high PFAS levels can become unusable for decades, as remediation technologies like activated carbon filtration are expensive and labor-intensive.

Disproportionate Effects on Rural Communities: Rural communities that rely heavily on local aquifers for drinking water and irrigation are disproportionately affected. Indigenous populations, in particular, face compounded risks due to their close cultural and economic ties to the land. O'Neill et al. (2019) highlights the inequities in PFAS management, with rural and Indigenous communities often receiving delayed support and inadequate remediation.

Impact on Flora and Fauna

PFAS disrupt critical ecological processes, affecting both plant and animal species across terrestrial and aquatic environments.

• Impact on Plants: PFAS exposure alters soil chemistry, negatively impacting plant growth and nutrient cycles. Navarro et al. (2021) found that PFAS interfere with microbial communities essential for nitrogen fixation and organic matter decomposition. This disruption reduces crop yields and increases soil salinity, further impairing agricultural productivity.

• Impact on Wildlife: PFAS bioaccumulate in aquatic and terrestrial species, with significant consequences for reproduction, growth, and survival. Hansen et al. (2020) demonstrated that PFAS exposure in amphibians and fish led to developmental abnormalities and reduced reproductive success. Apex predators, such as polar bears and raptors, are particularly vulnerable due to biomagnification, which increases PFAS concentrations at higher trophic levels.

• Ecosystem-Level Consequences: PFAS contamination affects entire ecosystems by disrupting food webs and reducing biodiversity. Predatory species experience declines due to reduced prey availability and reproductive challenges, leading to imbalances in ecosystem dynamics.

Long-Term Consequences

The long-term persistence of PFAS in soil and water compounds their environmental impact. **Kotthoff et al. (2021)** highlighted that even decades after initial contamination, PFAS residues can hinder ecosystem recovery by disrupting natural nutrient cycles and regeneration processes. Furthermore, the high cost and technological complexity of remediation methods, such as soil excavation and advanced filtration systems, make long-term solutions challenging to implement.

Global Implications:

Due to PFAS' ability to travel long distances via air and water currents, their contamination is not confined to local environments. **Ahrens et al. (2015)** documented PFAS in Arctic ecosystems far from industrial sources, illustrating their global reach and the need for international cooperation to address their impacts.

Human Health Impacts

PFAS contamination presents a significant risk to human health through multiple exposure pathways. Communities near contamination hotspots, such as renewable energy facilities, landfills, and industrial sites, are particularly vulnerable to these risks. The long-lasting nature of PFAS in biological systems and the environment compounds their potential for harm, leading to severe health effects that persist across generations.

4.1 Exposure Pathways

Humans are exposed to PFAS primarily through:

1. Contaminated Water:
PFAS are highly water-soluble, allowing them to infiltrate groundwater and municipal water supplies. Communities located near industrial facilities, firefighting training sites, or renewable energy projects are at greater risk. For instance, solar panel coatings and battery separators may release PFAS into surrounding water systems during production or disposal. A study by **Banzhaf et al. (2017)** identified PFAS in aquifers serving rural and urban populations, highlighting the challenges of providing clean drinking water.
2. Food Contamination:
PFAS accumulate in crops irrigated with contaminated water, livestock exposed to polluted feed or water, and seafood from contaminated rivers or coastal areas. **Navarro et al. (2021)** found that PFAS persist in agricultural soils, entering food chains and disproportionately affecting subsistence farmers and rural populations. Bioaccumulation in fish and seafood poses a direct risk to human health, particularly in coastal communities reliant on fishing for sustenance and economic livelihood.
3. Airborne Particles:
PFAS are released into the air during manufacturing processes, the degradation of renewable energy components, or improper disposal of waste materials. Vierke et al. (2012) highlighted that PFAS can travel long distances through atmospheric currents, contaminating areas far removed from their original source. Inhalation of PFAS particles during production or maintenance of renewable energy infrastructure may pose occupational hazards to workers.
4. Household Products and Dust:
PFAS are found in everyday items such as non-stick cookware, stain-resistant fabrics, and personal care products. Indoor exposure to PFAS from household dust is an under-recognized pathway, particularly for children who are more likely to ingest dust through hand-to-mouth contact.
5. Disproportionate Impact on Vulnerable Communities:
Indigenous populations and rural communities face heightened risks due to their reliance on local water and food sources, which are often directly affected by nearby contamination. O'Neill et al. (2019) emphasized that these populations frequently lack the resources and infrastructure necessary to mitigate exposure, compounding existing health disparities. For example, limited access to alternative water supplies or healthcare exacerbates the long-term impacts of PFAS exposure in these groups.
Health Effects
The health effects of PFAS are extensive, with scientific studies consistently linking exposure to a range of acute and chronic conditions. Key health impacts include:
1. Cancer:
o PFAS exposure has been strongly associated with an increased risk of kidney and testicular cancers. **Barry et al. (2013)** conducted longitudinal studies in communities exposed to PFAS-contaminated water, finding higher incidences of these cancers compared to non-exposed populations. These cancers are thought to result from PFAS' ability to disrupt cellular signaling and promote tumor growth.
2. Immune System Impairment:
o Chronic PFAS exposure compromises immune function, reducing the body's ability to fight infections and respond to vaccines. **Grandjean & Clapp (2015)** found that children with elevated PFAS levels had lower antibody responses to vaccines, leaving them vulnerable to preventable diseases. This immune suppression also increases the likelihood of chronic inflammation, autoimmune diseases, and longer recovery times from infections.
3. Neurodevelopmental Disorders:
o Prenatal and early childhood exposure to PFAS has been linked to cognitive delays and developmental abnormalities. **Braun et al. (2014)** demonstrated that children exposed to PFAS in utero scored lower on tests measuring memory, attention, and language skills. These effects are particularly concerning as they impact future generations and exacerbate educational and socio-economic inequalities.
4. Endocrine Disruption:
o PFAS interfere with hormone regulation, leading to reproductive and developmental disorders. **Blake et al. (2015)** documented hormonal imbalances in individuals exposed to PFAS, including reduced fertility, early puberty, and thyroid dysfunction. These disruptions may increase the risk of metabolic conditions, such as obesity and diabetes.
5. Cardiovascular Risks:
o Elevated cholesterol levels and hypertension have been observed in populations with high PFAS exposure. Studies by **Lind et al. (2020)** indicate that PFAS alter lipid metabolism, increasing the likelihood of cardiovascular diseases such as atherosclerosis and stroke.
6. Mental Health Impacts:

o Living in PFAS-contaminated areas can cause significant psychological stress due to concerns about health risks, property devaluation, and social stigma. **Ebi et al. (2020)** highlighted the mental health burden on communities dealing with PFAS-related crises, noting increased rates of anxiety, depression, and community tension.

Long-Term and Intergenerational Effects

PFAS exposure during pregnancy and early development has profound long-term consequences. Prenatal exposure has been linked to:

• **Reduced Birth Weights**: Studies by **Darrow et al. (2013)** found that infants exposed to PFAS in utero had lower birth weights, which are associated with increased risks of chronic health conditions later in life.

• **Epigenetic Changes**: PFAS may cause changes to DNA expression that are passed down to subsequent generations. Research into epigenetic impacts is ongoing, but early findings suggest that PFAS exposure may contribute to inherited health vulnerabilities.

Socio-Economic Implications

The economic burden of PFAS-related health conditions is significant. Healthcare costs, reduced productivity, and loss of property values in contaminated areas exacerbate financial disparities, particularly in already disadvantaged populations. Affected communities often face years of legal battles to secure compensation and cleanup efforts, as seen in cases such as Oakey, Queensland, and Wilmington, North Carolina.

Renewable Energy: Wind Turbine Blades

Research by **Henne et al. (2021)** found that PFAS used in wind turbine blade coatings degrade over time, releasing microplastics and chemical residues into surrounding ecosystems. This case exemplifies the environmental trade-offs associated with renewable energy technologies.

Conclusion on PFAS and the Need to Cease Its Use

The continued use of PFAS in renewable energy infrastructure, such as solar panels, wind turbines, and batteries, poses an unacceptable risk to the environment, human health, and ecosystems. These "forever chemicals" resist natural degradation, bioaccumulate in living organisms, and travel long distances through air and water, ensuring widespread and longterm contamination.

Evidence demonstrates the catastrophic impacts of PFAS contamination:

1. **Environmental Degradation**: PFAS contamination has been found in critical ecosystems, including soil, water, and marine environments. It disrupts food webs, reduces biodiversity, and weakens ecosystems' resilience. This contamination persists for decades, making recovery both costly and complex.
2. **Human Health Risks**: PFAS exposure is strongly linked to serious health conditions such as cancer, immune suppression, endocrine disruption, and developmental disorders. Vulnerable populations, particularly those in rural and Indigenous communities, face compounded risks due to their reliance on contaminated local water and food sources.
3. **Economic Burdens**: The cleanup of PFAS-contaminated sites is prohibitively expensive, often exceeding billions of dollars annually, while communities suffer property devaluation and lost livelihoods. These economic impacts disproportionately affect disadvantaged populations.
4. **Global Contamination**: PFAS are not confined to local environments; their presence in remote Arctic ecosystems highlights the global scale of this crisis. International studies reveal PFAS in apex predators and marine life, further endangering global biodiversity.

The use of PFAS in renewable energy, though advantageous for durability and performance, introduces unacceptable trade-offs. The degradation of turbine blades, improper disposal of solar panels, and contamination from battery components release toxic PFAS compounds into the environment. These risks undermine the sustainability goals that renewable energy seeks to achieve.

Reference 2021 : Wind turbines and adverse health effects: Applying Bradford Hill's criteria for causation. Dumbrille, Anne; McMurtry, Robert Y. Krogh, Carmen Marie. Environmental Disease 6(3):p 65-87, Jul–Sep 2021. | DOI: 10.4103/ed.ed_16_21

The weight of evidence indicates occurrences of adverse health effects (AHEs) from living and working near industrial wind turbines (IWTs). Descriptions of the AHEs being reported by those living or working near the turbines are similar. While these occurrences have been associated with exposure to audible and inaudible noise annoyance, the causation of reported wind turbine-associated health effects remains controversial. Establishing an argument of causation of adverse health outcomes has important clinical, scientific, and societal implications. Bradford Hill (BH) criteria have been widely used to establish causality between an environmental agent and risk of disease or disability, but have not previously been used to evaluate the relationship between IWTs and AHEs. The objective was to apply the

BH criteria to evaluate the relationship between IWTs and AHEs. The nine criteria include the strength of the association, consistency, specificity, temporal sequence, biological gradient, plausibility, coherence, experimental evidence, and analogous evidence. These nine criteria have been applied to IWT exposure and reported AHEs using peer-reviewed and other published literature that describes clinical, animal, and laboratory studies, testimony and reported experiences, and internet sources. Applying the BH criteria to the IWT-related clinical, biological, and experimental data demonstrates that the exposure to IWTs is associated with an increased risk of AHEs. This analysis concludes that living or working near IWTs can result in AHEs in both people and animals. Our findings provide compelling evidence that the risk of AHEs should be considered before the approval of wind energy projects and during the assessment of setback distances of proposed and operational projects.

Proof of causation typically requires the rigor of a scientific standard. Consequently, the evidence required to make a scientific determination about causality has a higher standard than the Precautionary Principle that is recommended by the World Health Organization (WHO).The Bradford Hill (BH) criteria, sometimes referred to as Hill's criteria for causation, are a set of nine criteria that have become a frequently cited framework for establishing epidemiologic evidence of a causal relationship between a presumed cause and an observed effect. They were established by Sir Austin Bradford Hill and have been reviewed in numerous articles and presentations.[Researchers have applied Hill's criteria in examining the evidence of causality of environmental and other exposures on health, for example, connections between smoking and asbestos and cancer, ultraviolet B radiation, Vitamin D and cancer, Vitamin D and pregnancy and neonatal outcomes, alcohol and cardiovascular disease outcomes, infections and risk of stroke, nutrition and biomarkers related to disease outcomes, and sugar-sweetened beverage consumption, and the prevalence of obesity and obesity-related diseases.

The nine criteria described by Hill are strength of association, consistency, specificity, temporal relationship, biological gradient, plausibility, coherence, experimental evidence, and analogous evidence. Three recent additional approaches that have been used to evaluate potential outcomes are (i) directed acyclic graphs, (ii) sufficient-component cause models, and (iii) the grading of recommendations, assessment, development, and evaluation methodology. The criteria that have been examined using these approaches are consistent with the BH criteria: strength of association (including analysis of plausible confounding); temporality; and plausibility and experiments (including implications of study design on exchangeability). The overlap between the BH viewpoints and the other approaches substantiates the ongoing influence and the application of BH criteria in causal assessments

Applying the BH criteria to the IWT-related clinical, biological, and experimental data gives evidence that exposure to IWTs is associated with an increased risk of AHEs.

Criteria 1: Strength of the association

The bulk of scientific evidence associated with AHEs due to IWT installations comes from individual exposure information from both those living near IWTs and from industrial workers. Evidence includes thousands of case reports and incident reports that have been submitted to the Government of Ontario, Canada, and international reports that are available through government inquiries, judicial proceedings, and from the Internet.

Criteria 2: Consistency

Compelling information is derived from the consistency of effects as described in published case reports and thousands of adverse event reports of those affected living near IWTs. These effects occur despite the range of international locations and the language spoken in the country in which these events originate. The descriptions of effects reported in different countries are consistent; the common factor is the siting of IWTs near family homes or in occupational settings. Epidemiological studies, reviews, and reports describe proximity to IWTs as being most commonly associated with annoyance/human distress, sleep disorders, headaches, mood disorders, inability to concentrate, tinnitus, and vestibular problems. Some describe effects from nonauditory pathways such as vibratory sensations, heart palpitations, or pressure changes.

Criteria 3: Specificity

Exposure to a risk factor does not necessarily result in a uniform incidence rate of AHE. For example, not all smokers develop lung cancer. The same is true of AHE resulting from IWTs where a nontrivial percentage, but not all, of the exposed population reports adverse events. Incident reports/complaints can serve as a valuable resource and a form of public health surveillance during the introduction of IWTs – a new noise source – into quiet rural communities. The large number of AHE formally reported to governments, the self-published reports on social media and Internet websites, and those collected systematically, such as the WindVOiCe collection from Ontario by Krogh et al., 2011, and the investigations by physicians such as Harry and Pierpont indicate that the AHEs associated with IWT exposure go well beyond a few rare individuals who are extremely susceptible.

Criteria 4: Temporality

A case-crossover study provides one of the most compelling sources of epidemiologic data. In a study of this type, subjects are exposed to a substance or environmental factor of perceived threat and exhibit symptoms, followed by a reduction of their exposure to that substance or factor and then followed once more by re-exposure. To date, only limited case-crossover safety studies have been performed on exposure to IWTs.

• A case series crossover study by Pierpont in the USA included families from Canada, the United States of *America, Ireland/United Kingdom, and Italy. Data documenting health status and medical problems for residents were collected: (1) before exposure to operating wind turbines, (2) during exposure, and (3) when people reduced their exposure to operating wind turbines by leaving their homes or spending a prolonged period away. The study involved 38 people from ten affected families (aged infant to 75 years), living 305 m to 1.5 km from IWTs. Adults and older teens completed a detailed clinical interview about their own and their children's symptoms, sensations, and medical conditions. A clear pattern of symptoms relating to exposure to operating wind turbines was documented. Symptoms developed are described in Criteria 1: Strength of Association. Symptoms developed after the turbines started operating near their homes and went away when the subjects temporarily and/or permanently vacated/abandoned their homes. The symptoms returned when the affected people went back to their homes. Eventually, 8 of the 10 families moved away with some abandoning their homes.*

• *An Australian case series crossover study was conducted and reported by Hansen et al. Hansen et al. documented symptoms correlating with the intermittent shut down of turbines. Full spectrum acoustic monitoring was conducted at six locations at distances from 1.3 km to 7.6 km from the Waterloo Wind Energy facility. The study compared the effects on the residents when the wind turbines were operating, then not operating for a week, and then when again operating. The authors documented symptoms in the residents that correlated with the intermittent shut down of the turbines. The acoustic survey report confirmed that sleep disturbance correlated with exposure to wind turbines at a distance of up to 8 km. The range in the overall A-weighted levels was noticeably larger indoors and ranged from 5 dB(A) to 38 dB(A). There was a direct correlation between LFN events and complaints registered in noise diaries. The Danish LFN guidelines were exceeded on a number of occasions, generally in downwind conditions and when hub height wind speeds were greater than 8 m/s. Based on these observations, the authors concluded that "there is a LFN problem associated with the Waterloo wind farm."*

• A comprehensive acoustic survey was conducted at the Cape Bridgewater Wind Development in Australia by *Cooper, an independent acoustical consultant, with The Acoustic Group (2014), where turbines were temporarily shut off and on. The study was commissioned by the wind energy developer to address several years of noise complaints received since the project was put in service in 2008. Tests, including measuring noise emissions, were performed inside three homes (6 occupants) located between 650 m and 1.6 km of the wind facility over 8 weeks. At the end of the 2nd week of the test program, the wind turbines were shut down daily for 10–12 h per day for 2 weeks. Residents were asked to record in a diary perceived impacts of noise, vibration, and other disturbances, on a 1–2 hourly basis. The study did not include any testing in relation to sleep disturbance. The results obtained showed a trend toward an association between the high-level "Sensations" disturbance and the operating power of the turbines. Sensation measured included headache, pressure in head, ears, or chest, ringing in ears, heart racing, or a sensation of heaviness. Participants recorded a significant sensation disturbance occurring when the turbines were about to start up, with a change in power output of 20%, and when the turbine had reached maximum power. No correlation of sensation disturbance with the dB(A) noise levels or impacts that residents identified as coming from the turbines was detected, indicating that emissions outside the hearing range were likely causing the sensations.*
In addition, before and after impact studies have reported that residents were symptom free before the start-up of an adjacent wind turbine project, and developed symptoms subsequent to the onset of wind turbine operation.
Criteria 5: Biological gradient (dose–response effect)
The process of quantitatively assessing the dose received and response by a biological entity produces a dose–response relationship. This is recognized as an important part of the process in assessing health risk associated with exposure to various contaminants in the environment. A correlation has been documented between distance to IWTs and/or the associated noise energy and reported AHE. Below, five studies are described: Four examined the association between AHE and noise levels, followed by one examining the effect of distance.
A stratified cross-sectional study by Nissenbaum et al. was performed in the USA to compare sleep and general health outcomes of participants living close to IWTs with those living further away from them. As described in Criteria 1: Strength of Association, enrolled participants lived between 375 m and 1.4 km (N = 38) and 3.3 km and 6.6 km (N =

41) from IWTs. Validated questionnaires were used to collect information on sleep quality (PSQI), daytime sleepiness (ESS), and general health (SF36v2), together with psychiatric disorders, attitude, and demographics. Descriptive and multivariate analyses were performed to determine if the distance to the nearest IWT had any effects on various health outcome measures. Analyses showed that participants living within 1.4 km of an IWT had worse sleep, were sleepier during the day, and had worse SF36 mental component scores compared to those living further than 1.4 km away. Significant dose–response relationships between PSQI, ESS, SF36 mental component score, and the log distance to the nearest IWT were identified after controlling for gender, age, and household clustering.

Taken together, the above studies demonstrate that dose–response relationships exist between exposure to IWTs and AHEs, as determined either with "dose" calculated as the distance to the turbines or SPLs. The responses (i.e., the AHEs) observed include annoyance, effects on sleep, and effects on mental health score. It is of importance to note that noise annoyance, including that associated with operational IWTs, has been acknowledged as a health/AHE by Health Canada (2005), quoting the WHO and by others.

Criteria 6: Plausibility

Research, incident reports/complaints, and reports by people living near IWTs indicate that wind turbines impact people's senses, resulting in adverse health symptoms. There may be more than one factor contributing to the effects. Evidence suggests that a plausible mechanism involves responses to audible and inaudible noise, including infrasound and LFN. In addition, evidence is emerging indicating that EMF and RF energy and shadow flicker contribute to turbine-associated AHE.

The precise noise and vibration frequencies which are causing the reported symptoms in people near IWTs are not fully elucidated. Indeed, the safe exposure cumulative dose (short and long term) of noise and vibration frequencies has not yet been defined for any age group.

Criteria 7: Coherence

In describing his criteria for causality, Bradford Hill noted that "... lack of such [laboratory] evidence cannot nullify the epidemiological effect on associations." However, as described above, in experiments during which people were exposed to infrasound, similar symptoms are reported by those living and working near turbines.

Although low-frequency hearing sensitivity depends on many factors including the mechanical properties of the middle ear, it is known to be correlated with cochlear length for many species with nonspecialized cochleae, including humans and guinea pigs. The thresholds of guinea pig hearing have been measured with stimulus frequencies as low as 50 Hz; the average sensitivity recorded in four studies at 125 Hz was SPL of 37.9 dB, which is 17.6 dB less sensitive than the sensitivity of humans at the same frequency and is consistent with the shorter cochlea of guinea pigs. It is therefore reasonable to assume that if responses are present in the guinea pig at a specified level of low-frequency sound, then they will be present in the human at a similar or lower stimulus level. Thus, the guinea pig may represent a valid experimental model which is likely to under-estimate the effect in humans.

Consistent with AHEs being reported several kilometers from IWTs, Schofield measured vibration signals at the Stateline wind farm in Oregon (US) that consisted of 399 wind turbines, each with a rated power of 0.66 MW. The study found that the propagation of a 4.3 Hz vibration signal was measurable at distances up to approximately 18 km from the turbines. Escaler and Mebarki demonstrated that vibrations measured in full-scale wind turbines were highest at less than 1 Hz.

Criteria 8: Experimental Evidence

While large-scale controlled clinical studies have not been performed, there is increasing evidence that the adverse events reported by those living at least 10 km from IWTs could in part be the result of infrasound emitted by the turbines. In experiments where people have been exposed to infrasound, similar symptoms are reported as by those living and those working near turbines.

There is experimental evidence that exposure to LFN/infrasound can lead to adverse events in animals as well as in people. Animal studies have demonstrated serious health effects from proximity to IWTs: geese, pigs; LFN: chick embryo; and high-frequency vibration: rats

There is clear experimental evidence that exposure to IWTs cause adverse events in animals and people.

LFN/infrasound such as that emitted by IWTs can lead to adverse events similar to those reported by people living near IWTs. This suggests that the infrasound emitted by turbines contributes toward the adverse events reports by those living within 10 km or more of IWTs.

Criteria 9: Analogous evidence

Stimuli that are not perceived by the senses, such as ionizing radiation and carbon monoxide, can be pathogenic. The claim that noise must be audible to be considered significant is not a defensible conclusion by analogy or by virtue of the literature on LFN, infrasound, vibration, and other potential contributors. AHEs reported in people living and

working near IWTs, the effects on animals, and the correlation between LFN and effects when turbines are turned off and on (described above) reveal an association between AHEs and IWTs.
The BH criteria represent an important tool for determining cause between an environmental exposure and a health outcome (i.e., disease or disability) in a scientifically rigorous manner. The criteria are far more stringent than the Precautionary Principle, which the WHO (1999) provides as the environmental management principles on which government policies, including noise management policies, can be based.
*The WHO document states that: "**When there is a reasonable possibility that the public health will be endangered, even though scientific proof may be lacking, action should be taken to protect the public health, without awaiting the full scientific proof**."*
Appendix 1: Reports of adverse effects on animals
Reported AHE of animals located near IWTs include the following:

• Disturbances in animal reproduction have been reported related to wind energy facilities in Wisconsin (USA). *Reported abnormalities include teratogenic effects in cattle (missing eyes and tails); health, teratogenic and reproduction problems in a formerly award-winning herd of cattle (cancer deaths, cows not calving properly, mutations such as absent eyeballs or tails, cows holding pregnancy only 1–2 weeks and then aborting, blood from nostrils); as well as teratogenic effects in chickens (crossed beaks, missing eyeballs, deformities of the skull, joints of feet/legs bent at odd angles)*

Farmers near a wind turbine development near Goderich, Ontario, Canada, observed health problems with *their livestock which began shortly after the wind turbines were installed. The cattle were reported to exhibit unusually aggressive and erratic behavior, "including the kicking of newborn calves, prolapsed birthing, weight loss, decline in fertility, a high incidence of mastitis, calves being deformed at birth, and a high incidence of stillbirths"*

• Similar adverse health effects and excess mortalities in various animal species have been reported that were *temporally coincidental with the installation of industrial wind turbines and associated generating stations, that include the following:* o Cows: Reduced fertility (Canada); fertility and structural issues (Japan); and mortality (France)
o Goats: Reduced fertility and health problems (Canada)and mortalities in 450 of 700 (Taiwan)
o Horses: Leg deformities (Portugal)
o Emu: Mortalities in 30 of 38 and reduced laying (Canada)
o Mink: 1600 miscarriages and birth defects (Denmark)
o Badgers: High cortisol levels, an indicator of stress (UK)
o Other effects.

Reference : A Madison County, Iowa, Cardiologist's Investigation and Response to Industrial Wind Turbines n the Rural Residential Countryside Regarding Concerns of Adverse Health Effects And, Exploration of the Relevant Accompanying Larger Issues. W. Ben Johnson, M.D. December 7, 2020.
Response from MLavelle: The applicants statement that health issues are not relevant is clearly nonsense. This Report is included in Appendices.

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12th November 2025

Deputy Niall Collins,
Dáil Éireann,
Kildare Street,
Dublin 2

Re:
To ask the Minister for Health if she is aware that the wind energy industry continues to rely on the outdated 2017 HSE Position Paper on Wind Turbines and Public Health, which is contrary to more recent advice issued by the HSE (details supplied); if the 2017 Position Paper has been formally withdrawn; if not, the reason it has not been withdrawn; and if she will make a statement on the matter.

Dear Deputy Collins,

At the time it was developed, the 2017 HSE Public Health Medicine Environment and Health Group Position Paper on Wind Turbines and Public Health provided a succinct account of the evidence regarding risks to public health from wind turbines. In the intervening time, the context has changed, and evidence-base has been developed further (See **Appendix)** and the HSE is reviewing its advice. Therefore, the 2017 HSE Public Health Position Paper is now under review and thus, has been withdrawn whilst this review is being undertaken.

The HSE role in the Planning and Development process is as a statutory consultee and HSE is consulted by planning authorities on planning applications that are likely to have a significant effect on public health.

The HSE has no role in the consenting or conditioning of any development or in deciding on the merits of any planning application.

If you require any further information or clarification, please do contact us.

Yours sincerely,

Dr. Éamonn J. O'Moore,

Director,

National Health Protection Office HSE.

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Appendix

Changes in context and evidence

The size, nature and location of wind turbine developments have substantially changed since the publication of the 2017 HSE Public Health position paper and the evidence base around any potential health impacts from these developments continues to evolve. The High Court Judgement in 2024 of WEBSTER and ROLLO v MEENACLOGHSPAR (WIND) LIMITED [2024] IEHC 136 [2018 8457 P] examined the protection of health during wind turbine operation and this judgement should be considered in any future wind turbine development.

It is the opinion of the HSE that the changed nature, size and location of wind turbines over the last 10 years warrants a comprehensive review of the current Department of Housing, Local Government and Heritage Wind Energy Development Guidelines (2006), which are the current guidance for assessing likely significant effects on health from wind turbine development. This review should include the most up to date evidence on likely impacts on Population and Human Health and the health protection standards that should be incorporated into any new guidance issued.

The effect of Noise and Shadow Flicker are addressed in ***Chapter 11: Noise*** *and* ***Chapter 15: Shadow Flicker.***

5.3.6.3 Electromagnetic Interference

Electromagnetic fields ("EMF") are invisible lines of force that surround electrical equipment, power cords, wires that carry electricity and outdoor power lines. Electric and magnetic fields can occur together or separately and are a function of voltage and current. When an electrical appliance is plugged into the wall, an electric field is present (there is voltage but no current); when that appliance is turned on, electric and magnetic fields are present (there is both voltage and current). Both electric and magnetic fields decrease with distance. Electric fields are also dissipated by objects such as building materials. On a daily basis, people are exposed to extremely low frequency ("ELF") EMF as a result of using electricity.

National and international health and scientific agencies have reviewed more than 35 years of research including thousands of studies. None of these agencies has concluded that exposure to ELF-EMF from power lines or other electrical sources is a cause of any long-term adverse effects on human, plant, or animal health. The International Commission on Non-Ionising Radiation Protection (ICNIRP) Guidelines give a limit of 100 μT for sources of AC magnetic fields. This compares to 0.13 μT that arises from a 110 kV underground cable when directly above it; 1.29 μT that arises from a 220 kV underground cable when directly above it and 11.4 μT that arises from a 400 kV AC underground cable that is one metre deep and measured directly above it. This is detailed in information booklet published by ESB in 2017 called "EMF & You" which provides information about Electric & Magnetic Fields and the electricity network in Ireland.

This indicates that any baseline EMF in the receiving environment from existing cable and electrical infrastructure is minimal.

5.5.7.1 Electromagnetic Interference

Electromagnetic fields from wind farm infrastructure, including the Grid Connection and Electrical Substation, are very localised and are considered to be an imperceptible, long-term effects. Residual effects are not expected.

Response from MLavelle:

Reference 2021 : High-Voltage Transmission Line Setback Policy Energy Grid ALLIANCE July 2021. Best Practice Guidelines for Australian Energy Transmission

1.4 Electromagnetic Fields (EMF)

The effects of transmission line frequency electromagnetic fields (EMF) on humans are scientifically uncertain at this point, but some studies indicate that chronic exposure to relatively high-level EMFs from overhead high-voltage AC transmission lines (and other AC equipment) can lead to an increased incidence of adverse health effects, including childhood leukaemia and miscarriage.

Although the health effects of chronic exposure to EMFs from AC transmission lines remain scientifically uncertain, many utilities and regulatory authorities employ EMF reduction practices, termed Prudent Avoidance, as a precautionary measure. This can be accomplished by one or more of the following methods:

- Use of HVDC instead of HVAC transmission. DC transmission produces primarily static electric fields and is therefore assumed to pose a minimal EMF-related human health concern.
- Use of underground cable, especially in populated areas.

Burying transmission lines can reduce the generated magnetic fields. The reduction occurs because the underground lines can be installed closer together than overhead lines. Overhead lines need to be further apart because air is used as an insulator, whereas underground cables use rubber, plastic, or oil for insulation.

As part of its Prudent Avoidance practices, it is recommended Australia (similar to other progressive countries and jurisdictions), consider undergrounding of transmission cables as world best practice and the preferred energy transmission standard. Proponents would be required to validate the safety and environmental impacts of any alternative approach. Setback distances may no longer be required as underground cable easement distances alone should provide suitable protection and mitigation of impacts.

5.1. Zone and Overlay Setback Distances

Applying Wind Turbine Guidelines to Overhead Transmission Infrastructure

Setback distances for wind turbines are typically based on the distance from centre-line of the wind turbine to the residence or property boundary. The same methodology has been applied in developing guidelines for overhead transmission infrastructure. Setback distances to residence, zones and boundaries are calculated from the centre line of the transmission infrastructure (lines and towers).

Core recommended setback distances:

Setback distance from Planning Scheme Overlays Four times the Tower height + 50 metres (or 350m, whichever is greater)
Setback distance from Public Use Zones (Park, sporting) Four times the Tower height + 50 metres (or 350m, whichever is greater)
Setback distance from Public Use Zones (Education) Four times the Tower height + 50 metres (or 350m, whichever is greater)
Setback distance from Road Zones Tower height + 50 metres
Setback distance in Rural Zones from Habitable Dwelling Four times the Tower height + 50 metres (or 350m, whichever is greater)
Setback distance from Residential Zones Four times the Tower height + 50 metres (or 350m, whichever is greater)
Reference - Wind Turbine Setback Distances
Setback distances from an asset to a residence vary across states. For example, prior to 2011 there were no setback distances for wind turbines in Victoria. The current setback distance is 1km.
Queensland has introduced a setback distance of 1.5km, while the New South Wales framework is based on a merit assessment of each project against the criteria and performance standards in the framework.
Western Australia has recently recommended a 1.5km setback in their Position Statement: Renewable Energy Facilities *(Western Australian Planning Commission, March 2020)*.
While setback distances are typically based on the distance from the wind turbine to the residence, there may also be circumstances where the distance of the turbine from the neighbour's property boundary should also be a consideration. Such circumstances could include the potential effect of wind turbines on animals such as horses, driving distractions on nearby roads or other situations where turbines may impact neighbouring properties due to their proximity to land use activities on a property.
5.2.8.4 In addition to a setback distance between a turbine and a residence, a minimum setback distance of 200 metres (as measured at ground level from the centre of the tower or 150 metres from the extended horizontal blade tip, whichever is the greater) and a neighbour's boundary fence line or public road carriageway, should also be considered.

Figure 15-43 illustrates the magnetic field from overhead AC lines operating in Ireland

RECEIVED: 29/09/202

THE EFFECT OF DISTANCE ON MAGNETIC FIELDS

Both AC and DC technologies produce magnetic fields and both decrease with distance as you move away from the line or cable. See graph below:

AC LINES AND CABLES

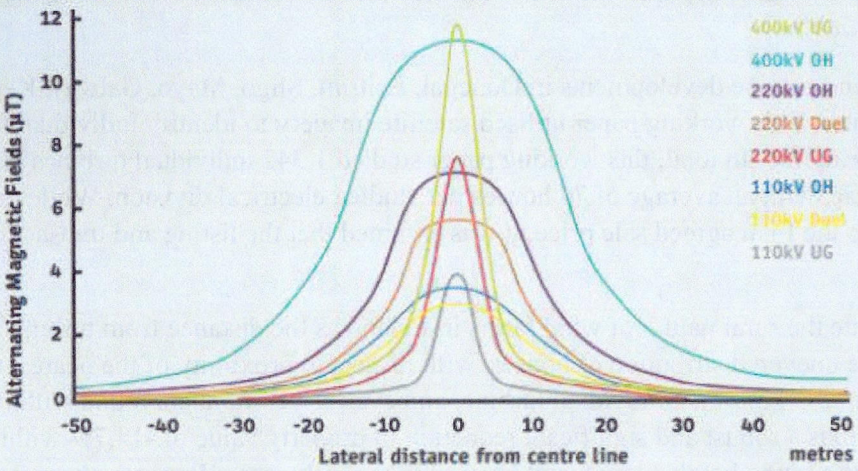


Figure C Illustrates the magnetic field from overhead AC lines operating in Ireland. The field strength decreases with distance. The fields from these AC lines are far below the 1998 ICNIRP Guidelines for exposure to AC magnetic fields (100μT). In 2010 ICNIRP updated its ELF-EMF guidelines, which included the recommendation for a 200μT reference level for exposure for the general public, but these have not yet been adopted by the European Union.

Response from MLavelle: The issue of Electromagnetic radiation is "scientifically uncertain" as stated above & hus the Precautionary Principle applies.

5.3.6.5 Noise

A study by the Australian Environmental Protection Agency in South Australia on low frequency noise near wind farms and in other environments found that '*Overall, the study demonstrates that low frequency noise levels near the wind farms in the study are no greater than levels in urban areas at comparable rural residences away from wind farms'*.

Chapter 11: Noise provides an assessment of noise in relation to the Proposed Development.

5.3.6.9 Turbine Safety

The Department of the Environment, Heritage and Local Government (DoEHLG)'s '*Wind Energy Development Guidelines for Planning Authorities 2006'* state that there are no specific safety considerations in relation to the operation of wind turbines. Fencing or other restrictions are not necessary for safety considerations. People or animals can safely walk up to the base of the turbines. The DoEHLG Guidelines state that there is a very remote possibility of injury to people from flying fragments of ice or material from a damaged blade. However, most blades are composite structures with no bolts or separate components and the danger is therefore minimised. The build-up of ice on turbines

is unlikely to present problems. The wind turbines will be fitted with anti-vibration sensors, which will detect any imbalance caused by icing of the blades. The sensors will prevent the turbine from operating until the blades have been de-iced.

Turbine blades are made of fibre-reinforced polymer or unsaturated polyester, a non-conducting material which will prevent lightning strikes. Lightning protection conduits will be integral to the construction of the turbines. Lightning conduction cables, encased in protection conduits, will follow the electrical cable, from the nacelle to the base of the turbine. The conduction cables will be earthed adjacent to the turbine base. In extremely high wind speed conditions, (usually at Beaufort Storm Force 10 or greater) the turbines will shut down to prevent excessive wear and tear, and to avoid any potential damage to the turbine components.

5.3.7 Property Value

There is currently only one study within the context of Ireland detailing the effect of wind farms on property values. This section provides a summary of this paper by the Centre for Economic Research on Inclusivity and Sustainable (CERIS), as well as summaries on the largest and most recent studies from the United States and Scotland.

In 2023 CERIS published a working paper entitled '*Wind Turbines and House Prices Along the West of Ireland: A Hedonic Pricing Approach*'.

This paper looked at wind turbine developments in Donegal, Leitrim, Sligo, Mayo, Galway, Kerry and Cork and associated property values. This working paper utilised satellite imagery to identify individual turbines and sourced its housing data from www.daft.ie. In total, this working paper studied 1,342 individual turbines and 90,469 housing listings from www.daft.ie, with an average of 74 houses per studied electrical division. While the published price on Daft is not equivalent to the final agreed sale price, it was assumed that the listing and transaction prices are correlated.

The findings demonstrate the rural nature of wind farms in Ireland as the distance from turbine bands (0-5 km and 5-15 km bands) shows the uneven distribution of houses, with respect to proximity of the nearest turbine, with a limited number of houses within 2-3 km of an individual turbine, and even fewer numbers found within 1km of a turbine location. The analysis finds a robust and significant reduction in property value of -14.7% within 1 km of a turbine. The effect increases with turbine height, count, and level of urban influence. ***However, there is evidence that the price effect decays over time, becoming insignificant after 10 years.*** As well, this effect was found only on a limited subset of studied houses.

The largest study of the impact of wind farms on property values has been carried out in the United States. '*The Impact of Wind Power Projects on Residential Property Values in the United States: A multi-Site Hedonic Analysis*', December **2009**, was carried out by the Lawrence Berkley National Laboratory (LBNL) for the U.S Department of Energy. This study collected data on almost 7,500 sales of single-family homes situated within ten miles of 24 existing wind farms in nine different American states over a period of approximately ten years. The conclusions of the study are drawn from eight different pricing models including repeat sales and volume sales models. Each of the homes included in the study was visited to demonstrate the degree to which the wind facility was visible at the time of the sale, and the conclusions of the report state that "The result is the most comprehensive and data rich analysis to date on the potential impacts of wind energy projects on nearby property values."

The main conclusion of this study is as follows:

"Based on the data and analysis presented in this report, no evidence is found that home prices surrounding wind facilities are consistently, measurably, and significantly affected by either the view of wind facilities or the distance of the home to those facilities. Although the analysis cannot dismiss the possibility that individual or small numbers of homes have been or could be negatively impacted, if these impacts do exist, they are either too small and/or too infrequent to result in any widespread and consistent statistically observable impact."

*This study has been updated by LBNL who published a further paper entitled 'A Spatial Hedonic Analysis of the Effects of Wind Energy Facilities on Surrounding Property Values in the United States', in August **2013**. This study analysed more than 50,000 home sales near 67 wind farms in 27 counties across nine U.S. States yet was unable to uncover any impacts to nearby home property values. The homes were all within 10 miles of the wind energy facilities - about 1,100 homes were within 1 mile, with 331 within half a mile. The report is therefore based on a very large*

sample and represents an extremely robust assessment of the impacts of wind farm development on property prices. It concludes that:

"Across all model Specifications, we find no statistical evidence that home prices near wind turbines were affected in either the post-construction or post announcement/pre-construction periods."

Both LBNL studies note that their results do not mean that there will never be a case of an individual home whose value goes down due to its proximity to a wind farm – however if these situations do exist, they are considered to be statistically insignificant. Therefore, although there have been claims of significant property value impacts near operating wind turbines that regularly surface in the press or in local communities, strong evidence to support those claims has failed to materialise in all the major U.S. studies conducted thus far.

*A further study was commissioned by RenewableUK and carried out by the Centre for Economics and Business Research (Cebr) in March **2014.** The findings of the study were produced in a report titled 'The Effect of Wind Farms on House Prices' and its main conclusions are:*

- *Overall, the analysis found that the county-wide property market drives local house prices, not the presence or absence of wind farms.*
- *The econometric analysis established that construction of wind farms at the five sites examined across England and Wales has not had a detectable negative impact on house price growth within a 5 km radius of the sites.*

*In September **2023**, the Energy Policy Journal published 'Commercial wind turbines and residential home values: new evidence from the universe of land-based wind projects in the United States.'54 This study targeted urban counties in the United Stated with populations over 250,000 persons, and found that on average, after a commercial wind energy project is announced, houses located within 1 mile of a proposed wind energy project experience a decrease in value of 11% relative to homes located within 3-5 miles of the proposed wind energy project. The decline in property values was found to recover post construction with property value impacts becoming relatively small (~2%) and statistically insignificant 9 years or more after project announcement (roughly 5 years after operation begins). This suggests that the housing market is reacting negatively to the expectation of likely impacts (after announcement) and the heightened activity during construction, but after operation begins, those negative perceptions and related home price impacts appear to fade.*

Although there have been no empirical studies carried out in Ireland on the impacts of wind farms on property prices, the literature described above demonstrates that at an international level, wind farms have potential to impact property values in local areas; however, it is important to note that this impact is proven to reduce throughout the operational phase of a wind farm.

A study issued in October 2016 'Impact of wind Turbines on House Prices in Scotland' (2016) was published by Climate Exchange. Climate Exchange is Scotland's independent centre of expertise on climate change which exists to support the Scottish Governments policy development on climate and the transition to a low carbon economy.

The report presents the main findings of a research project estimating the impact on house prices from wind farm developments. It is based on analysis of over 500,000 property sales in Scotland between 1990 and 2014.

The key findings from the study are:

- *No evidence of a consistent negative effect on house prices: Across a very wide range of analyses, including results that replicate and improve on the approach used by Gibbons (2014), we do not find a consistent negative effect of wind turbines or wind farms when averaging across the entire sample of Scottish wind turbines and their surrounding houses. Most results either show no significant effect on the change in price of properties within 2km or 3km or find the effect to be positive.*
- *Results vary across areas: The results vary across different regions of Scotland. Our data does not provide sufficient information to enable us to rigorously measure and test the underlying causes of these differences, which may be interconnected and complex.*

Correspondingly, a 2024 study by BiGGAR Economics looked at house price trends of properties in close proximity to Scotland's Beauly-Denny electricity transmission line, which runs overhead for more than 130 miles from north of

Inverness to near Falkirk. The study examined house prices along the Beauly-Denny route since it became operational in 2015, finding that they had mirrored wider trends of the four local authority areas it passes through. Since 2015, house prices have surged across the local authorities of Highland, Perth and Kinross, Stirling, and Falkirk, with properties along the Beauly-Denny power line matching this growth. A similar rate of growth can be seen in house prices across South Lanarkshire, East Renfrewshire and Dumfries and Galloway, all of which host a significant number of wind farms. This again suggests broader macroeconomic factors are the primary determinant of house prices, and that visible energy infrastructure does not have a prominent influence.

It is a reasonable assumption based on the available international literature, that the provision of a wind farm at the proposed location would not impact on the property values in the area.

Table 5.9: Summary of Research Finding's between Wind Farms and Property Values

Year	Country	Research Group	Finding
2009 and 2013	USA	LBNL	Analysed nearly 7,500 home sales near wind farms and found no consistent negative impact on property prices. likely to be small, if there is any effect at all. They found no statistical evidence of wind farms affecting home prices before or after construction.
2014	UK	Centre of Economic Research	In summary the analysis found that country-wide property market drives local house prices, not the presence or absence of wind farms; and The econometric analysis established that construction of wind farms at the sites examined across England and Wales has not had a detectable negative impact on house price growth within a 5 km radius of the sites
2014	UK	London School of Economics	There was an average reduction in the value of houses (based on 125,000 house sales between 2000 and 2012) of between 5% and 6% within 2 km of very large wind farms.
2016	UK (Scotland)	ClimateXChange	Following a wide range of analyses, including results that replicate and improve on the approach used in the 2014 study by London School of Economics, the study did not find a consistent negative effect of wind turbines or wind farms when averaging across the entire sample of Scottish wind turbines and their surrounding houses. Most results either show no significant effect on the change in price of properties within 2 km or 3 km o[illegible]d the effect to be positive. Some wind farms provide economic or leisure benefits (e.g., community funds or increasing access to rural landscapes through providing tracks for cycling, walking.
2023	Ireland	Centre for Economic Research on Inclusivity and Sustainability	14.7% reduction in the value of properties located within 1 km of wind turbines and impact on property prices is correlated with taller turbines. It finds no evidence of a significant impact on properties outside 1 km and it also finds that the impact on the house price within 1 km diminishes over time becoming insignificant after 10 years

5.4.2 Economic Activity

The Proposed Development has the potential to bring significant positive benefits to local communities. It will support sustainable local employment; it could contribute annual rates between €770,560 to €908,160 to the local authority (depending on the final installed capacity, and the Annual Rate on Valuation set by the council)

If consented the proposed Tirawley Wind Farm will also provide a community fund calculated in accordance with the Renewable Electricity Support Scheme (RESS) Terms and Conditions at €2 per MWh of electricity produced by the project. This is to be made available to the local community for the duration of the RESS (15 years). The average capacity factor of wind energy projects in Ireland is 28.3% (SEAI, 2019). Assuming this efficiency, and a capacity of c. 68.8 MW, the community benefit fund would amount to an average of €341,121 per annum. The actual fund will vary around this average from year to year, depending on each year's wind conditions. Wind resource monitoring undertaken in the Study Area indicate that Tirawley Wind Farm could be capable of achieving an above average capacity factor and therefore contribute towards a larger community fund.

The overall effect is predicted to be a moderate, positive, short-term effect during the construction phase of the Proposed Development and moderate, positive and long-term during the operational phase.

No likely adverse significant effects are predicted on economic activity.

The Proposed Development will create approximately two full-time jobs during the operational phase. In addition to these jobs, various personnel will be required for the successful and continued operation of the wind farm.

Response from MLavelle: The statement that the "*It is a reasonable assumption based on the available international literature, that the provision of a wind farm at the proposed location would not impact on the property values in the area".*is untrue. The following references prove that research proves such a devaluation. Quoting Reports from 2009, ?013 & 2014 is nonsense. They are historic when turbines were far smaller & related to central USA, which is largely npopulated.
The attached list of published Scientific Reports clearly shows a huge issue on property prices. Any competent applicant should have referenced them as part of their application. The alternative is that the supposedly independent planning application is biased & ignores what doesn't suit. The existing body of research supports claims that windfarms significantly devalue nearby properties in the short & long terms. If we assume a 9% reduction in property prices and an average house value of €400,000 for the 266 houses within 2km of this development, this community are looking at a loss of €36,000 per house & a community loss of €9.576million.
On top of this is the micrometrological temperature -3^{0}C effects of Wake on vegetation growth for 55diameters (6,435m) downwind & for the 35-year period. This has very large loss potential. 20,221ha will be effected annually for the 35-year period. This community are being subjected to losses in the €10's of millions.

Reference 2014 : The Impact of Wind Turbines on Rhode Island Residential Property Values. Susan Shim Gorelick. University of Rhode Island. DigitalCommons@URI
This study employs the hedonic price model to examine the impact of Rhode Island wind turbines on property sales price in terms of view and proximity. Since RI communities are heterogeneous, residential demographics and regional fixed effects are used to properly identify the impact of wind turbines on property prices. Community attitudinal effect s examined with announcement and construction timelines of wind turbine
development. The difference-in-differences estimations with fixed effects show that the view of wind turbines has no significant impact. The interaction term between proximity and the time periods of wind turbine development shows that both post announcement and post construction have statistically significant positive impact on property sales price with a smaller positive post construction effect than post announcement. This result indicates that wind turbines are sited in locations that have lower property values. The findings from this study show that demographic attributes are important when considering wind energy site selection and lay the groundwork for further study as more post construction observations become available with the maturity of wind energy development.

The potential negative impact on local property owners has been classified into three stigma categories: scenic vista, nuisance, and area (Hoen et al., 2009, 2011). Scenic vista stigma results from adverse effect and/or obstruction of views from a property. For example, a wind turbine might adversely affect an otherwise pristine ocean view. Since a scenic view is considered a premium attribute for property value, scenic vista stigma has
been commonly examined in hedonic studies of wind energy (e.g., Dent, P. and S. Sims, 2007; Sims et al. 2008; Hoen et al. 2009, 2011). Nuisance stigma includes noise, infrasonic vibration, and shadow flicker. Nuisance stigma primarily impacts homeowners within a small proximity as they bear disproportioned externality (Pierpont, 2008; Colby et al. 2009; Heintzelman and Tuttle, 2011).
Area stigma includes the perception that the community is an industrial location. This is the most subjective of the three forms of stigma and could be the most far reaching, as this brings the concern from an individual property owner

perspective to that of the wider community (Heintzelman and Tuttle, 2011). For this most subjective form of stigma, inclusion of area demographics would enhance understanding of wind turbine effect on community attitude and location impact. This study's combination of residential demographics and RI's unique geographical features helps examine all three stigmas and guide wind energy development.

Reference 2022 : Valuating the negative externality of wind turbines: traditional hedonic and difference-in-difference approaches. Working Paper 2022:6. Hans Westlund, Mats Wilhelmsson. Department of Urban Planning and Environment. Royal Institute of Technology, Stockholm, Sweden

Local negative externalities of an establishment of wind turbines have been documented in research; often with the help of the hedonic methodology and property values. We use mixed methods including hedonic methodology, propensity score matching, and the difference-in-difference approach to estimate causal effects, using almost 600,000 real estate transactions in Sweden from 2005 to 2018. The results indicate that we can reject the hypothesis that proximity to wind turbines does not impact property values, and this impact is relatively strong and varies over time and geographic region. Difference-in-difference with matching confirms estimates in the hedonic price equation studies. Furthermore, there is no indication of pre-event differences in house price outcomes based on distance from new wind turbines. Depending on the region, **the total negative capitalisation amounts to between 10 and 25 percent within 0–2 kilometres from the wind power plant**. We apply these estimates to the total housing stock in three different potential future development areas. Although effects per property are relatively marginal, the total effects of a wind farm establishment will be significant if they are located in densely populated areas.

Based on data from nearly **600,000 Swedish property transactions** from 2005 to 2018, our analysis has shown that proximity to wind turbines has a negative effect on property values and that this effect decreases with distance from the wind turbines and falls to 0 after 10 kilometres. The latter result holds true for Sweden as a whole, but when we analyse NUTS1 regions, it is only in southernmost Sweden that the effect stretches 10 kilometres; in the other two regions, the effect is 0 after 8 kilometres. We have also shown that the negative impact of wind turbines on property values has increased over time and with the total number of wind turbines being built.

The main result of this study—that wind turbines exert a negative effect on property values—corresponds with the results of the above mentioned earlier European studies. However, compared with these studies, our results mainly indicate a stronger effect and an effect with a longer spatial extension.

Reference 2025 : Capitalisation of onshore wind turbines on property prices in Sweden: The need to compensate for negative externalities. Hans Westlund, Mats Wilhelmsson. Economic Analysis and Policy 87(2025) 1452 – 1468.

Due to, for example, disturbing sound and deteriorated scenery, wind turbines might constitute a negative externality. By using a revealed preference method, we examine the impact of onshore wind turbines on property values in Sweden, analysing over 600,000 real estate transactions from 2005 to 2018. We find that wind turbines are built in areas with lower prices in general (as they are built outside population centres), that property values start declining when a building process is started (due to anticipations of negative impacts) and that price decline continues after the wind turbine has been commissioned (due to the perceived negative effects). **Property values within 2km of wind turbines decrease by approximately 10-15%, diminishing the effect to zero beyond 6-10km.**

Reference 2024 : Commercial wind turbines and residential home values: New evidence from the universe of land-based wind projects in the United States. Eric J. Brunner, Ben Hoen, Joe Rand, David Schwegman. Energy Policy 185 (2024) 113837.

We examine the impact of proximity to land-based commercial wind turbines on residential home values in the United States using data on the universe of commercial wind turbines and residential property transactions from 2005 to 2020. Using event study and difference-in-differences identification strategies we find that, on average, homes located within 1 mile of a commercial wind turbine experience approximately an **11% decline** in value following the announcement of a new commercial wind energy project, relative to counterfactual homes located 3 to 5 miles away.

Reference 2021 : Wind turbines, solar farms, and house prices. Martijn I. Droes , Hans R.A. Koster. Energy Policy 155 (2021) 112327.

This paper examines the effect of wind turbines and solar farms on house prices. Using detailed data from the Netherlands between 1985 and 2019, the results show that tall wind turbines have considerably stronger effects on

house prices, as compared to small turbines. For example, **a tall turbine (>150m) decreases house prices within 2 km by 5.4%**, while a small turbine (<50m) has an effect of maximally 2% and the effect dissipates after 1 km. Further results indicate that solar farms lead to a decrease in house prices within 1 km of about 2.6%. By comparing the overall impact on house prices, we show that the external effects of solar farms per unit of energy output are comparable to those of wind turbines. Thus, building solar farms instead of wind turbines does not seem to be a way to avoid the external effects of renewable energy production.

Renewable energy production may have external effects on local residents (Meyerhoff et al., 2010; Groth and Vogt, 2014). Wind turbines make noise, cast shadows, and create flickering. Moreover, turbines can visually pollute the landscape, particularly if they are tall.

Because the effects of wind turbines and solar farms are local, the effect on house prices is indicative that the burden of renewable energy production is not necessarily distributed equally within society.

This paper explicitly focuses on the role of turbine height on house prices. In particular, we investigate whether tall turbines have a larger effect on house prices *and* at a larger distance. Given the substantial increase in wind turbine height in the last years, we would expect heterogeneity in the effect of turbines of different heights on house prices. This is important for spatial policies regarding the placement of wind turbines.

The results in this paper show that the construction of a wind turbine leads to a decrease in local house prices of 1.8%. In particular, we find that a turbine taller than 150m decreases prices within 2 km by 5.4%, while the effect of small turbines (<50m) is statistically indistinguishable from zero. Also, the effect of tall wind turbines does not extend much beyond 2 km, but we do find evidence that the impact radius is smaller (<1 km) for low wind turbines.

The dataset concerning house prices has been provided by Brainbay. The data cover approximately 70% of the market. The data contain sales of existing properties between 1985-(mid)2019. In addition to property prices, the dataset includes information on many different property features. Based on this, we can calculate the distance to the nearest existing wind turbine for each (transacted) home in our sample. The descriptive statistics are reported in Table 1. The average house price between 1985 and 2019 is €214.178. This is based on more than 3 million transactions **(2.7 million homes)**. The average house price is slightly lower (€206.658) within 2 km of an existing wind turbine, suggesting there is a slight tendency to built turbines in areas with lower prices. In Appendix A.2 we provide more details on differences between treated and control areas. Finally, the average distance of properties to wind turbines in 2019 is 8.7 km. This distance has been decreasing for years; in 1995 for example the distance was still 26.6 km. However, for many households, wind turbines are still relatively far away. Only 5.1% of the housing transactions between 1985 and 2019 occur within 2 km wind turbines *after* they have become operational. Yet, the total number of transactions near all wind turbines present in 2019 is 290,002 (238,164 houses).

Impact area of turbines

Distance to a wind turbine is likely an important factor in determining the possible decrease in prices. Within 5 times the axis height there is a possible effect of sound and for the average turbine up to 1 km there is also possible shadow. Up to 2 km (and beyond), there is potentially visual pollution. In Fig. 5 we, therefore, show a specification where we interact the effect of turbines by 250m distance band dummies. Hence, we estimate the treatment effect for different distance bands. The number of observations increases as we now include housing transaction prices within 2.5 km of a (future) turbine. Fig. 5 shows that within 500m the confidence bands are large because the number of observations is low. Hence, we cannot precisely determine the effect of the opening of a wind turbine on transaction prices within short distances. Between 500 and 750m the effect is about □ 3%. The effect gradually decreases until at 2500m the effect is small and indistinguishable from zero. Hence, the impact area of turbines seems to be maximally 2250m.

Although the average effect across all turbine heights is of interest, it is important to investigate whether the impact area is different for tall turbines. Therefore, we re-estimate the regression but now allow the effects to vary by wind turbine height *and* distance. Even with this large dataset, the number of observations for tall turbines is small. Hence, we aggregate the distance bins for the tallest turbines by 500m instead of 250m. The results are depicted in Fig. 6. Small turbines only have a statistically significant effect of about 2% at 1 km and the effect is essentially zero beyond 1 km. At 500m and 750m the effects are imprecisely measured. A turbine with a height between 50 and 150m yields a statistically significant effect of -3.4% at 750m. The effect decreases over distance, but at a relatively low rate. At 2500m the effect is no longer statistically significant. For the tallest wind turbines, the effect is again larger than for small turbines. **At 750m the effect is -8.3%,** albeit very imprecise due to the low number of observations (within 500m of a turbine exceeding 150m there are even no transactions available). The effect again decreases with distance, but more rapidly, and the effect is small and no longer statistically significant at 2500m.

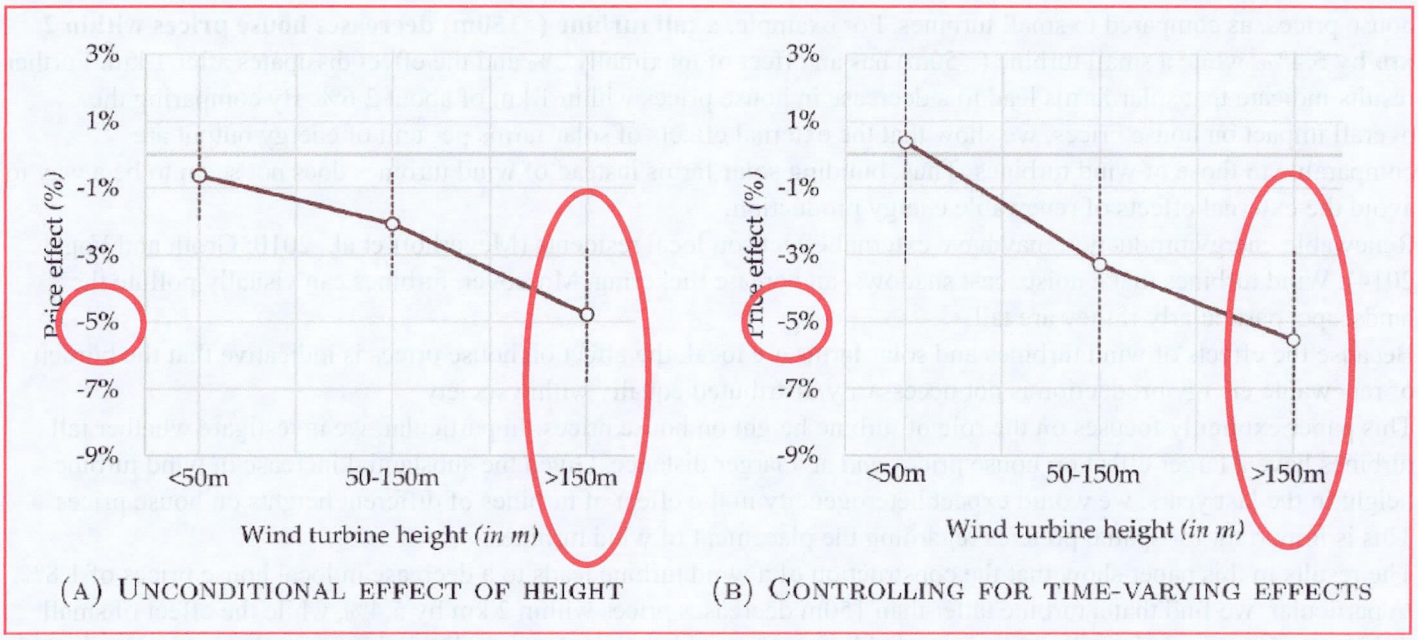


Fig. 4. Price effects for different turbine heights

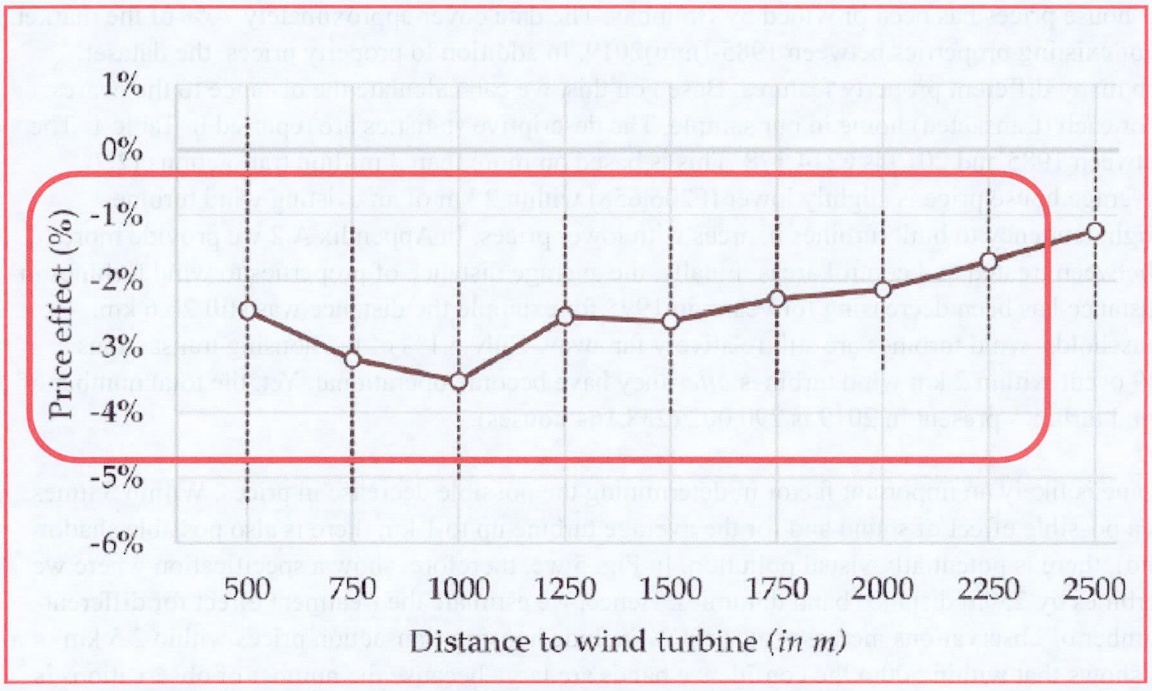


Fig. 5. Wind Turbines: Price effects at different distances (1985–2019)

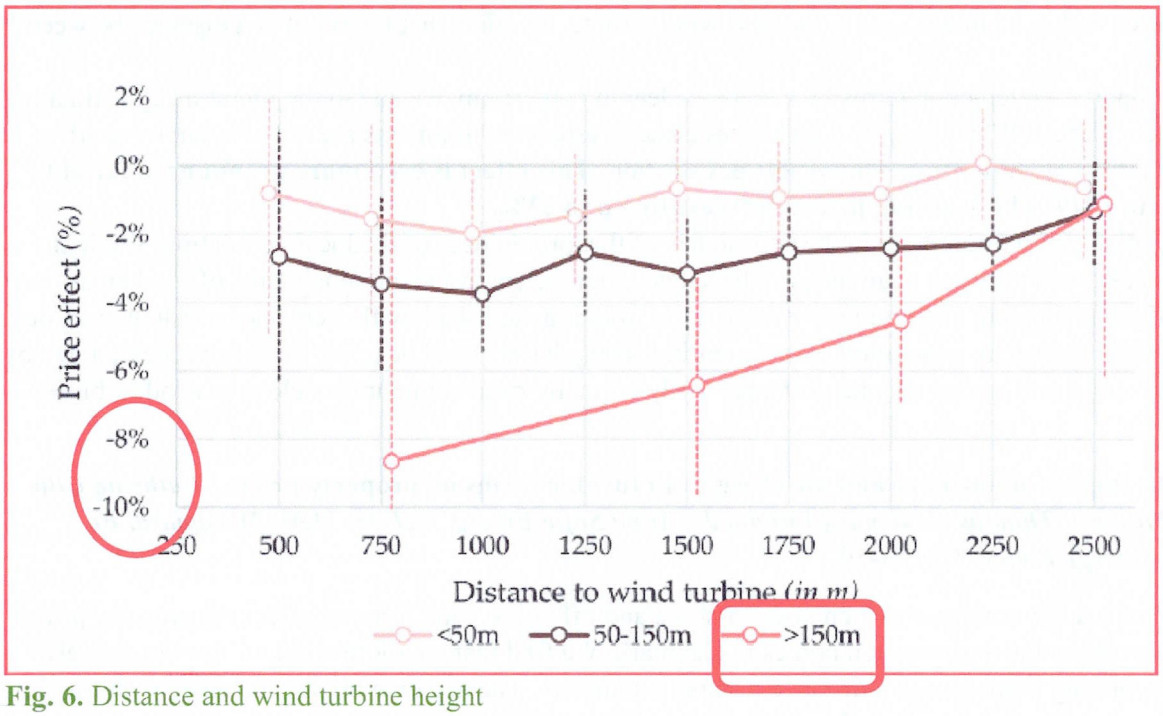


Fig. 6. Distance and wind turbine height

Reference 2019 : Local Cost for Global Benefit: The Case of Wind Turbines. Manuel Frondel, Gerhard Kussel, Stephan Sommer, and Colin Vance. Ruhr Economic Papers #791. http://dx.doi.org/10.4419/86788919. ISSN 1864-4872 (online). ISBN 978-3-86788-919-3

Drawing on a dataset of asking prices from more **than 2.7 million houses** in Germany posted between 2007 and 2015 on the site of Germany's leading online broker, our approach employs a hedonic pricing model whose specification is informed by the causal forest machine leaning algorithm to identify sources of heterogeneity.

We find an average treatment effect (ATE) of up **to -7.1%** for houses within a one kilometer radius of a wind turbine, an effect that fades to zero at a distance between 8 and 9 km. As suggested by the causal forest algorithm, additional specifications are estimated that allow for differential effects of the wind turbines by the house's location and age. We find that very old houses and houses in rural areas suffer price reductions of up to 23%, probably due to stronger preferences for a pristine landscape, while house prices in urban areas are not affected at all. Our results illustrate that while electricity generation via wind turbines may have global benefits, these are accompanied by substantial local externalities.

Table 3: OLS Regression Results of Equation 1

	Coefficients	Standard Errors
Wind turbine within		
1 km distance	-0.0735**	(0.00763)
1 to 2 km distance	-0.0615**	(0.00424)
2 to 3 km distance	-0.0560**	(0.00399)
3 to 4 km distance	-0.0441**	(0.00381)
4 to 5 km distance	-0.0416**	(0.00384)
5 to 6 km distance	-0.0294**	(0.00394)
6 to 7 km distance	-0.0253**	(0.00393)
7 to 8 km distance	-0.0139**	(0.00413)
8 to 9 km distance	-0.000786	(0.00427)

Reduction in property price for Turbine to 1km = -7.35%, 1km to 2km = -6.15%, 2km to 3km = -5.6%, 3km to 4km = -4.41%, 4km to 5km = -4.16%, 5km to 6km = -2.94%, 6km to 7km = -2.53%, 7km to 8km = -1.39%

Using asking prices from Germany's leading online broker and a hedonic pricing model coupled with a machine leaning algorithm, we fill this gap by analyzing the effect of wind turbines on prices of surrounding single-family houses. Accounting for detailed property and locality characteristics, we estimate an average treatment effect

of up to **7.1%** for houses within 1 km distance to the next wind turbine, an effect that fades out at a distance between 8 and 9 km.
Identifying the most important interaction terms by a machine leaning algorithm, we add to the literature by estimating heterogeneous treatment effects: While the prices of houses close to urban environments are not affected by nearby windmills, houses in rural areas suffer from remarkable devaluation. **This effect is even more pronounced for old buildings built prior to 1949, whose asking prices decrease by up to 23%.**
Our findings can be explained by differences in the appearance of the preferences of the local population. While the urban population is accustomed to living in an industrialized and dynamic environment, inhabitants of rural areas may lose the impression of pristine nature and tranquility when noise, rotation, and shadow flickers appear. Altogether, our results illustrate that while electricity generation via wind turbines may have global benefits, these are accompanied by substantial local externalities and environmental costs, primarily borne by rural communities close to wind turbines.

Reference 2018: The impact of on-shore and off-shore wind turbine farms on property prices. ***Cathrine Ulla Jensen, Toke Emil Panduro, Thomas Hedemark Lundhede, Anne Sofie Elberg Nielsen, Mette Dalsgaard. Bo Jellesmark Thorsen. Energy Policy, 116, 50-59.***

We present the results of a large-scale analysis on how on-shore and off-shore wind turbines affect the property prices of nearby single family residential and vacation homes in Denmark. We find that on-shore wind turbines negatively affect the price of surrounding properties to a distance of three kilometers. The negative impact increases with the number of wind turbines at a declining marginal rate but declines with distance.

We generated a range of different variables in order to determine how wind turbines in the landscape are perceived by households in the housing market. These variables included the number of wind turbines from 0.5 to 5 km, the number of wind turbines from 0.5 to 5 km of different heights, the shortest distance to a wind turbine and the average distance to wind turbines from 0.5 to 5 km. Based on model performance, we found a clear impact on price from wind turbines of up to 3 km away. This is an average and a result of the wind turbine composition within Denmark. The results, however, do not deviate much from the findings of other studies. Dröes and Koster (2016), a Dutch study, find the effect to be negligible beyond 2 km, **and Gibbons (2015) find a negative price premium of 5-6% at 2 km in the UK**. Given that we do not model the actual disamenities (view and noise, as in Jensen et al. (2014)) but use distance and numbers as a proxy, the spatial extent may very well increase as the average size of wind turbines increases over time.
In this study, we have provided further evidence on the impact of on-shore wind turbines on nearby property prices. We add to the literature by presenting the first results to distinguish between residential and vacation homes. Our results across several spatially distinct housing markets show unequivocally that significant negative effect of wind turbines exist if placed up to as much as 3 kilometers away from a property, which is partly a result of the existing stock of turbines in the analyzed areas. Interestingly, however, the size of the effects we find are very similar to those in other studies in other areas.

Recent research documents effects on the stated well-being of people living in close proximity to wind farms find an effect of up to as much as 4,000 meters (Krekel and Zerrahn 2017) from one or more wind turbines. **Heintzelman and Tuttle (2012) find that property prices decrease by between 8.8 % and 14.87 % at a distance of 0.5 miles (equal to approx. 800 meter) to the nearest wind turbine in the State of New York, USA**. Jensen et al. (2014) document a significant effect of noise and visual pollution from wind turbines of a similar size in Denmark.

Reference 2023: The visual effect of wind turbines on property values is small and diminishing in space and time. Wei Guoa, Leonie Wenzc, and Maximilian Auffhammere. Edited by Geoffrey Heal, Columbia University, New York, NY; received June 3, 2023; accepted January 10, 2024. 121 (13) e2309372121. https://doi.org/10.1073/pnas.2309372121
Results Property Value Impacts.

We find that having at least one wind turbine in a home's viewshed (10 km radius) reduces the sales price of such a property on average by 1.12%.

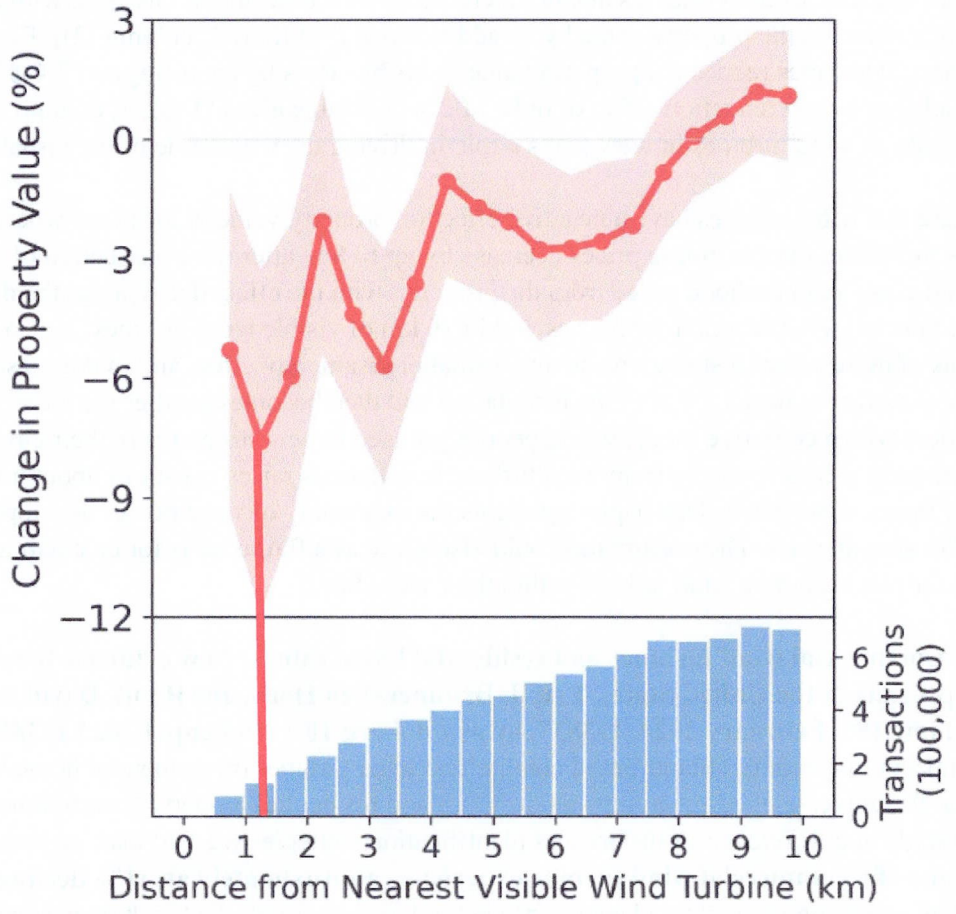


Fig. 2. Effect of wind turbine visibility on property value by distance. The effect of wind turbine visibility on property values for different distance bins. Each distance bin represents a 500-m range, determined by the distance from the nearest visible wind turbine. Red dots indicate estimated coefficients, as obtained by interacting the coefficient of interest from the difference-in-difference model (interaction between post-treatment status and treatment assignment) with distance bin indicators. Shaded areas represent 95% CIs constructed using two-way clustered SEs at the census tract and year level. Bars in the *Lower* panel show the number of transactions within each distance bin, corresponding to the right y-axis.

Note -9% for 1km separation distance

The impact of visual disamenity created by wind turbines may also vary depending on the distance from the nearest visible turbine. To test how the effect varies by distance, we re-run the baseline specification with the indicators of interest interacted with 500-m (_ 0.3-mile) distance bin indicators for the proximity of the closest wind turbine. The effect of wind turbine visibility decreases as distance increases (Fig. 2). **The effect is largest in immediate proximity of wind turbines—with the visual disamenity reducing property values by up to 8% within a neighborhood range of 1.5 km (_ 0.9 miles). Even though this number is economically large, there are two noteworthy caveats. First, the CI is sizable including reductions in property value between 3 and 13%. Second, the number of properties within this distance bin is small. Nationally, there are fewer than 250,000 transactions within 1.5 km of the nearest wind turbine, as opposed to approximately 8.5 million transactions within 10 km.**

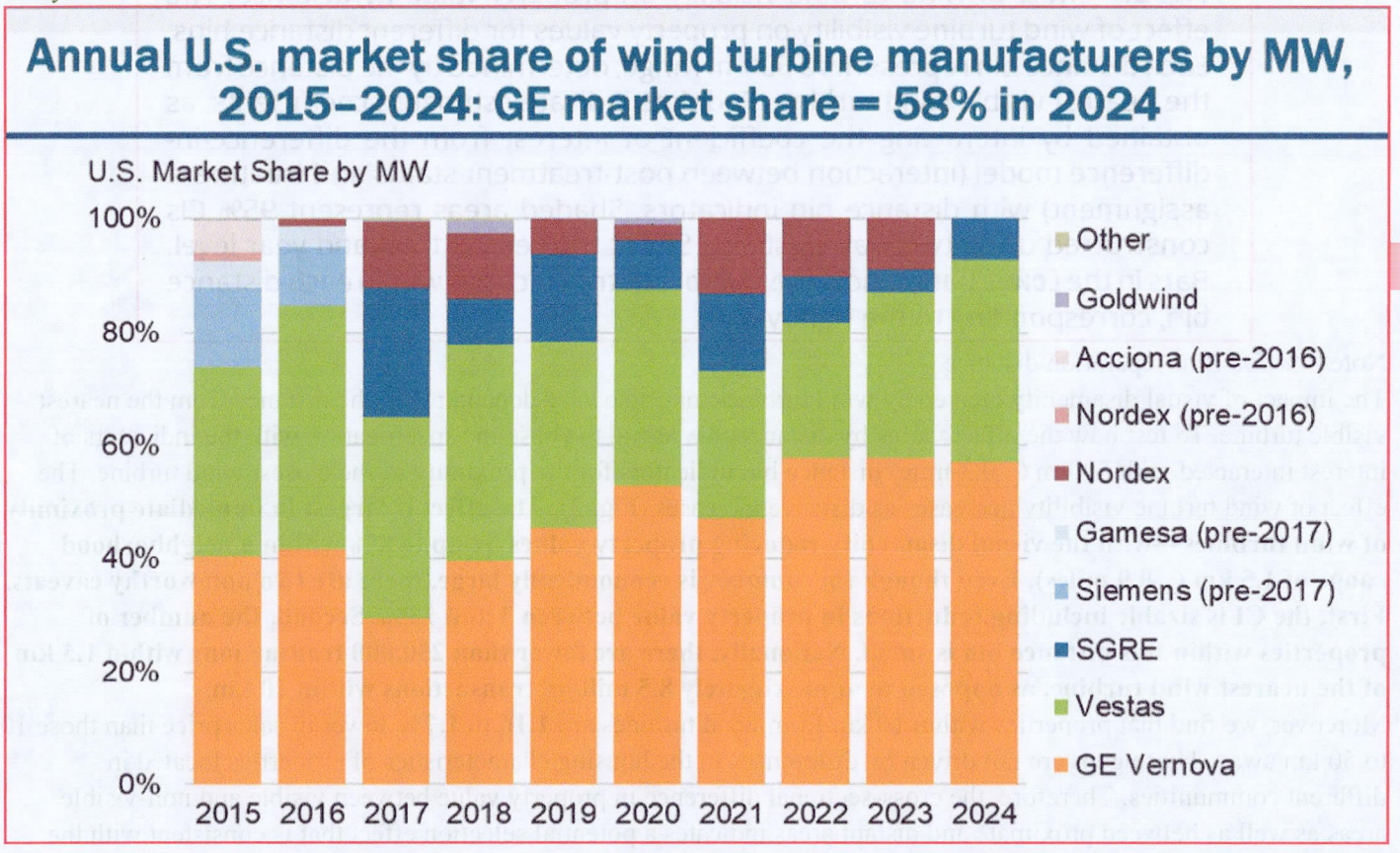
Moreover, we find that properties within 10 km from wind turbines are **1.16 to 1.7%** lower in sales price than those 10 to 50 km away. These gaps are not driven by differences in the housing characteristics of properties located in different communities. Therefore, the cross-sectional difference in property value between visible and non-visible areas as well as between proximate and distant areas indicates a potential selection effect that is consistent with the siting of wind turbines in places with lower property values.

We investigate whether the visual impact of wind turbines varies with the intensity of visibility using two measures: The number of wind turbines in view and the intensity classified by whether there are more than 20 turbines in sight. We find that the capitalization of the visual disamenity increases with the treatment intensity, with every additional 10 wind turbines in view reducing the property value by an additional 0.2% [Table 1, column (2)]. Furthermore, wind farms with more than 20 turbines reduce the property value in visible areas by an average of 2.48%, whereas those with less than 20 turbines have a reduction effect of only 1.02% on visible areas [Table 1, column (3)]. These findings suggest that the density of wind turbines in view plays a role in driving the magnitude of the visual disamenity valuation.

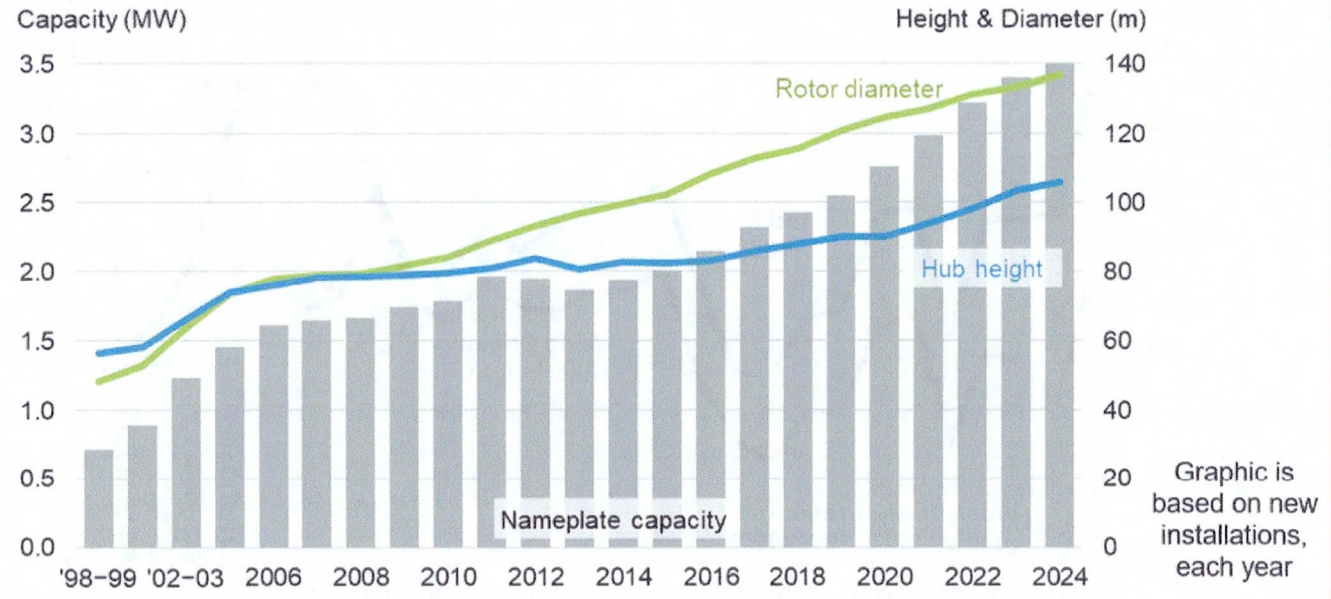
The findings indicate that wind turbines have a negative effect on property value in locations where they are visible. On average, across the whole sample, house prices decrease by up **to 8%** after the construction of a wind turbine within viewshed and close neighborhood range from the property, with the effect decaying as the distance increases. The average effect falls to a 1% reduction for houses within 10 km of visible wind turbines. It also diminishes over time—both in terms of more recent installations having a smaller disamenity effect and in the sense that the reduction in value a property experiences peaks 3 y after the installation and then becomes smaller the more years pass. These findings are consistent with a cognitive model where people get used to new structures in their environment over time. The reduction in property values resulting from wind turbine installations raises questions about how this might affect siting decisions for future wind farms. This paper highlights the externality of wind power developments as they are capitalized in the housing markets. These estimates could also serve as a future basis for calculating compensation to local homeowners for placing a new wind turbine within their viewshed."

Reference 2024 : Commercial wind turbines and residential home values: New evidence from the universe of land-based wind projects in the United States, Eric J. Brunner, Ben Hoen, Joe Rand, David Schwegman. Energy Policy Volume 185, February 2024, 113837. https://doi.org/10.1016/j.enpol.2023.113837

We examine the impact of proximity to land-based commercial wind turbines on residential home values in the United States using data on the universe of commercial wind turbines and residential property transactions from 2005 to 2020. Using event study and difference-in-differences identification strategies we find that, on average, **homes located within 1 mile of a commercial wind turbine experience approximately an 11% decline in value** following the announcement of a new commercial wind energy project, relative to counterfactual homes located 3 to 5 miles away.

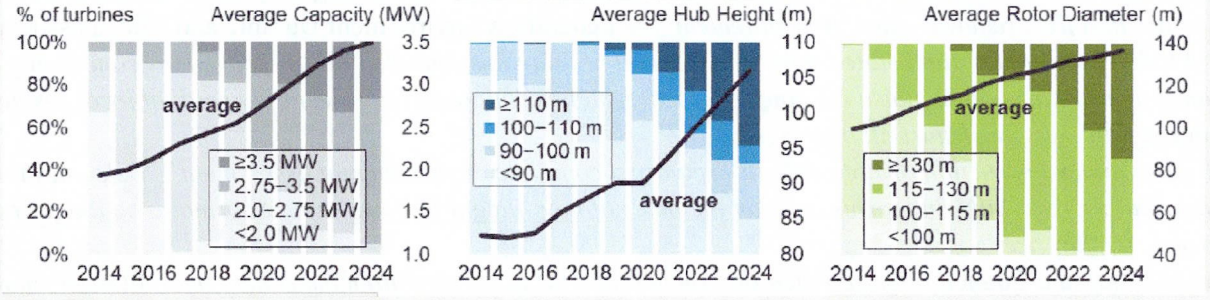


Average turbine capacity (3.5 MW in 2024), hub height (106 m in 2024), and rotor diameter (137 m in 2024) for land-based wind, over time

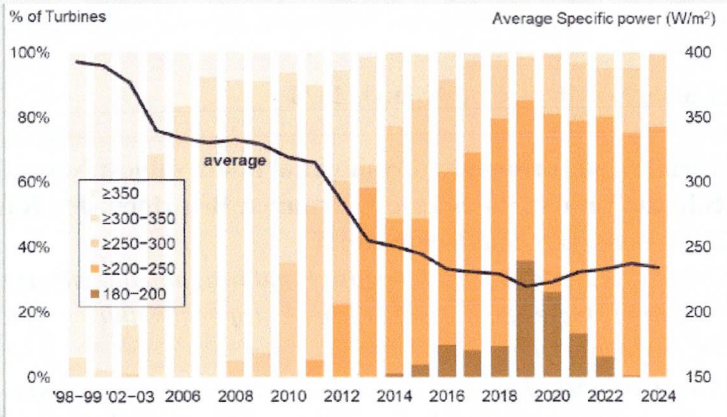


Note wind turbines in 2010 had a Capacity of 2Mw, Hub height of 80m & Rotor diameter of 85m. The height to the tip of the wind turbine would have been 80+42.5=122.5m. The present application is for a 6.2Mw capacity with a tip height of 185m. These are not comparable. The 2016 scenario for Scotland is similar. Comparing property prices from 2009, 2013, 2014 is irrelevant to present day sizes.

Trends in turbine nameplate capacity, hub height, rotor diam and specific power

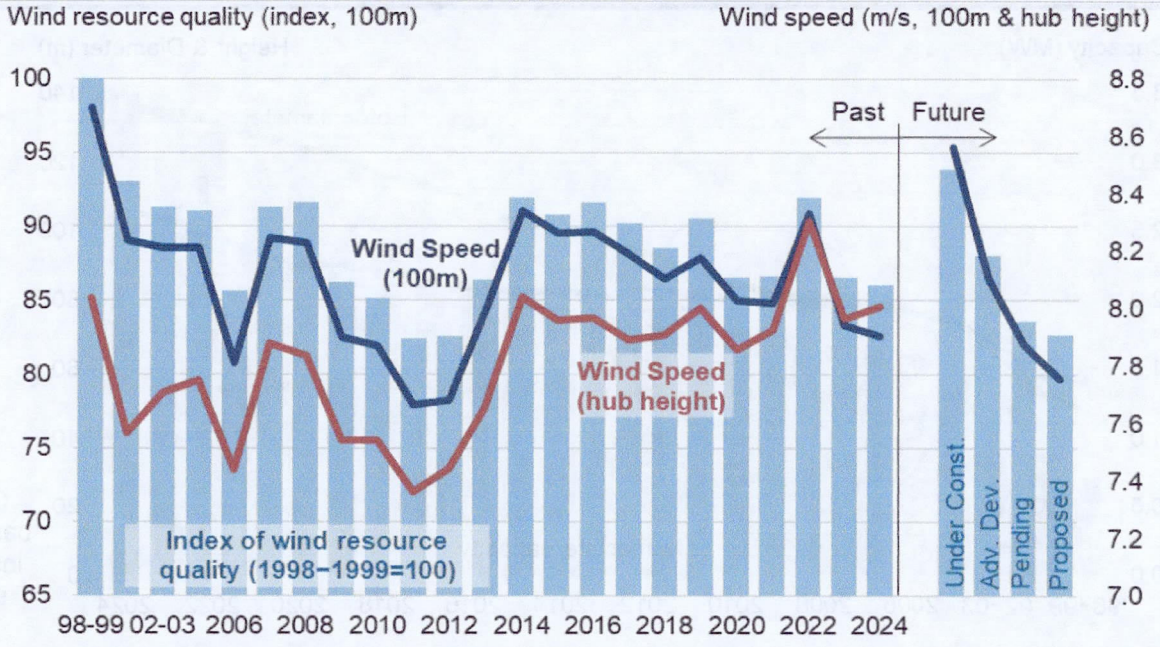


Specific power: turbine capacity divided by swept rotor area; lower specific power leads to higher capacity factors, as shown later



Sources: ACP, Berkeley Lab

Wind resource quality by year of installation at 100 meters and turbine hub height



Sources: ACP, Berkeley Lab, AWS Truepower, FAA files

Notes: Turbines used in this figure have been screened to remove offshore turbines and those >1000ft. Wind speed at hub height is determined using a straight-line average between AWS Truepower wind speed estimates at 80 and 100m. The wind resource quality index is based on site estimates of gross capacity factor at 100 meters, with values indexed to projects built in 1998—1999; this quality index controls for site elevation and wind speed distributions but assumes a common turbine power curve.

Reference 2024 : Decision of the French Council of State No. 465036 of 8 March 2024

On 8 March, the French Council of State issued a historic decision by making illegal permits for onshore wind turbines and fleet renewal rules. In a statement, the Fédération Environment Durable and fifteen associations, which *had lodged the application, stated that "the Council of State has annulled all the provisions concerning the three successive versions of the noise nuisance protocol which is supposed to protect the health of local residents."*

Ongoing projects must start all over again

Projects under instruction or not yet built "require a complete environmental assessment", welcomes the Federation, while stating that "all wind farms built on the basis of now-illegal by-laws should normally no longer be allowed to operate as they are."

Beyond that, the Council of State noted that the ministerial noise measurement orders had not been subject to an environmental assessment, "which constitutes a violation of the law". He also stressed that decisions to approve the acoustic protocol "have not been subject to public participation, thereby violating the principles of participation and transparency."

Decision of the Council of State No. 465036 of 8 March 2024

Reference 2023 : Commercial wind turbines and residential home values: New evidence from the universe of land-based wind projects in the United States Eric J. Brunner, Ben Hoen, Joe Rand, David Schwegman, Energy Policy21 September 2023 www.elsevier.com/locate/enpol

While the majority of U.S. studies have found small negative and insignificant effects of proximity to wind turbines on property values, the evidence from studies that use data from European countries typically finds that proximity to wind turbines reduces residential property values.

For example, using data from Denmark, Jensen et al. (2014) estimate that homes where residents can see a turbine decline in value by 3%, and these homes decline by an additional 2% if residents can hear the turbines when compared to those properties outside of visible or auditory range. They also find effects fade as distance increases. Gibbons (2015) finds that English and Welsh homes with a visible wind energy project within 2 km experience approximately a 5%–6% decline in value relative to homes without a view and those located farther away.

From the Netherlands and using a difference-in-differences identification strategy, Droes and Koster (2016) find a 1.4% reduction in home prices for homes located within 2 km of a wind turbine with the effects being larger for homes located near turbines in urban areas and for larger turbines.
Similarly, using data from Germany, Sunak and Madlener (2016) and Sunak and Madlener (2017) find that turbine visibility and close proximity to wind turbines reduces residential home values by approximately 9%–20% respectively.
Jensen et al. (2018), Droes and Koster (2021) and Eichholtz et al. (2023), using data from Denmark, the Netherlands, respectively, find that close proximity to wind turbines reduces residential property values by between 3%, 6% and 7%.
The stark difference in findings between studies conducted in the U. S. and those conducted in Europe raises an important question: why do European studies nearly universally find that wind turbines reduce residential property values (and in many cases by a considerable magnitude), while studies from the U.S. typically find small and statistically insignificant effects? While the existing literature provides no definitive answer to that question, there are several possibilities. First, the population density of Europe is approximately 3.5 times higher than that of the U.S. Furthermore, that figure represents average population density and most wind turbines in the U.S. are located in the less densely populated areas of the Midwest and Southwest. Thus, it is simply harder to site wind turbines farther away from residential locations in Europe than in the U.S. Second, and relatedly, European studies tend to have significantly more residential sale transactions in close proximity to a wind turbine. For example, Droes and Koster (2016) observe 149,939 transactions within 2 km of a wind turbine while in the largest U.S. study to date, Hoen et al. 2015) observe approximately 1200 homes within 1 mile of a turbine.

Reference 2023 : Influence of onshore wind turbines on land values Jan von Detten, Johann V. Seebaß, Jan C. Schlüter, Florian Hackelberg. 4 May 2023. Springer . https://doi.org/10.1365/s41056-023-00067-5
The economic consequences of wind turbines on property prices and land values are a widely discussed political and social issue. In this study, in addition to the previous research on the impact of wind turbines on property prices, the influence of wind turbines on standard land values was examined for the first time. The study thus provides new insights, particularly with regard to the debate on distance areas and financial compensation payments for residents. The chosen investigated area is located in Northern Germany and comprises three coastal districts in the state Schleswig-Holstein with a total of 1382 land zones and a high density of wind turbines. Using ordinary least squares models, the significant influence of wind turbines on the standard land values could be shown within a radius of up to 9km. ***Using an exemplary municipality for the study area, an average change in the standard land value of 7.33% per 1000m distance could be determined****. Overall, the standard land values of less densely populated areas were affected more than urban areas.*
Jensen et al. (2018) examined around 40% of Denmark's total area in their study and found that, within a radius of 3km around a wind turbine, property prices are negatively influenced. In addition, they demonstrated a correlation between the number of wind turbines and the amount of price decrease. Studies from the Netherlands and England also found that the visibility of the plant has a decisive influence (Gibbons 2015; Dröes and Koster 2014). Gibbons (2015) found that properties with visible wind turbines within a radius of 2km have a 5–6% decrease in value. This effect depended largely on the height of the wind turbines. For Greece, Skenteris et al. (2019) applied various hedonic pricing models to evaluate the visual impact of wind farms on dwelling prices. Depending on their modelling setup, they found either no significant effects or a negative correlation within 2km radius. Westlund and Wilhelmsson (2021) found reductions in the value of Swedish properties in vicinity to wind turbines, which exponentially decrease in distance. Moreover, their results indicate that not only the sheer existence of such turbines but also their number and their height impacts value changes.
Sunak and Madlener (2016) took disturbing variables into account, the authors found that their difference-in-difference approach had a significant effect of 9–14% on the offer prices when a wind turbine has a clear visual impact on the property. The most recent study is provided by Frondel et al. (2019), who have evaluated more than 2.7 million offer prices over the years 2007 to 2015 using an OLS model. An average negative influence of 7.1% was found for properties located within one kilometre of a wind turbine. The influence decreases steadily up to a distance of 8–9km from the plant, after which no further effect could be determined. With up to 23.0%, wind turbines have a particularly high influence on the supply prices of old and rural properties, whereas no significant effect was observed in urban areas. The results of Sunak and Madlener (2016), who applied augmented spatial models on German data, imply that sheer distance to wind turbines is of less importance than the actual visual impact on a specific dwelling or property.

Reference 2015 : The impact of wind farm visibility on property values: A spatial difference-in-differences analysis. Yasin Sunak, Reinhard Madlener. Energy Economics Volume 55, March 2016, Pages 79-91. https://doi.org/10.1016/j.eneco.2015.12.025

Today's investment decisions in large-scale onshore wind projects in Germany are no longer determined only by the *investment's economic benefit, but also by concerns associated to social acceptance. Despite a mostly positive attitude towards the expansion of wind power, local public concerns often stem from the belief that the proximity to large-scale* wind farms may lead to a decrease in property prices. *In particular, the change in landscape caused by the construction of a wind farm may have an adverse impact on the view from some properties, and thus may negatively affect their price. To investigate the potential devaluation of properties in* Germany due to wind farms, *we use a quasi-experimental technique and apply a spatial difference-in-differences approach to various wind farm sites in the federal state of North Rhine-Westphalia. We adopt a quantitative visual impact assessment approach to account for the adverse environmental effects caused by the wind turbines. To properly account for spatial dependence and unobserved variables biases, we apply augmented spatial* econometric models. *The estimates indicate that the asking price for properties whose view was strongly affected by the construction of wind turbines decreased by about 9–14%. In contrast, properties with a minor or marginal view on the wind turbines experienced no devaluation.*
Even if wind turbines are visible from distances of up to 30 or 40 km under certain circumstances, usually the significance of a visual impact can be expected to drop substantially beyond distances in excess of two to three kilometers (Bishop, 2002, Sullivan et al., 2012).

Reference 2019 : Clean Energy Wire, Journalism for the energy transition. Benjamin Wehrmann 21 Jan **2019.**
German homeowners could see the value of their property fall if wind turbines are built in their vicinity, according to a study *by research institute RWI.* ***The value of a one-family house falls by an average of 7 percent when a wind turbine begins operation within 1 kilometre of the property,*** *RWI estimates, based on a review of close to 3 million offers on an online real estate website. The effect disappears at a distance of 8 to 9 kilometres, RWI says, adding that the drop in value is down to potential noise pollution and the turbines' aesthetic impact on the landscape. The study found that the value of older houses in rural areas dropped by up to 23 percent, while almost no devaluation was observed for houses built on the outskirts of larger towns. "Wind power may be important for the success of the energy transition but* implications for property owners can be severe in some cases," RWI researcher Manuel Frondel *said. Several regional governments in Germany have imposed* strict minimum distances from residential areas for *new* onshore wind turbines, but critics argue this could pose a significant challenge to meeting the *country's* renewable power targets. *According to a study commissioned by* WWF in October 2018, available land will *become* "the new currency" of Germany's energy transition.

Reference 2020 : Impact Analysis of the Niyol Wind Farm on Surrounding Rural Residential and Agricultural land Values in Logan County Colorado. June 11, 2020. FORENSIC APPRAISAL GROUP 116 E. Bell Street Neenah, WI 54956 ph (920) 558-4638 www.forensic-appraisal.com.

- *The Landsink (Ontario, CA) study* ***found a loss range of -8.85% to -50%, with a loss average of -39%*** *for residential homes within 664ft to 2,531ft of a wind farm.*
- *The Appraisal Group One Wisconsin Study found a typical loss of 1-10 acre residential lots within ½-mile of wind turbines to be* ***-19% to -40%.***
- *The Clarkson University upstate New York study of both residential and agricultural properties found a loss ranging from* ***-15.6% to -31%*** *within 1-3 miles of a wind farm.*
- *The Forensic Appraisal Coral Springs (WY) study of large residential lots (35 acres) which would be abutting a proposed wind farm* ***suffered a value impact of -25% to -44%.***
- *The McCann study (IL) of residential properties found an average impact* ***of -25% within 2-miles of a*** *wind farm.*
- *The Forensic Appraisal Big Sky (IL) study found a loss range of* ***-12% to -25% of residences within 0.31mi*** *to 1.72mi of a wind turbine, with an average impact of -19% at an average distance of 0.65 miles to a wind turbine.*
- *The Twin Grove II Wind Farm (McLean County, IL) study of a 198MW wind farm comprised of 120 turbines being 397ft in height over an 11,000 acres area.*

A paired sales analysis of residential property within the influence of the wind farm found the improved property is negatively impacted by the presence of wind turbines. The impact measured ranged ***from -46.6% to -7.7%,*** *with the*

higher impact closest to the wind turbines and the impact diminishing as the distance is increased. The distances measured ranged 1,483ft to 5,481ft away from a residence.
The Twin Grove II Wind Farm also found an overall impact of -6.63% to -8.5% for vacant agricultural properties within the wind farm zone.
*Properties within the Wind Farm Footprint= **-35% impact on property value***
*Properties : 1-Mile outside of the Wind Farm Footprint = **-22%***
impact on property value : Agricultural Properties within the Wind Farm Footprint= 8.5% impact on property value

Application of these estimated losses to the client's property value is: Niyol Wind Farm Loss to Property Value Estimate			
Total assessed value		*impact*	*value loss*
Properties within the footprint	*$6,948,960*	*-35%*	*--$1,405,051*
Properties 1-mile outside of the Footprint	*$4,014,430*	*-22%*	*-$1,528,771*
$2,933,822			*-*

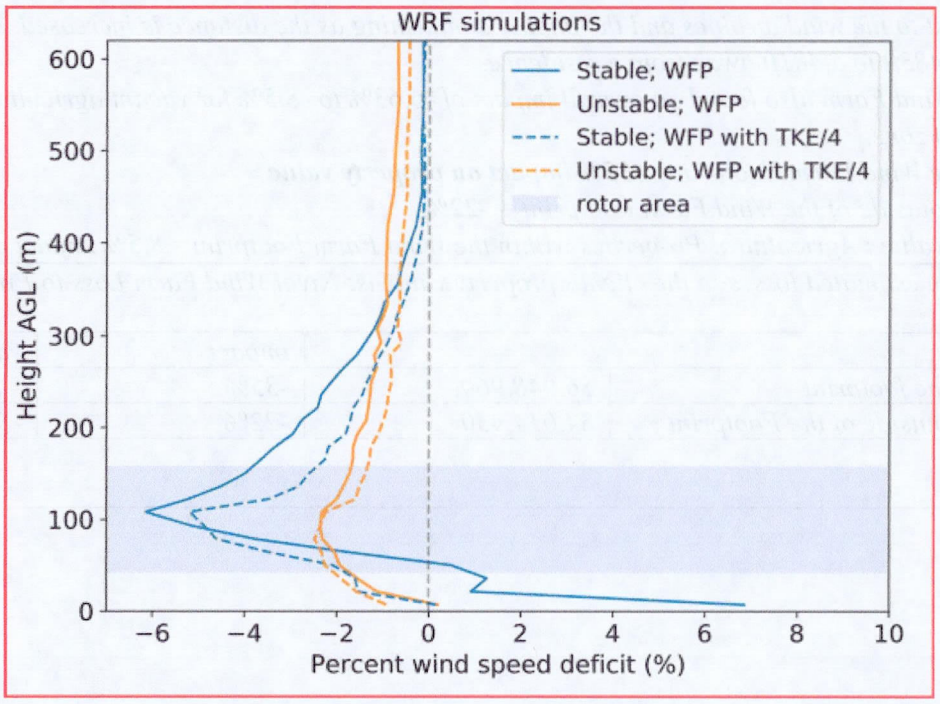
Response from MLavelle:

Reference 2022 : Impacts of 319 wind farms on surface temperature and vegetation in the United States. Yingzuo Qin et al 2022 Environ. Res. Lett. 17 024026

Despite the climate benefits of wind power, there is a growing concern about the environmental effects of the increased land use and land cover change for wind farms. For example, the large deployment of wind farms can adversely affect local animal habitats, and the rotary blades of wind turbines can kill birds (Bright et al 2008) and bats (Voigt et al 2012). Wind farm construction can also result in deforestation, soil erosion, and impacts on land carbon sequestration (Dai et al 2015, Armstrong et al 2016).
The modification of land surface properties by wind farms also strongly influences the local and regional climate (Kirk-Davidoff and Keith 2008, Baidya Roy and Traiteur 2010, Zhou et al 2012), which in turn will influence ecosystem processes (Armstrong et al 2016). Changes to the climate are attributable to the wind turbines increasing the surface roughness (Kirk-Davidoff and Keith 2008) with implications for turbulence (Xia et al 2016) and mixing in the atmospheric boundary layer (ABL) (Baidya Roy and Traiteur 2010). Moreover, the wind turbines remove energy from the system and decrease downstream wind speeds (Miller and Kleidon 2016).
*As for impacts on vegetation, **our results showed decreased vegetation for most wind farms,** especially those large farms. However, positive and insignificant impacts were observed as well. The decreased vegetation is mainly caused by the construction of wind farms and the associated land cover changes, limiting vegetation growth in wind farms (Tang et al 2017, Urziceanu et al 2021). The increased vegetation in wind farms may be caused by the changing microclimate conditions induced by wind farms.*
Our results from a large sample of wind farms revealed significant local warming effects at night, insignificant impacts during the daytime, and the mostly negative impacts on vegetation.

Reference 2021 : Wind plants can impact long-term local atmospheric conditions Nicola Bodini, Julie K. Lundquist, & Patrick Moriarty. Scientific Reports | (2021) 11:22939 | https://doi.org/10.1038/s41598-021-02089-2.

The presence of the wind plant induces a wake that varies with wind speed, wind direction, and ambient turbulence. The magnitude of the wake increases as wind speed increases toward the rated wind speed of the turbines; the wake erodes quickly in daytime convective conditions but persists for long distances downwind in stable conditions.



Supplementary Abstract

Long-term weather and climate observatories can be affected by the changing environments in their vicinity, such as the growth of urban areas or changing vegetation. Wind plants can also impact local atmospheric conditions through their wakes, characterized by reduced wind speed and increased turbulence. We explore the extent to which the wind plants near an atmospheric measurement site in the central United States have affected their long-term measurements. Both direct observations and mesoscale numerical weather prediction simulations demonstrate how the wind plants induce a wind deficit aloft, especially in stable conditions, and a wind speed acceleration near the surface, which extend c30km downwind of the wind plant. Turbulence kinetic energy is significantly enhanced within the wind plant wake in stable conditions, with near-surface observations seeing an increase of more than 30% a few kilometers downwind of the plants.

As wind flows past the rotating blades of a wind turbine, some of its momentum is devoted to moving the blades and generating electricity. As a result, the downwind flow is slower and more turbulent. Assessing the characteristics of this wake has been identified as one of the grand challenges that wind energy science needs to face to drive innovation in the sector and meet future energy demand. Wakes are particularly complex: their characteristics depend on the incoming wind speed, wind direction, and turbulence, as well as turbine operation and associated parameters. In convective conditions, wakes tend to be eroded rapidly by ambient turbulence. In stably stratified conditions with weak turbulence, wakes tend to exhibit a large wind speed deficit and persist for long distances downwind. For example, aggregated wakes from multiple turbines, i.e., wind plant wakes, can extend more than 50 km downwind of a wind plant, offshore in stable conditions. In addition to the wind speed deficit and the enhancement of turbulence at the heights above the surface corresponding to the wind turbine rotor, wakes can affect local surface conditions.

Reference 2023 : Impacts of wind turbines on vegetation and soil cover: a case study of Urla, Cesme, and Karaburun Peninsulas, Turkey Talha Aksoy, Mehmet Cetin, Saye Nihan Cabuk, Muzeyyen Anil Senyel Kurkcuoglu, Gulsah Bilge Ozturk, Alper Cabuk. Clean Technologies and Environmental Policy (2023) 25:51–68 https://doi.org/10.1007/s10098-022-02387-x

Wind turbines, similar to many other artificial structures such as communication masts, tall buildings and windows, power lines, and fences, are discussed in the literature as one of the sources of bird fatalities (Drewitt and Langston 2008). However, the effects of wind turbines on bird fatality are associated with various factors such as the location, season, topography, and bird species (Fernandez et al. 2007; Kuvelsky et al. 2007; Farfan et al. 2009; Sovacool 2013; Wang et al. 2015). For instance, Farfan et al. (2009) studied the impact of wind farms with a case study from southern Spain. They concluded that the turbines did not harm passerine birds but had a negative effect on the raptors in the region.

In a study conducted in Mongolia, the vegetation change in the 50 km buffer zones around Wind Power Plants between 2008 and 2014 was monitored and assessed using NDVI analysis (Li et al. 2016). The impact of WPPs on

vegetation was reported to be more significant after the operations started compared to the installation period, and the highest rate of change was detected in the 30-km buffer zone around the turbines. *WPPs can have a significant impact on climate-affected vegetation due to the local climate. Tang et al. (2017) analyzed the effects of WPPs on vegetation growth and productivity in summer (June–August) in the Bashang region of North China. WPPs showed a significant inhibitory effect on vegetation growth as evidenced by decreases in leaf area index (LAI), increased vegetation index (EVI), and normalized difference vegetation index (NDVI).*

Shen et al. (2017) evaluated the direct impact on the pasture lands during the construction of WPPs in China using the Landsat 8 satellite and the GF-2 HD satellite imageries. The study concluded that the construction of a single wind turbine damaged approximately 3000 m2 of pasture land, and China's GF-2 HD satellite (GF-2) could accurately detect the damage in the area.

All of the research mentioned above show that wind turbines cause turbulence, wake effect, and temperature change nearby; therefore, measurable impacts on vegetation occur or are likely to occur.

Land principally occupied by agriculture, with significant areas of natural vegetation, experienced the most negative change in the 3–5% slope group. It is 1.76 times higher in the control buffer area compared to the WPP surrounding. The most degradation was observed in the northern facing aspect group, with 2.43 times higher in the control buffer zone compared to the areas closer to WPP in the northern aspect group

In natural grasslands–pasture lands, it was observed that the degradation was high in the 1–2% slope group, and it was 7.61 times higher around the Wind Power Plant compared to the control buffer zone. In addition, the south-facing aspect group experienced the most negative change, with 9.24 times higher change surrounding the WPP than the control buffer zone. So, it was inferred that areas close to the WPP are exposed to more degradation than control buffer areas.

It was determined that the highest degradation in the natural vegetation class is on the 3–5% slope and in the area far from the WPP in the north direction. There could be no analysis since at least two of the groups in the same year did not have WPP. When the same WPP in different years was examined, the slope groups were found to be 3–5% and had a north-facing aspect. As a result of the study, it is thought that the degradation in agricultural areas with natural vegetation is more prone to damage caused by WPP—in areas with 3–5% slope and north-facing aspect.

The biggest degradation in the pasture lands class was identified on a 1–2% slope and in the area closest to the WPP in the south direction. Examining the WPPs in the same years, which were divided into groups, it was found that the highest deterioration was predominantly on the 0–1% slope, but a common direction could not be determined. When the same WPPs were evaluated in various years, it was discovered that the degradation was concentrated in the 0–1%slope group, with certain groups exhibiting consistency within themselves in terms of aspect.

Turbines change the humidity and temperature in the local area, which creates a positive or negative effect depending on the vegetation type.

Reference 2022 : ***A new USGS report shows a link between air disturbed by wind turbines and vegetation patterns***

By Communications and Publishing September 26, 2022 ***Denver, CO.*** *— The trails of disturbed air produced by wind turbines—known as wakes—can alter downwind temperatures and humidity, and a new U.S. Geological Survey study has demonstrated for the first time that wakes can impact vegetation in the vicinity.*

The study's insight into the effects of wakes from wind turbines on vegetation is an important first step to understanding how wind energy affects terrestrial ecosystems. Wind energy is rapidly and globally expanding, with five-fold increases since 2010 and predictions of up to 10-fold growth over the next 30 years.

"We are just beginning to understand how the wakes from wind turbines affect both the terrestrial and offshore environment," said ***USGS Research Ecologist, Jay Diffendorfer****, "The next step will be to better understand where and why these effects occur."*

In the study, scientists modeled wake and non-wake zones around 17 wind facilities across the United States, to test if wakes influenced vegetation condition, which was measured using data from USGS's Landsat satellites. The study was designed to isolate the effects of turbine wakes from other factors that could affect vegetation condition around wind facilities, such as new roads or agriculture.

These wake-induced changes in vegetation condition were found for part or all of the growing season at 10 of the 17 facilities studied. Researchers found that wakes can have both positive and negative effects on vegetation greenness, a measure that is often used in remote sensing to assess vegetation density and crop health, and that the magnitude of the change in greenness depended primarily on earlier precipitation. The changes observed at some facilities were consistent with levels that other studies found can affect breeding bird clutch size, species richness, and ungulate abundance.

As wind energy expands, understanding where and when wind turbines positively or negatively affect vegetation may aid in future decisions about where to site wind energy infrastructure. For example, careful placement may benefit agriculture or grazing while minimizing unwanted reductions to the vegetation greenness in the vicinity.
Widely acknowledged environmental impacts include wildlife deaths from turbine collisions, habitat loss, and behavioural avoidance of wind facilities by some species (Allison et al 2019).
A newly emerging, potential environmental impact may be the effects of turbine wakes ('wakes') on microclimates and vegetation. Wind turbines generate wakes as they remove energy from wind resulting in lower wind speeds and increased turbulence. These wakes are large enough to reduce energy generation at downwind facilities (Lundquist et al 2019). They can also change air, surface, and soil temperatures, as well as humidity (Zhou et al 2012, Armstrong et al 2016, Xia et al 2016, Rajewski et al 2020), but not always (Moravec et al 2018). Field-collected and remotely-sensed surface temperature data show wakes can cause nighttime warming up to 1.5 °C–1.9 °C (Rajewski et al 2013, Smith et al 2013) and cool daytime temperatures (Rajewski et al 2013, Xia et al 2016), although these effects vary with wind conditions and season.

Reference 2023 : Wind farms dry surface soil in temporal and spatial variation. Gang Wang, Guoqing Li, Zhe Liu. MethodsX Volume 10, 2023, 102000 https://doi.org/10.1016/j.mex.2023.102000

Wind farms have been proved to have potential impact on the ecology. As an important ecological factor, soil moisture has a great impact on the ecosystem. Therefore, it is of great significance to explore the effect of wind farms on soil moisture. At present, the remote sensing data can be used to calculate the soil moisture of wind farm conveniently, but its spatial resolution is poor. Moreover, the measured soil moisture can't express the spatial difference. Therefore, through the effective combination of remote sensing data and measured data, this method can accurately judge the impact of wind farm on soil moisture. This method investigated wind farms located in the grasslands of China. Remote sensing images and field data were used to explore the area and extent of influence of wind farms on grassland soil moisture. We use Landsat images and field measurements to derive a linear relationship between the soil moisture and the TVDI, which was calculated based on the land surface temperature and NDVI, was developed in this work. The correlation was used to reverse spatial distribution map of soil moisture before and after the construction of wind farms. The diurnal and seasonal variation of the influence of the wind farm on the grassland soil moisture was also judged.
Ecosystem impacts during construction and operation have been widely reported, including the potential to reduce, fragment, or degrade habitat for wildlife, fish, and plants. However, the impacts on local climate, and thus longer-term impacts on ecosystems are less well understood. Soil moisture changes are important for nutrient and energy cycling in ecosystems and have a direct impact on local wildlife. Xie (2015) used the measured data to monitor the effects of wind farms on vegetation and soil in low-water, semi-arid regions. After the wind farm is built, there is no consistent trend in soil moisture based on wind direction or distance from the wind farm (0–100 m) . Armstrong et al. (2016) used observation data from a wind farm in Scotland to judge the impact of wind turbine operation on the local climate in podzolic soil. They found that there was no significant trend in changes in soil moisture (to a depth of 10 cm) caused by the operation of wind turbines, which may be related to the high water table at the wind farm. Tang et al. (2017) used 0.25° × 0.25° climate change initiative (CCI) soil moisture data derived from MODIS data to judge the impact of wind farms on vegetation in Texas and Illinois, USA. By comparing the annual soil moisture difference between the wind farm and non-wind-farm regions, it was found that the wind farm soil moisture reduced by 0.3% after construction in the desert and yellow-brown soils . With remote sensing data, although the soil moisture before and after a wind farm has been built can be calculated, the spatial resolution of the data is low and cannot be effectively combined with field-measured data. Therefore, many difficulties remain in accurately judging the impact of wind farms on soil moisture.
Therefore, this paper investigated wind farms located in the grasslands of China. Remote sensing images and field data were used to explore the area and extent of influence of wind farms on grassland soil moisture.
Conclusions
We used remote sensing and field-measured data to analyze changes in soil moisture before and after the construction of wind farms. We found that wind farms significantly reduce soil moisture to different extents according to season and wind direction. We obtained the following main conclusions;
- *(1) Wind farms significantly reduced soil moisture within the wind farms and in the upwind and downwind directions. Compared with the upwind and downwind directions, the decrease in soil moisture within the wind farms was the most, and the annual decrease in soil moisture within wind farms reached 4.4%.*

- *(2) Wind farms have different influences on the soil moisture in the upwind and downwind directions in each season. Reductions are greatest in the upwind direction in spring and the downwind direction in summer and autumn.*
- *(3) The wind farm reduced the soil moisture most significantly downwind of the wind farm throughout the day, with an average value of up to 2.85%. The decrease in the soil moisture upwind was the least significant, only by 0.21%.*

Reference 2021 : A Review on State-of-the-Art Reviews in Wind-Turbine- and Wind-Farm-Related Topics : Sawant, M.; Thakare, S.; Rao, A.P.; Feijóo-Lorenzo, A.E.; Bokde, N.D. Energies 2021, 14, 2041. https://doi.org/10.3390/ en14082041

WA Wind Turbine extracts wind's kinetic energy and converts it into mechanical energy. During this process, the WT reduces the wind speed behind the rotor, which creates a wind shadow or wakes effect, as shown in Figure 9.
Due to the wake effect, the downstream WTs receive wind with lower speed and higher turbulence level, which reduces the energy yield . In Figure 10, uo is the direction of wind, T1 to T7 are WT locations, and it is clear that the downstream WTs receive modified wind; hence, it affects the energy yield.
The parameters that influence the wake effect are Wind Farm size and layout, number and size of WTs, wind speed and direction, and turbine blade design . General impacts of the wake generated by WTs are a mechanical failure, extra maintenance cost, and reduction in power.

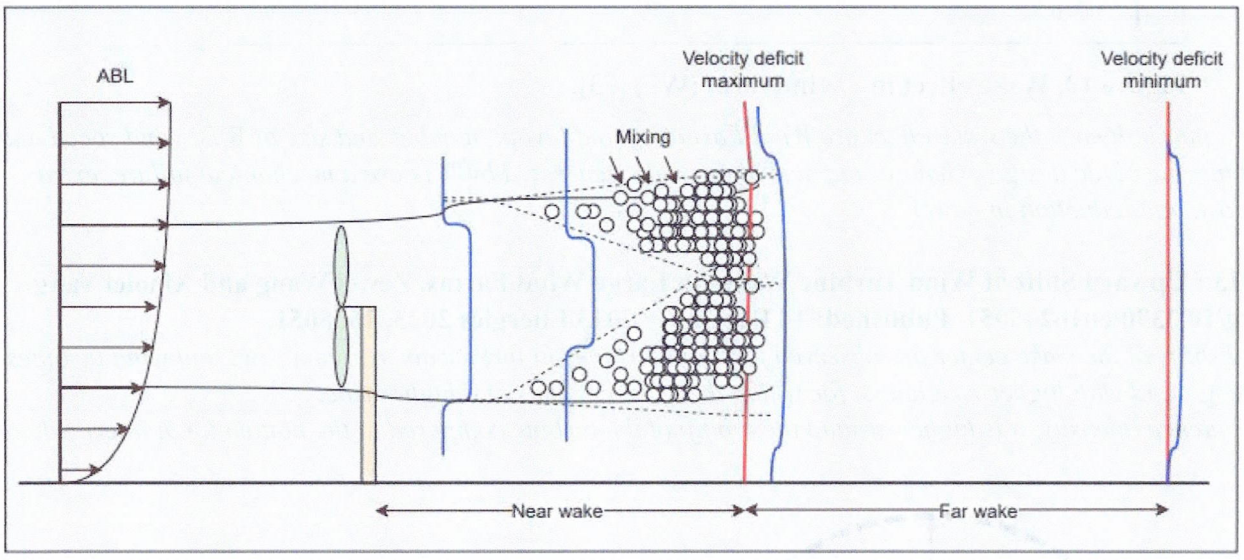


Figure 9. The velocity profile behind WT [85].

Due to the wake effect, the downstream WTs receive wind with lower speed and higher turbulence level, which reduces the energy yield . In Figure 10, uo is the direction of wind, T1 to T7 are WT locations, and it is clear that the downstream WTs receive modified wind; hence, it affects the energy yield.

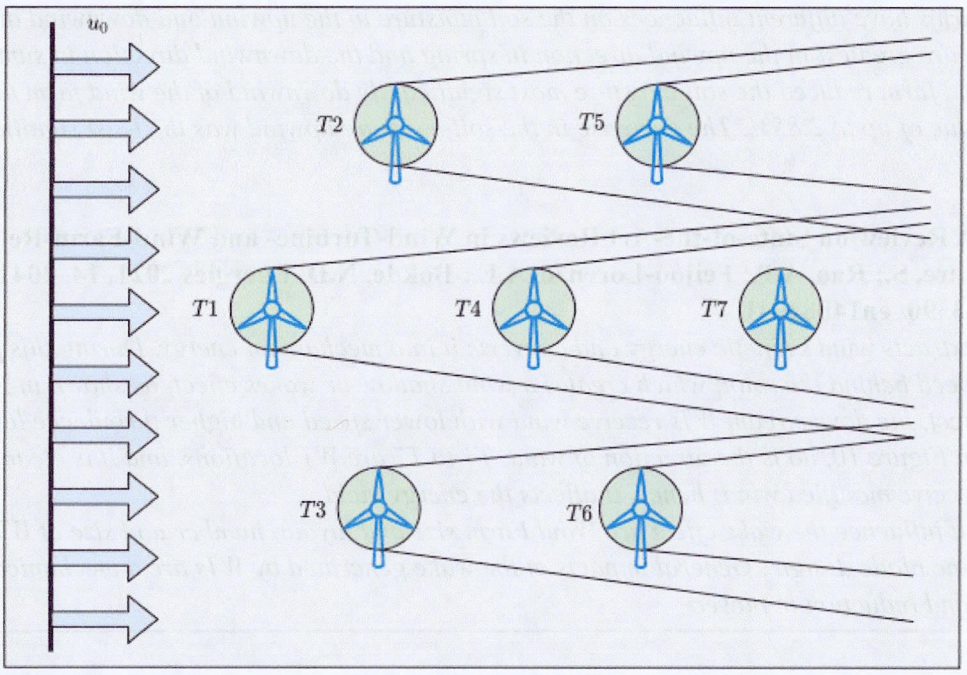


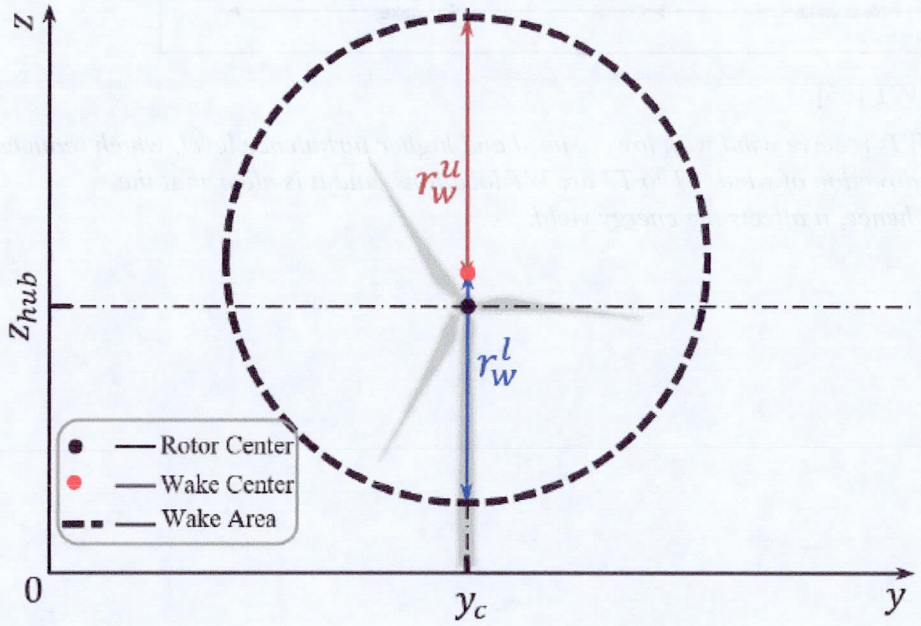
Figure 10. Wake effect in a wind farm (WF) [73].

The parameters that influence the wake effect are Wind Farm size and layout, number and size of WTs, wind speed and direction, and turbine blade design . General impacts of the wake generated by WTs are a mechanical failure, extra maintenance cost, and reduction in power.

Reference 2023 : Upward Shift of Wind Turbine Wakes in Large Wind Farms. Zewei Wang and Xiaolei Yang. https://doi.org/10.3390/en16248051. Published: 14 December 2023 Energies 2023, 16, 8051.

Larger upward shifts of the wake center are observed for wind turbines in further downstream rows and wind turbines installed on the ground with higher roughness, for which the wake expands at a higher rate.

Regarding turbulence intensity, it is higher around the top tip of the turbine compared to the bottom tip at intermediate wake locations



Schematic of the wake area in the streamwise plane, which are indicated as wider & higher than the blades. The potentially 100m higher levels above the blades bring much colder air down to ground level.

Reference 2025 : Impacts of wind turbine characteristics on wake turbulence. Shifeng Wang, Sicong Wang. *Energy Storage and Conversion* 2025, 3(1), 1956. https://doi.org/10.59400/esc1956.

The enhanced wake turbulence generated by wind turbine has remarkable effects on the power generation and fatigue loads of wind farm and the environment. The turbulence can sustain strength and distance for several miles before fully dissipating.

Reference 2018 : Wind turbine impact on near-ground air temperature, Renewable Energy Volume 123, August 2018, David Moravec , Vojtěch Barták , Vladimír Puš , Jan Wild . https://doi.org/10.1016/j.renene.2018.02.091

"Impacts on local climate are especially crucial in situations where allocating more turbines is justified by reducing carbon emissions, because these effects could have subsequent impacts on the carbon cycle in the affected area. Wind farms can affect local climates in two main ways. The first is by extracting kinetic energy, which slows wind flow. The second is by further heightening turbulence flow downwind. Turbulence can be generated in the wake of rotors and also by the shear between the non-affected faster air layer below the turbine and the upper air layer slowed by the turbine .

The generated turbulence has a secondary effect by enhancing vertical mixing of air. Several studies showed that enhanced turbulence produced by wind farms has impact on heat and moisture exchange between the surface and the atmosphere. In stable atmospheric conditions, when a warm air layer is present above cooler air, increased turbulence results in a warming near the surface by transferring thermal energy from higher levels to the lower. On the other hand, when unstable atmospheric conditions are present, i.e. cool air lying above a warmer layer, enhanced turbulence leads to mixing the layers and provides a cooling effect on the ground. These impacts depend on the ratio of natural turbulence to turbulence generated by the wind turbine. The stability of atmospheric layers can also influence a wind farm's impacts. The effect of vertical mixing can be 10–15% stronger when a wind turbine is present in the atmospheric boundary layer."

"Theoretical models have been tested in wind tunnel experiments. The outcomes of these experiments have shown that the effect of the wake can be found up to a distance of 20 rotor diameters . A computational study has suggested this to be a shorter still distance of 15 diameters . Maximum turbulence has been found at a distance of 4–4.5 rotor diameters above rotor hub height in neutral cases of atmospheric layers and 3–6 diameters in stable cases. Heightened turbulence intensity is associated with strong shear of layers and turbulent kinetic energy produced by regional features or wind farm layout ."

The effect of the turbine: For every 1,000ft you ascend, the temperature drops approximately 3.5-5 degrees Fahrenheit.[1.94- 2.77 degrees Centigrade]..The proposed windfarm will reduce temperatures by a minimum of 4 degrees Centigrade & a maximum of 6 degrees Centigrade. The Meterological Maps indicate the effect on the Wake area. Basically pasture lands & crops will be dramatically affected as will carbon sequestration.

Reference 2022 : Wind turbine wakes can impact down-wind vegetation greenness Jay E Diffendorfer, Melanie K Vanderhoof and Zach H Ancona United States Geological Survey, Geosciences and Environmental Change Science Center, Denver, CO 80225, United States of America *Environ. Res. Lett.* 17 (2022) 104025 https://doi.org/10.1088/1748-9326/ac8da9 26 September 2022

Global wind energy has expanded 5-fold since 2010 and is predicted to expand another 8–10-fold over the next 30 years. Wakes generated by wind turbines can alter downwind microclimates and potentially downwind vegetation. However, the design of past studies has made it difficult to isolate the impact of wake effects on vegetation from land cover change. We used hourly wind data to model wake and non-wake zones around 17 wind facilities across the U.S. and compared remotely-sensed vegetation greenness in wake and non-wake zones before and after construction. We located sampling sites only in the dominant vegetation type and in areas that were not disturbed before or after construction. We found evidence for wake effects on vegetation greenness at 10 of 17 facilities for portions of, or the entire growing season. Evidence included statistical significance in Before After Control Impact statistical models, differences >3% between expected and observed values of vegetation greenness, and consistent spatial patterns of anomalies in vegetation greenness relative to turbine locations and wind direction. Wakes induced both increases and decreases in vegetation greenness, which may be difficult to predict prior to construction. The magnitude of wake effects depended primarily on precipitation and to a lesser degree aridity. Wake effects did not show trends over time following construction, suggesting the changes impact vegetation greenness within a growing season, but do not accrue over years. Even small changes in vegetation greenness, similar to those found in this study, have been seen to affect higher trophic levels. Given the rapid global growth of wind energy, and the importance of vegetation condition for agriculture, grazing, wildlife, and carbon storage, understanding how wakes from wind turbines impact vegetation is essential to exploit or ameliorate these effects.

Reference 2025 : Observations of wind farm wake recovery at an operating wind farm Raghavendra Krishnamurthy1, Rob K. Newsom1, Colleen M. Kaul1, Stefano Letizia2, Mikhail Pekour1, Nicholas Hamilton2, Duli Chand1, Donna Flynn1, Nicola Bodini2, and Patrick Moriarty. Wind Energ. Sci., 10, 361–380, 2025 https://doi.org/10.5194/wes-10-361-2025 ©Author(s) 2025.

Wind turbine wakes, i.e., velocity deficits due to extraction of the kinetic energy from an operating wind turbine, are observed to extend several kilometers during stable atmospheric conditions both onshore and offshore (Hirth et al., 2012; Banta et al., 2015; Krishnamurthy et al., 2017; Fernando et al., 2019; Ahsbahs et al., 2020; Zhan et al., 2020). Wind farm wakes from a large cluster of wind turbines in mesoscale model simulations, and offshore observations **can reach over 50km downwind** under stable atmospheric conditions (Platis et al., 2018; Lundquist et al., 2019, Schneemann et al., 2020). Large-eddy simulations of large wind farms also show that wind farm wakes can alter the surface momentum and heat fluxes (Calaf et al., 2011). Wind farm wakes are known to impact the local meteorological conditions by, for instance, increasing or decreasing the temperature and enhancing turbulence downwind of a wind farm (Baidya Roy et al., 2004; Smith et al., 2013; Siedersleben et al., 2018; Miller and Keith, 2018, Bodini et al., 2021), although the intensity of the impact depends on atmospheric stability, local atmospheric processes, orientation of the wind farms, downwind distance, and the number and operative regimes of wind turbines. In operational wind farms, intra-farm wakes can result in significant power losses, and it is important to understand the dissipation of wakes within a wind farm. The effect of a wind turbine is to decrease the mean velocity and increase the turbulent kinetic energy above the rotor layer (the layer from the bottom of the wind turbine blade tip to the top of the blade tip; VerHulst and Meneveau, 2014). The turbulent transport term in a steady-state filtered-energy equation includes the entrainment of the mean momentum due to turbulence and the entrainment of the turbulent kinetic energy due to fluctuating velocities (Allaerts and Meyers, 2017).

Today's wind turbines operate within the lowest 300m of the atmospheric boundary layer (ABL), and in offshore or stable atmospheric conditions the ABL can be lower than 300m (Shaw et al., 2022). Although wind farms operate within 300m above ground level, their impacts can be observed through the entire depth of the boundary layer. Therefore, to accurately assess such impacts, observations of mean and turbulent characteristics of wind and temperature should extend up to the top of the ABL.

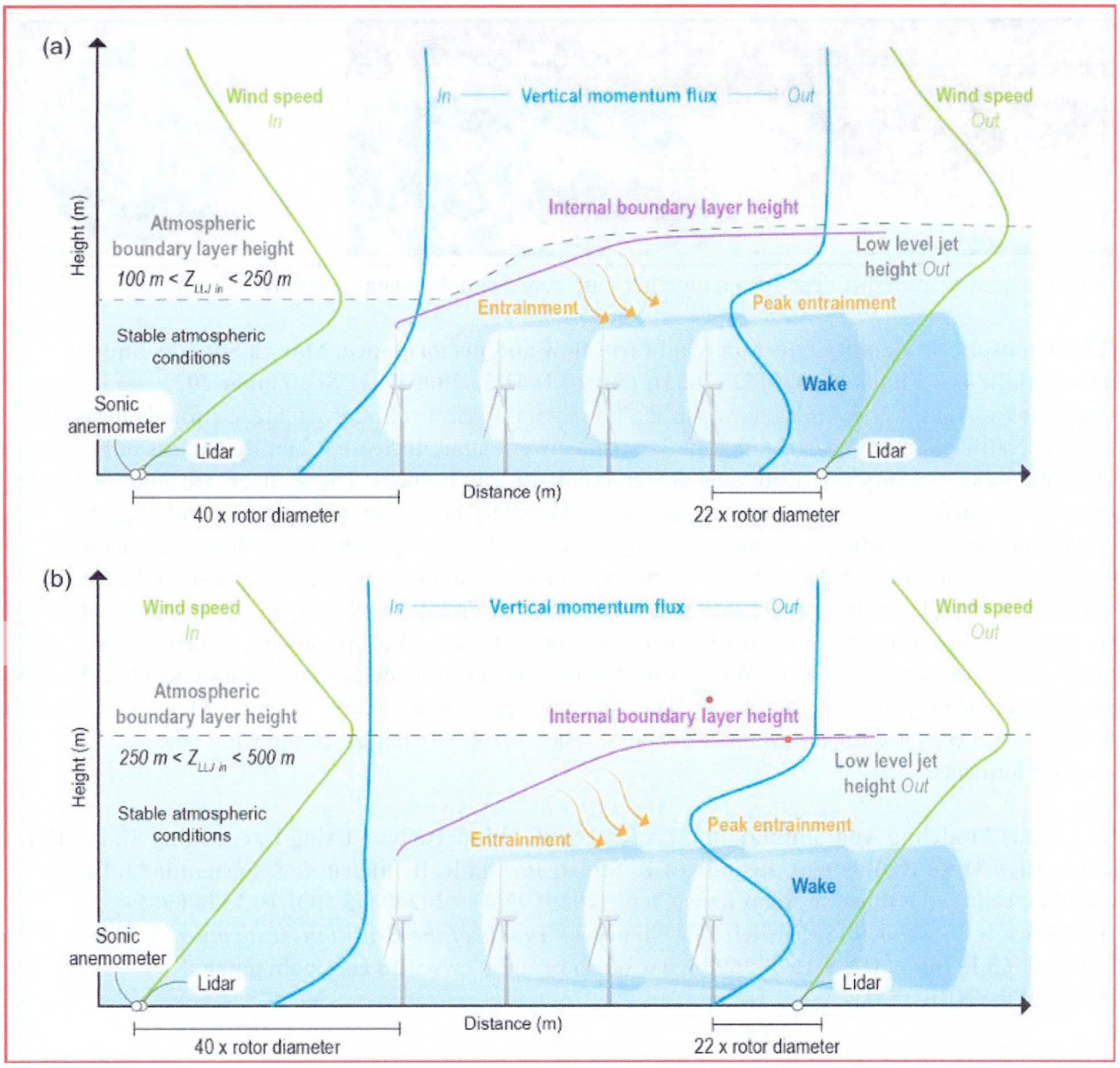
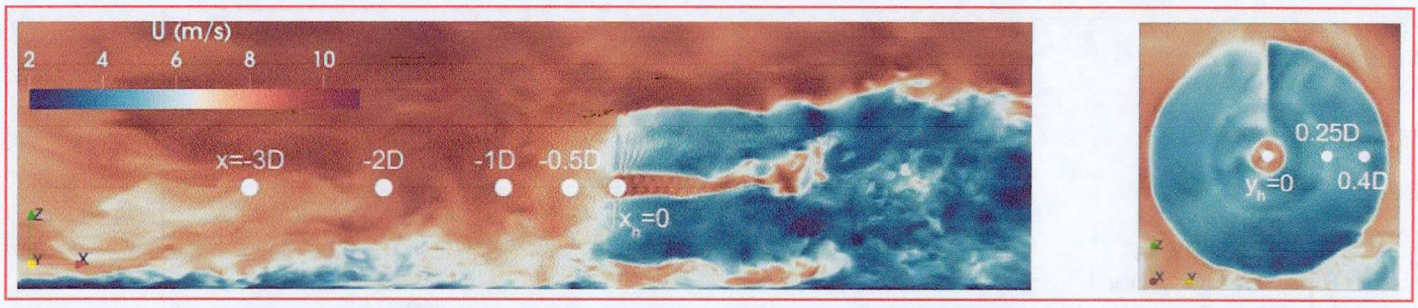


Figure: Schematic of the impact of LLJs on a wind farm boundary layer when (a) 100m<ZLLJ<250m and (b) 250m<ZLLJ<500m.

Reference 2025 : Turbulence Distortion Matters in Predicting Inflow Turbulence Noise of Future Wind Turbines. Ozgur Yalcın, Andrea Piccolo, Riccardo Zamponi, Daniele Ragni, and Roberto Merino-Martinez. https://doi.org/10.5194/wes-2025-214. Preprint. Discussion started: 29 October 2025

Aerodynamic noise can be classified mainly into blade self-noise and inflow turbulence (IT) noise. Considering blade optimization and operational flow regimes, trailing edge (TE) noise is a dominant self-noise source, which inherently scatters in the mid-to-high frequency range (Oerlemans et al., 2007). On the other side, IT noise arises from the interaction between the incoming turbulent flow and the blade leading edges (LEs), predominantly emitting low-frequency noise (f <200 Hz, corresponding to acoustic wavelengths larger than blade chords and comparable to large WT rotor scales) (Lowson, 1993; Buck et al., 2016).

Recent developments, such as TE add-ons and active flow control mechanisms, have yielded notable reductions in TE noise (Zhou et al., 2022; Lahoz et al., 2024). However, increasing rotor sizes and hub heights of next-generation turbines shifts the noise spectrum to lower frequencies, thus amplifying the relevance of IT noise (Moller and Pedersen, 2011). This shift is particularly important considering that low-frequency sound waves propagate over longer distances and experience reduced air absorption and transmission losses by building materials. T**herefore, they are more perceptible indoors due to room resonances, which increase their negative health impact** (Blumendeller et al., 2020). Consequently, accurate prediction of IT noise has become as critical as TE noise for the development of quieter WTs.



Streamwise velocity contours from different views, together with some sampled data locations

Reference 2025 : Atmospheric stability effect on wind farm flow and performance. Marwa Souaiby and Fernando Porte-Agela, Phys. Fluids 37, 095152 (2025); doi: 10.1063/5.0280027. 11 September 2025

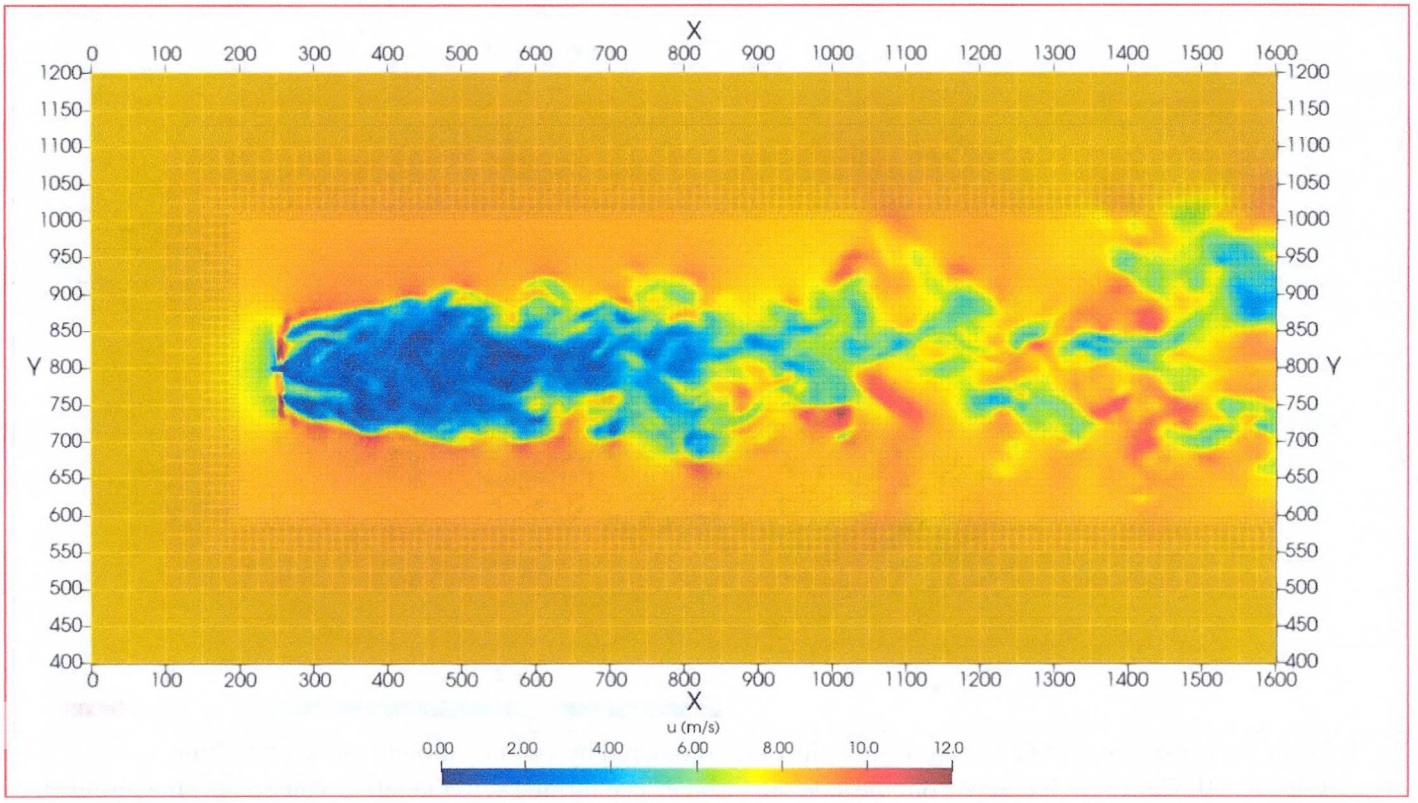
Large-eddy simulations are used to investigate how surface-layer stability (from strongly stable to strongly unstable) and free-atmosphere stratification influence wind farm flow and power output. Increased stability reduces turbulence intensity (TI), limiting wake recovery and decreasing power to downstream turbines. These effects are amplified under strong free-atmosphere stratification, which confines the internal boundary layer, suppresses vertical mixing, and reduces momentum entrainment, leading to stronger velocity deficits and greater power losses. Blockage effects, including entrance-region wind speed reduction, also intensify with increasing stratification—more so in the free atmosphere than in the surface layer. In strongly stratified cases with low Froude numbers (Fr_1:2), pronounced standing gravity waves form, accelerating the flow in the exit region and near wake, but slowing wake recovery further downstream due to reduced ambient TI. While wake recovery is generally delayed under stronger stratification, wind speed recovers more slowly than TI, particularly when freeatmosphere stratification is strong. Overall, the results highlight the need to consider both surface-layer and free-atmosphere stability when assessing wind farm aerodynamics and performance.

Reference 2025 : Wake Modeling And Simulation Of A Real Scale Wind Turbine Using Large Eddy Simulation And Dynamic Adaptive Mesh Refinement. Leandro J.L. Stival, Joshua R. Brinkerhoff & Fernando O. De Andrade & João Marcelo Vedovotto. An Acad Bras Cienc (2025) 97(4): e20240875 DOI 10.1590/0001-3765202520240875 Anais da Academia Brasileira de Ciências | *Annals of the Brazilian Academy of Sciences* Printed ISSN 0001-3765 I Online ISSN 1678-2690 www.scielo.br/aabc | www.fb.com/aabcjournal

Table I. Parameters of the NREL 5MW Wind Turbine.

Parameter	Value
Number of rotor blades	3
Rotor Diameter	126 m
Rated Power	5.3 MW
Rated Wind Speed	11.4 m / s
Rated Rotational Speed	12.1 rpm
Blade Length	61.5 m

The inflow wind velocity profile was imposed at the inlet with a hub height velocity of u = 8m/s.



Response from ML: This is a view from above the turbine looking towards ground. The turbine is to the left & you can see the turbulence towards the right & extending beyond 1,600m downwind. Note it extends outside the diameter of the turbine.

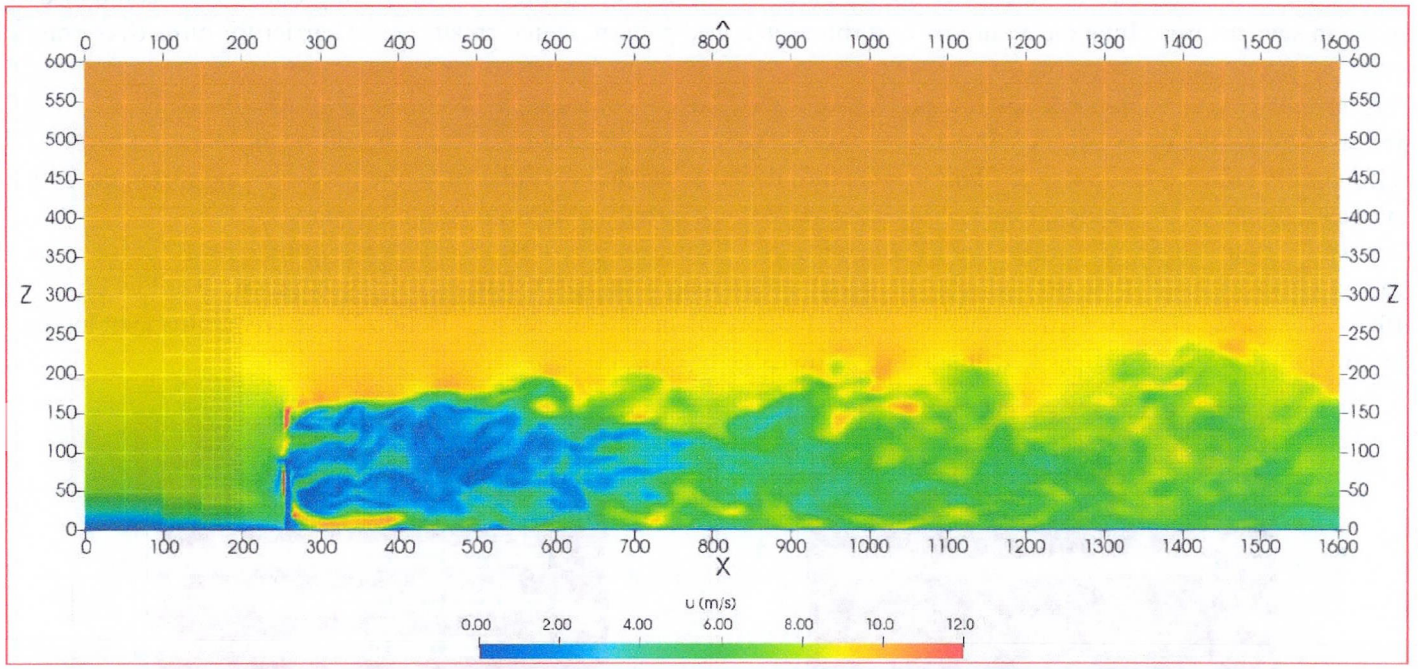


Fig. 2: The flow velocity contours development in lateral view of the NREL 5MW wind turbine.

Response from ML: This is a vertical view from the side the turbine. The turbine is to the left & you can see the turbulence towards the right & extending beyond 1,600m downwind. Note it extends above the diameter of the turbine.

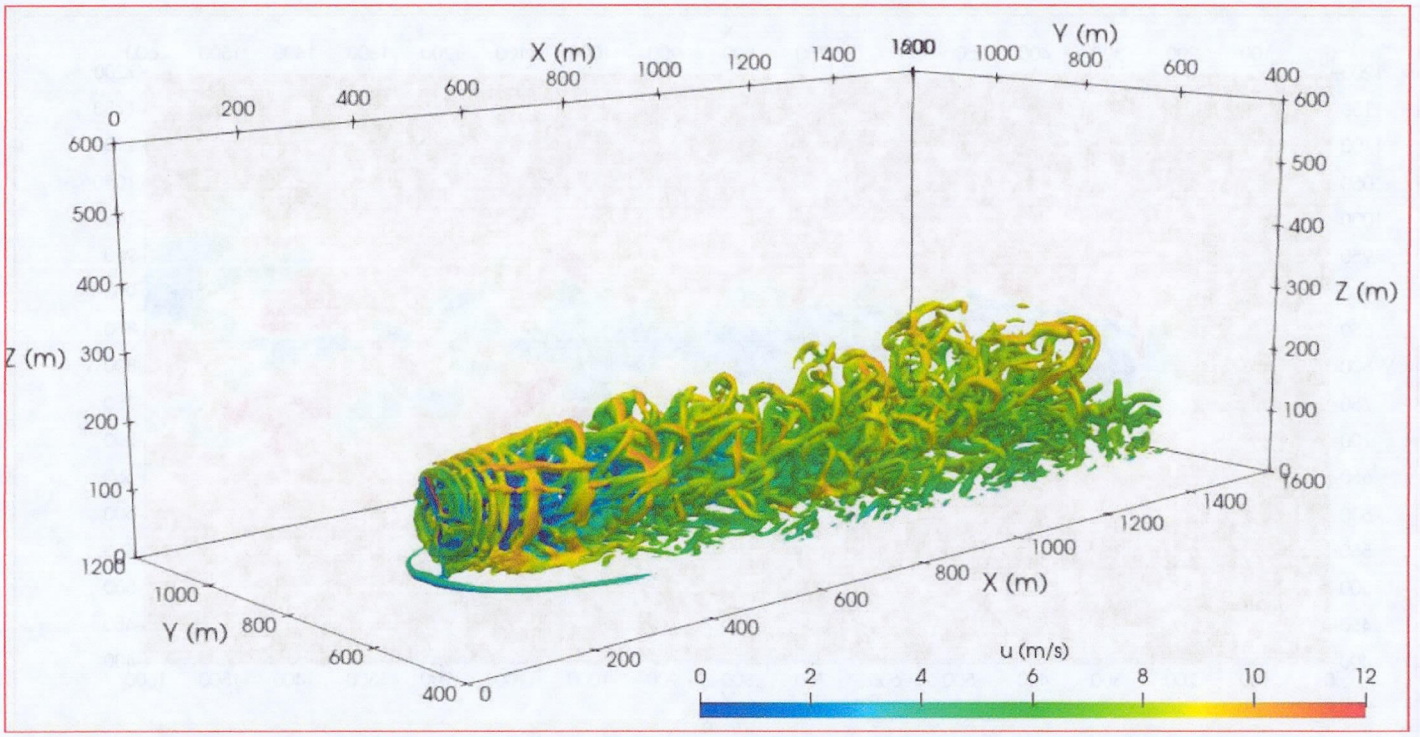


Fig. 3: Dynamic iso-surfaces of Q (Jeong & Hussain 1995), coloured by velocity around the wind turbine.

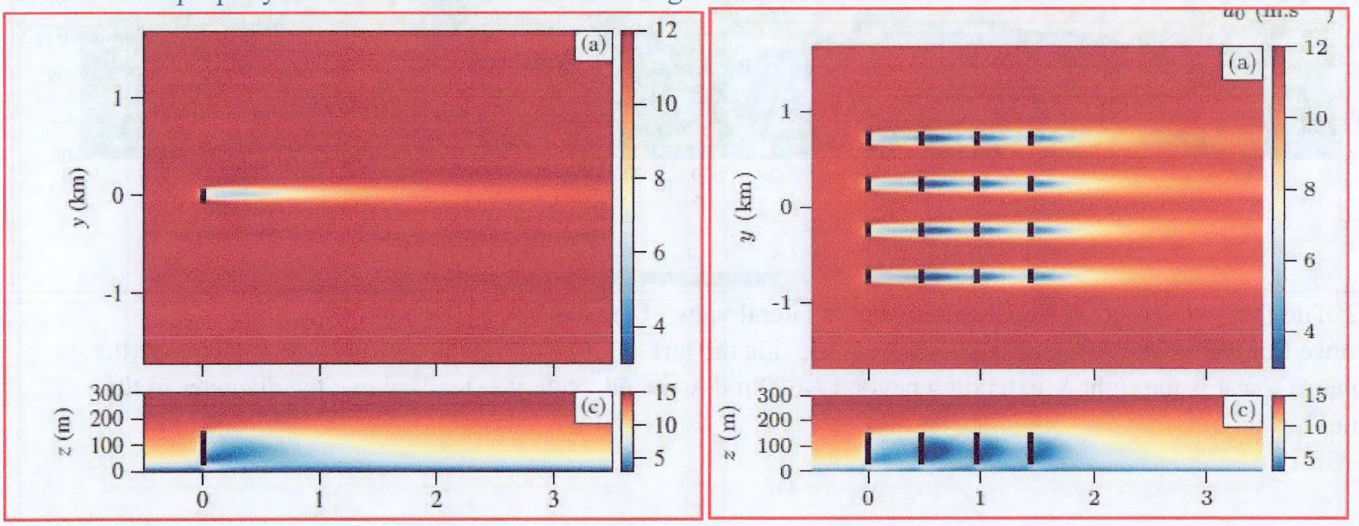
Response from ML: This is a 3D view from the side the turbine. The turbine is to the left & you can see the turbulence towards the right & extending beyond 1,600m downwind. Note it extends above and outside the diameter of the turbine.

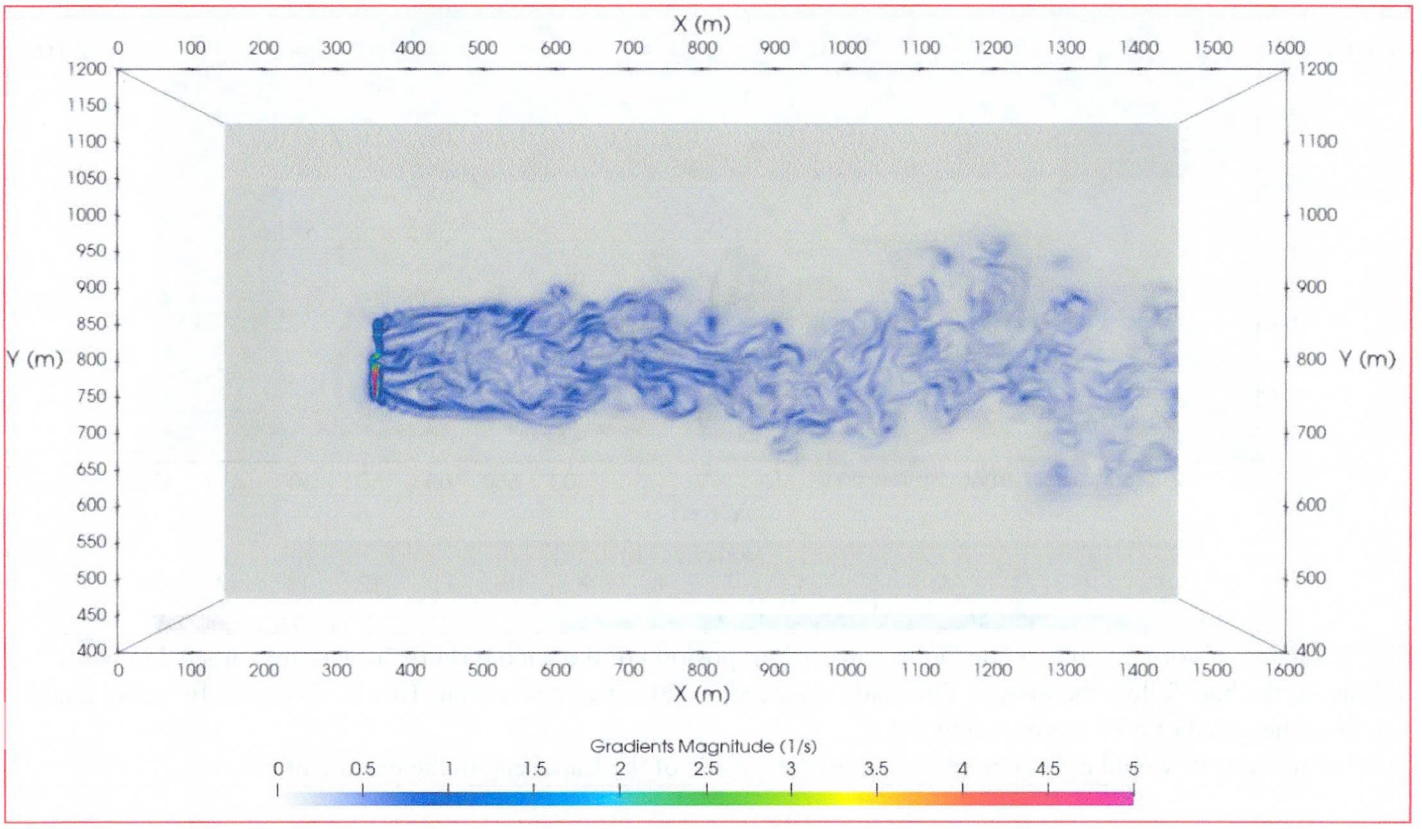
How could a bird cross this turbulence & up to a 5km width? How could they take off from ground? How could birds forage in such an area? Imagine a number of turbines in a grid pattern, which create a total barrier for birds over kms wide.

This turbulence creates noise in down wind turbines as well as power losses. It is similar to air turbulence in an aircraft. Aircraft are delayed by c1.5minutes at take off to avoid such turbulence from preceding aircraft.

In my opinion birds could not take flight in such turbulence & would be displaced by the barrier created from ground up to c300metres in the vertical plane. Windfarms have these turbulent areas on parallel turbines.

This wake in our temperate climate brings cold air from c300m above ground level down to ground level. This action creates a microclimate at the ground with a reduction of around 3 degrees Centigrade. This temperature reduction effects crop growth for kilometres downwind & reduces residential temperatures. Both of these create financial losses for downwind property owners & without their knowledge or consent.





Note the distance of 1.6km & width of 1.2km

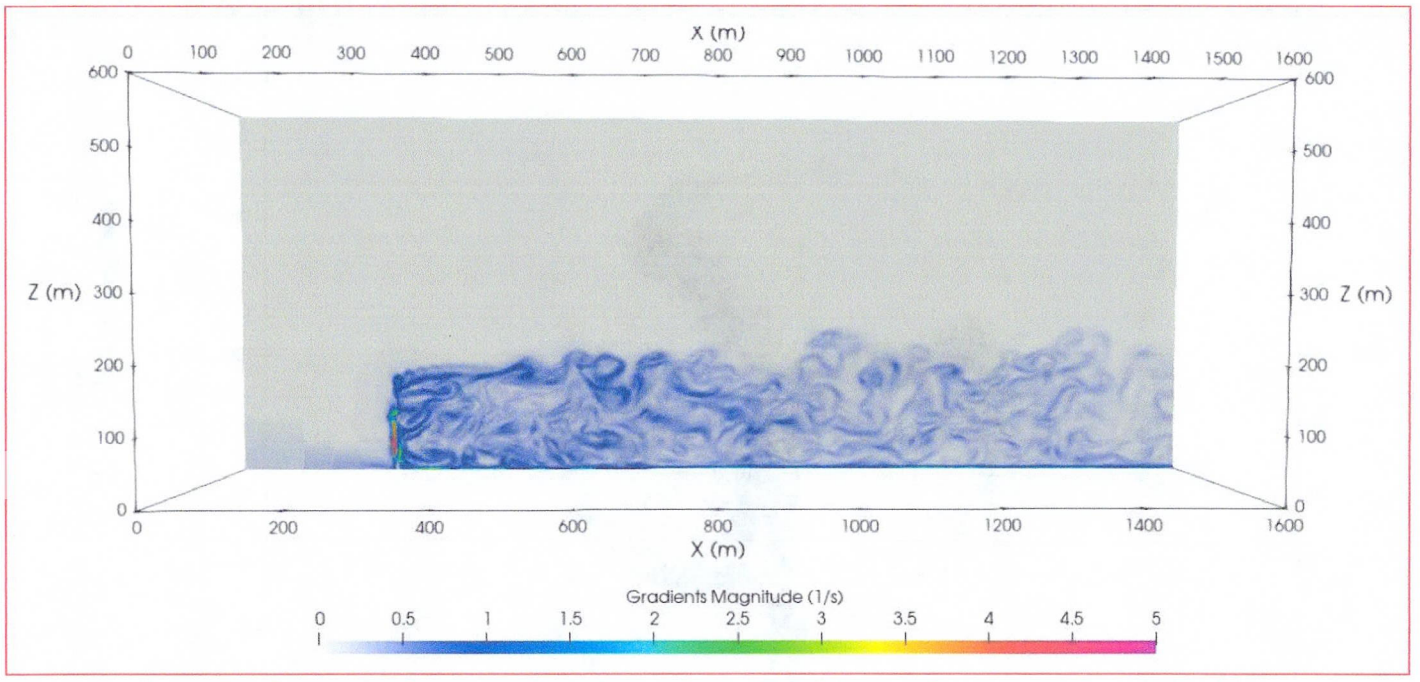


Fig. 6: Similar to Fig. 2: Vertical Contours of gradients of velocity of the overflow around the wind turbine.

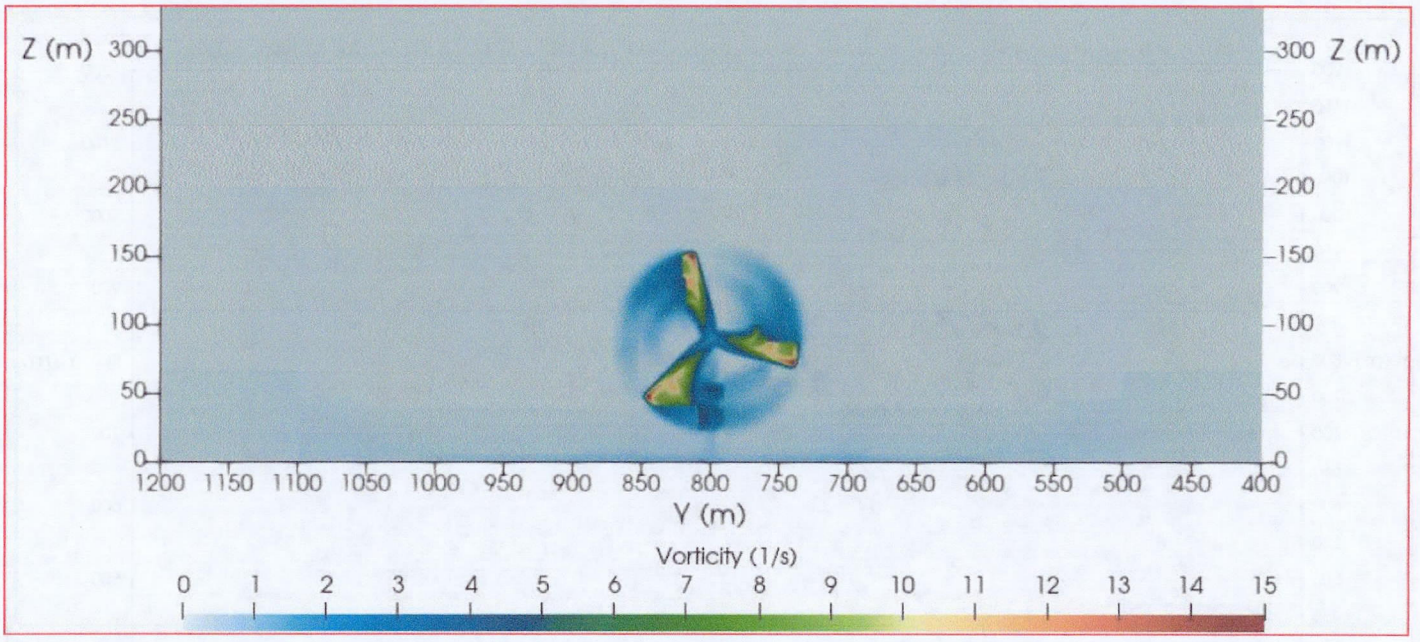


Fig. 7: Vectors of vorticity magnitude in the downstream position of the wind turbine. Insects are attracted to wind turbines & the bats follow the insects. The blade tip speed is c90metres per second. This is 324km/hr. In reality about 1.5 times the speed of a F1 motor racing car.
The 162m diameter would cover Croke Park from the outside of the Canal end to the outside of Hill 16.

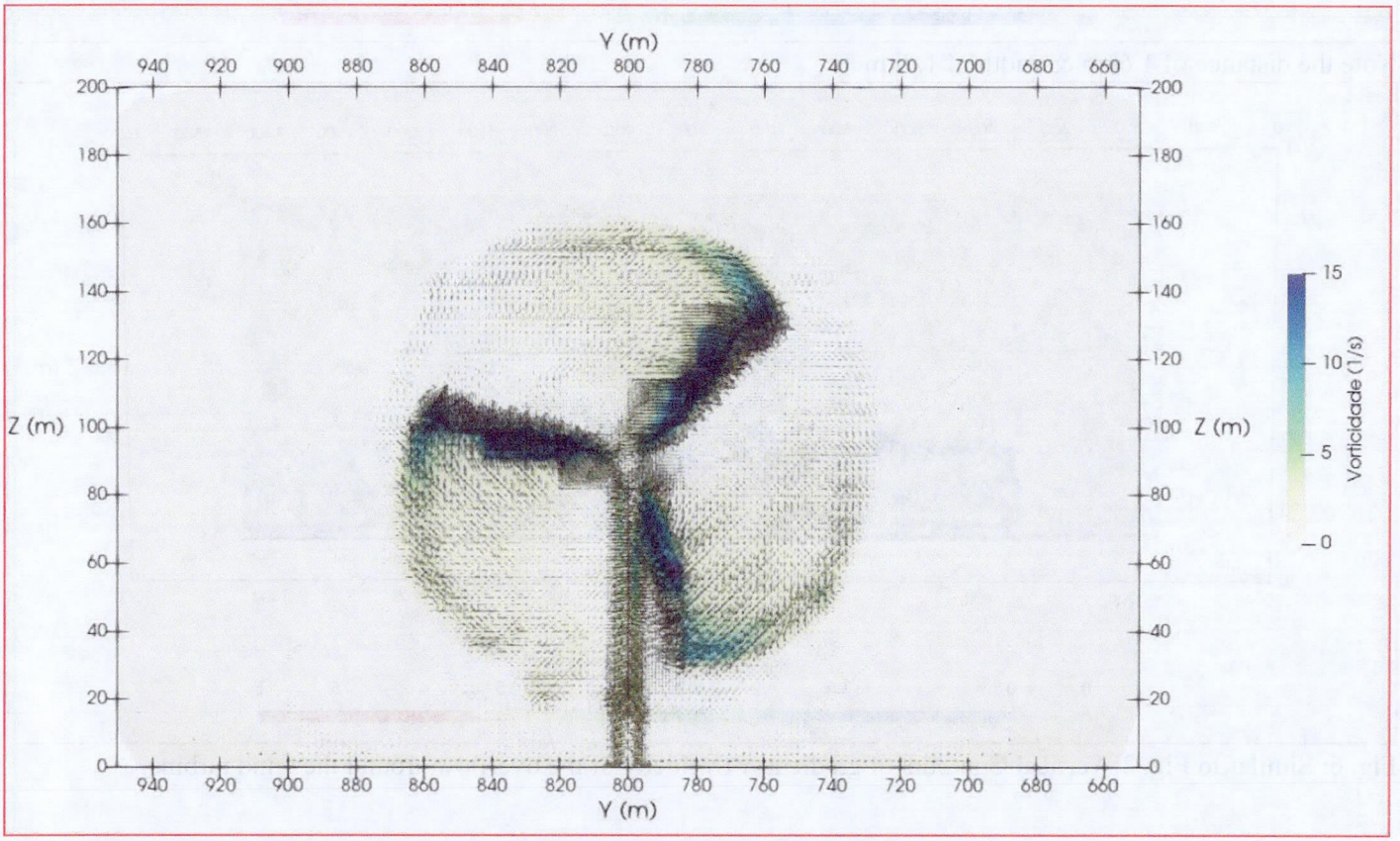


Fig. 7: Contours vorticity magnitude in the downstream position of the wind turbine

Reference 2025 : Wind turbine noise generation and propagation through large eddy simulation and acoustic analogy. Giacomo Rismondo, Giovanni Petris, Marta Cianferra and Vincenzo Armenio. *J. Fluid Mech.* (2025), *vol.* 1024, A33, doi:10.1017/jfm.2025.10709

The analysis is representative of medium-sized turbines with low tip Mach number (~0.10). The fluid dynamic analysis revealed: a turbulent boundary layer over the blades, together with a trailing edge vortex sheet; a complex near-wake structure, including tip and root vortices; an intermediate wake with vortex instabilities triggering leap-frogging and vortex grouping mechanisms; and a far wake characterised by fully developed turbulence. Two primary noise generation mechanisms were identified. The unsteady pressure field over the turbine surface generates tonal

noise at the blade passing frequency and a high-frequency broadband noise, associated with the trailing edge vortex sheet (linear-noise contribution). The turbulent wake generates broadband low-frequency noise, driven by the complex fluid-dynamic processes outlined previously (nonlinear noise contribution). The linear part of the noise was found to dominate over the nonlinear one in the acoustic far field, while the opposite is true in the acoustic near field. As a composition of the two contributions to the noise, the directivity exhibits a non-symmetric dipole shape oriented along the flow direction, with lobes recovering symmetry moving from the near to the far field. Finally, analysis of the acoustic decay rates reveals that the linear term in the near field decays according to an $r^{-(n+1)}$ law within the rotor plane, where n is the number of blades, consistent with recent findings on the acoustics of rotating sources.

The near wake is influenced by the presence of the rotor itself and its geometrical properties; a three-dimensional complex flow is present, characterised by coherent periodic helicoidal vortex structures, namely the root and tip vortices; in the case of an isolated marine propeller, a strong rectilinear vortex is evident, namely the hub vortex. These vortex structures are connected through a thin vortex sheet released by the blades. The breakdown and instability of the hub and tip vortices, occurring in the intermediate wake, are responsible for the transition from the near to the far wake, with a considerable amount of turbulent kinetic energy detected at the outer radii. Finally, a fully composite turbulent wake develops in the far wake. Further downstream, a self-similar behaviour is detected with the mean streamwise velocity deficit profile collapsing into a single Gaussian distribution.

Several experimental and numerical investigations are present in the literature, exploiting the dynamics of rotor wake, as well as the instability mechanism responsible for the transition from near to far wake. Most of them used simplified methods such as actuator technique, which may give some information about the characteristics of the wake. Geometry-resolving simulations are more recent, and few of them have been carried out using eddy-resolving techniques, like large eddy simulation.

Rotor acoustics

The noise produced by rotors, especially wind turbines, is classified into three main groups, namely low-frequency noise, inflow turbulence noise and aerofoil self-noise. The rotation of blades produces the so-called thickness noise, characterised by a tonal spectrum, with peaks at the blade passing frequency (BPF) and its super-harmonics.

The rotating lifting surfaces, namely the loading noise source, contribute to BPF and broadband noise, the latter in the high-frequency range; this is because the transition from laminar to turbulent boundary layer and flow separation induce fluctuating pressures on the blade surface, as well as a thin vortex sheet radiating from the blade trailing edge. This noise-generation mechanism is known as trailing-edge noise and contributes to the acoustic signature over a wide range of frequencies (Lee *et al.* 2021). The noise emitted by the tip vortex influences both the low- and high-frequency regions of the spectrum and is not yet fully understood. The incoming turbulence, associated with the atmospheric boundary layer (ABL) or upwind wind turbines (in wind farm applications), produces a broadband noise. Depending on the characteristics of the turbulence, such as the time and length scales of the disturbances, the inflow turbulence noise mechanism contributes both to high- and low-frequency noise.

Experimental studies have contributed to the knowledge of noise generated by rotors. Specifically in the field of wind turbines, Debruijn, Stam & Dewolf (1984) performed acoustic measurements in small and medium wind energy conversion (WEC) systems, finding that the radiated noise is more affected by the rotational speed than the wind inflow velocity. Van der Borg & Vink (1994) carried out noise measurements on wind turbines, evaluating separately the contribution of tonal noise and that obtained with different blades on the same rotor, finding that changing blade geometry has a marginal effect on noise production. Oerlemans, Sijtsma & López (2007) performed acoustic field measurements for a three-blade wind turbine with a rotor diameter of 58 m, to characterise noise sources and to verify the dominance of trailing edge noise over other mechanisms. Ramachandran, Raman & Dougherty (2014) exploited the beamforming method to measure the aerodynamic noise sources in wind turbines, confirming that the trailing-edge noise source is dominant in the noise produced by the blade.

The fluid dynamic analysis showed the following features: a turbulent boundary layer develops over the blades together with a composite system of tip vortex, blade wake and root vortices in the near wake; the intermediate wake is characterised by destabilisation of the tip vortex and the mutual inductance mode triggering the leap-frogging mechanism; the fully turbulent wake populated by a number of turbulent structures is present in the far field. Our results agree with those of the relevant literature.

The contribution of the wake to the noise is significant in the low-frequency range $f < 4\,fT$. Among the vortical structures present in the wake, the role of vortex grouping has been highlighted: it causes the loss of tonal peaks, at the blade passing frequency, and generates low-frequency broadband noise.

The contribution to the noise originating from different regions has been investigated, considering two different configurations, the first composed of three different annular concentric regions, and the other composed of different

sub-regions of the wake. The analysis of the first configuration confirmed that the trailing edge vortex system is the most important noise source, as regards the linear part of the noise; while the tip vortex system, together with its instability and evolution in the intermediate wake, is the dominant mechanism of the nonlinear noise source.

Reference 2023 : Exploring the effect of wind farm flow on wind turbine noise propagation through numerical simulations. Jules Colas, Ariane Emmanuelli, Didier Dragna, Philippe Blanc-Benon, Benjamin Cotté, Richard Stevens. 10th International Conference on Wind Turbine Noise Dublin - 21st to 23rd June 2023

The rapid expansion of onshore wind farms has led to increasing concern over the noise impact on the surrounding areas. Noise from wind turbines comes primarily from the aeroacoustic broadband noise generated by the wind interacting with the rotating blades. This noise is mostly in the low-frequency range and can propagate over several kilometers. Recent measurements have demonstrated the importance of amplitude modulation (AM) in wind farm noise annoyance(van den Berg, 2005; Hansen *et al.*, 2019). Numerical simulations have explored the AM phenomenon, revealing that close to the source, AM is primarily caused by the rotating source and changes in noise production due to flow inhomogeneity (Tian and Cotté, 2016). AM occurring downwind is attributed to the focusing zone generated by the wind turbine's wake. The displacement of these focusing zones due to blade movement creates high variations in downwind sound pressure levels (Barlas *et al.*, 2017a). Therefore, precise sound propagation simulations and source models, that take the atmospheric boundary layer (ABL) into account, are necessary to predict these noise characteristics. Studies have investigated the effects of flow on sound propagation for single wind turbines, including the effects of the wake (Barlas *et al.*, 2017b) and the 3D effects of the flow (Heimann and Englberger, 2018). **However, the precise interaction between multiple turbines and its impact on AM or sound pressure level (SPL) has not been fully explored.**

Reference 2025 : The need for ecosystem restoration to mitigate the impacts of onshore wind energy Lukas Seifert, Bente Jessen Graae, Dagmar Hagen and Roel May. Sustainable Environment, Vol. 11, No. 1, 2567100 Https://Doi.Org/10.1080/27658511.2025.2567100

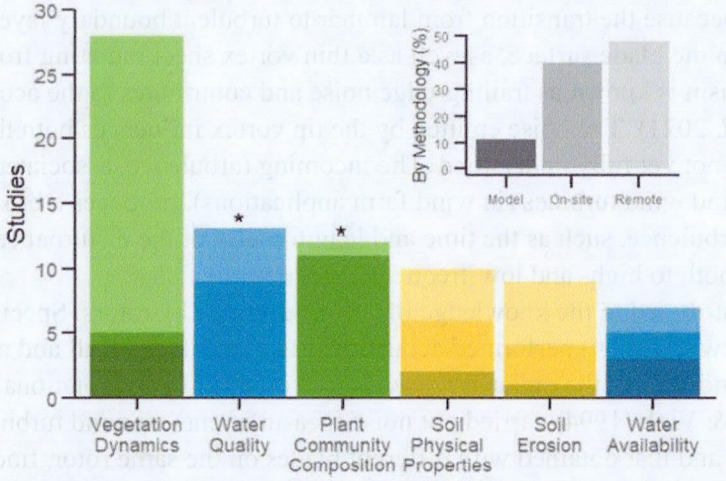


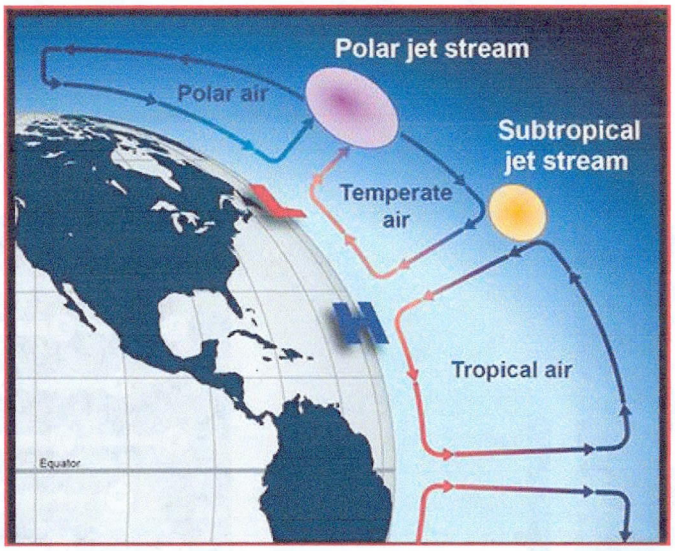
Figure 3. The number of empirical studies on the specific impacts of onshore wind energy on ecosystems. Each impact group is represented by a stack of bars, with different shades (dark, medium, and light) indicating the proportions of different methodologies used. The inset displays the overall proportions of methodologies used across all empirical studies ($N = 62$).* No model simulations were used in studies on water quality and plant community composition.

Reference 2022 : How far the wake of a wind farm can persist for? Guodan Dong, Zhaobin Li, Jianhua Qin, Xiaolei Yang. Theoretical and Applied Mechanics Letters 12 (2022) 100314.

With the increased penetration of wind energy in our nation's energy portfolio, wind farms are placed in a way close to each other. Thus, their wakes have to be fully considered in the design and operation of a wind farm. In this study, we investigate the wake of a wind farm using large-eddy simulation with wind turbine rotor modelled by the actuator disk model. The simulated results show that the wake of a wind farm can persist for a long distance in its downstream. For the considered wind farm layout, the velocity in the wake recovers 95% of that of the undisturbed inflow at **55 rotor**

diameters downstream from its last row, suggesting that the wake of a wind farm should be fully considered in the optimal design and operation for its downstream wind farms.
The simulated results show that the streamwise velocity recovers 95% of the undisturbed incoming wind speed at 55 *D* downstream of the last row of the wind farm. The influences of wind turbine wakes persist for a very long distance, which are still observed even at **165 *Diameters*** downstream of the last row of the wind farm.
For a 162.5m rotor diameter wind turbine, 55D = 8.937km & 165D = 26.812km. Thus houses & farms are subject to property losses, agricultural output losses over these distances, temperature losses & housing heating costs without their consent.

Reference 2018 : Climatic Impacts of Wind Power. Miller & Keith, Joule 2, 2618–2632 December 19, 2018. 2018 Elsevier Inc. https://doi.org/10.1016/j.joule.2018.09.009
Climatic impacts due to wind power extraction were first studied using general circulation models (GCMs). These studies found statistically significant climatic impacts within the wind farm, as well as long-distance teleconnections, with impacts outside the wind farm sometimes as large in magnitude as impacts inside the wind farm. Note that such impacts are unlike greenhouse gas (GHG)-driven warming, as in some cases wind power's climatic impacts might counteract such GHG warming—at least four studies have found that mid-latitude wind power extraction can cool the Arctic. However, these studies often used idealized or unrealistic distributions of turbines installed at unrealistic scales. Model simulations of geometrically simple, isolated wind farms at smaller scales of 3,000–300,000 km2 (10- to 1,000 times larger than today's wind farms) in windy locations found substantial reductions in wind speed and changes in atmospheric boundary layer (ABL) thickness, as well as differences in temperature, precipitation, and vertical atmospheric exchange.
In central USA, The warming is greatest in an N-S corridor near the center of the wind turbine array, perhaps because of an interaction between wind turbines and the nocturnal low level jet (LLJ). The LLJ is a fast nocturnal low-altitude wind (>12 m/ s at 0.5 km) common in the US Midwest, which occurs when the atmosphere decouples from surface friction, resulting in a steep vertical temperature gradient —meteorological conditions that might be sensitive to perturbations by wind turbines.



The climatic impacts of wind power may be unexpected, as wind turbines only redistribute heat within the atmosphere, and the 1.0 W m2 of heating resulting from kinetic energy dissipation in the lower atmosphere is only about 0.6% of the diurnally averaged radiative flux. ***But wind's climatic impacts are not caused by additional heating from the increased dissipation of kinetic energy. Impacts arise because turbine-atmosphere interactions alter surface-atmosphere fluxes, inducing climatic impacts that may be much larger than the direct impact of the dissipation alone.***
As wind turbines extract kinetic energy from the atmospheric flow and slow wind speeds, the vertical gradient in wind speed steepens, and downward entrainment increases. These interactions increase the mixing between air from above and air near the surface. The strength of these interactions depends on the meteorology and, in particular, the diurnal cycle of the atmospheric boundary layer(ABL).

Reference 2026 : Assessment of Onshore and Offshore Wind Energy Potential in the Eastern Baltic Sea Region: LCOE and Wind Turbine Layout Optimisation. Svetlana Orlova , Nikita Dmitrijevs, Marija Mironova, Vitalijs Komasilovs and Edmunds Kamolins. Energies 2026, 19, 1448 https://doi.org/10.3390/en19061448.

Turbine spacing is a widely studied topic influenced by numerous interdependent factors. As a result, wind farm layout optimisation remains an active and essential area of research. Although theoretical spacing recommendations exist to maximise efficiency, they must often be adjusted to accommodate real-world constraints, such as limited land availability and economic considerations. Consequently, a range of optimal spacing configurations has been proposed in the literature. For example, McKenna, R.; Pfenninger, S.; Heinrichs, H.; Schmidt, J.; Staffell, I.; Bauer, C.; Gruber, K.; Hahmann, A.N.; Jansen, M.; Klingler, M.; et al. High-resolution large-scale onshore wind energy assessments: A review of potential definitions, methodologies and future research needs. Renew. Energy 2022, 182, 659–684. , recommends **a spacing of 8–12 rotor diameters in the downwind direction to minimise wake losses and 4–6 rotor diameters in the crosswind direction.**

In practice, published studies report wake-induced energy losses of roughly 5–20% of the AEP, depending on site conditions, turbine layout, and atmospheric stability. A meta-analysis shows that many projects report average wake losses of 5–15%, with an average of around 10% often used as a representative value. More recent operational analyses of modern projects find long-term wake losses in the ≈2–6% range for well designed wind farms. Based on these results, wake losses below about 5–10% can be considered very good or optimised, 10–15% is standard for large or offshore wind farms with higher density, and values above 15–20% generally indicate strong wake interactions and typically motivate further optimisation of turbine spacing, layout, or wake-mitigation control strategies.

Wake losses due to wind interference between turbines also increase noticeably, from 10.3% to 15.7% on average.

2.4. Wind Flow and Wake Modelling

The Jensen N.O. wake model, implemented in windPRO, (version 4.1) is an analytical model based on simplified aerodynamic assumptions. It assumes that the wake downstream of a wind turbine expands linearly with distance, neglecting the near-wake region behind the rotor. The wake is instead treated as a fully developed turbulent wake or negative jet. Two fundamental equations (see Equations (1) and (2)) describe the wake expansion and the associated velocity deficit. The resulting distribution of velocity deficits and wake spreading along the downstream direction is illustrated in Figures 4 and 5.

$$R_{wake}(x) = R_{rotor} + kx \quad (1)$$

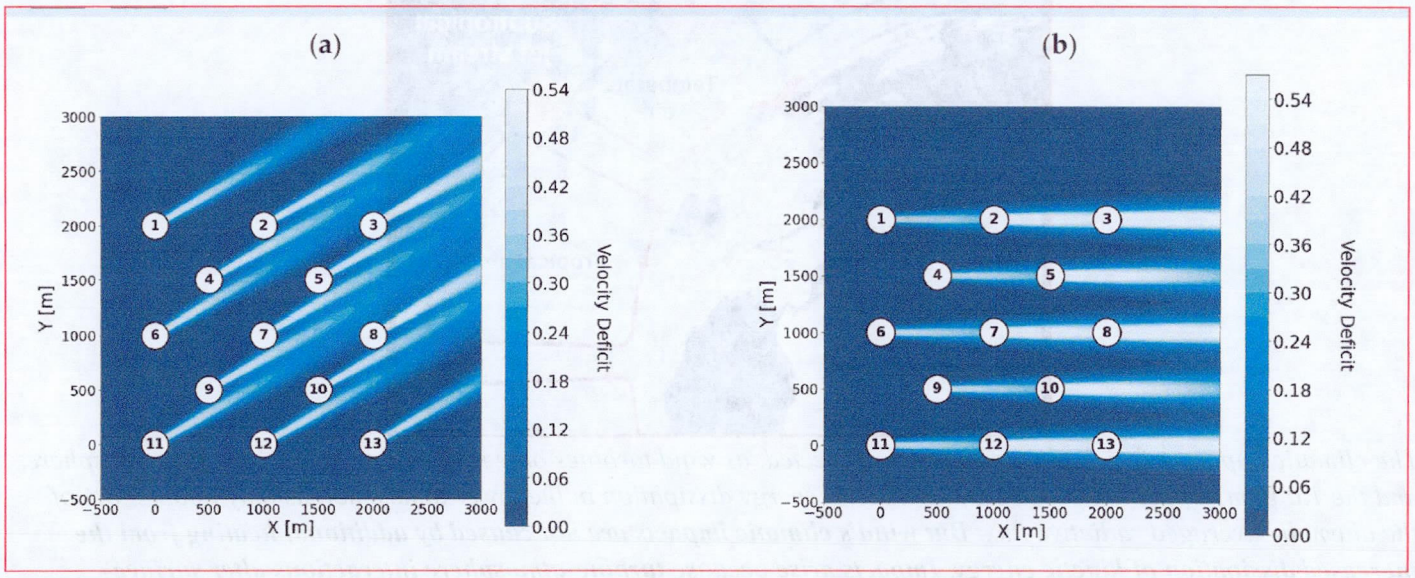


Figure 4. Wake expansion patterns for a chessboard-like turbine arrangement under different incoming wind directions: (**a**) 240◦ (south-westerly wind); (**b**) 180◦ (southerly wind).

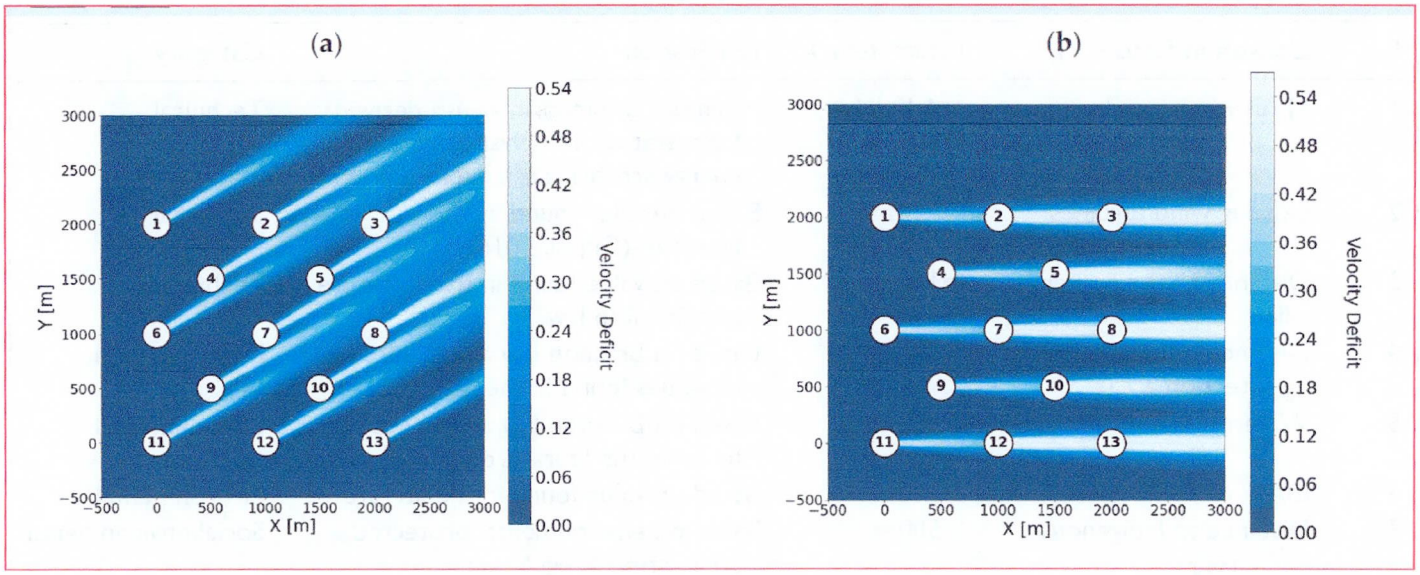


Figure 5. Wake expansion patterns for a linear turbine arrangement under different incoming wind directions: (**a**) 180◦ (southerly wind); (**b**) 240◦ (south-westerly wind).

To calculate wake radius at downstream distance $R_{wake}(x)$, the following parameters are used: R_{rotor}—turbine rotor radius [m]; x—downstream distance [m]; and k—empirical wake decay constant.

Standard Jensen Model velocity deficit equation:

$$\frac{\Delta U}{U} = \left(1 - \sqrt{1 - C_T}\right) \times \left(\frac{D}{1 + 2kx}\right)^2 \quad (2)$$

where C_T—thrust coefficient of the turbine; $\Delta U(x)$—mean wind speed in the wake at the distance x [m/s]; U—free stream wind speed [m/s]; D—rotor diameter [m].

Equation (3) demonstrates a simplified version of the velocity decrease for coding purposes, if the thrust coefficient of the turbine CT ≈ 1:

$$\frac{\Delta U}{U} = \left(\frac{D}{D + 2kx}\right)^2 \quad (3)$$

Figures 4 and 5 illustrate the velocity deficit across the simulated wind farm, calculated based on the Jensen wake model equations (Equations (1)–(3)). The velocity deficit distribution results from incoming wind from either a straight direction or a direction dislocated by 30◦ from the original axis. Each turbine generates a wake, a region of reduced wind speed, immediately downwind. These wakes appear as darker-coloured trails, signifying a high velocity deficit. Consistent with the Jensen wake model, the wake is represented as a simple cone that expands linearly with downstream distance, producing the characteristic straight-edged, cone-like shapes. The staggered turbine layout and wind direction lead to upstream wake interference, resulting in velocity deficits and reduced power production for downstream turbines.

Response from MLavelle: This Windpro wake model was not supplied with application.

Reference 2026 : Spatial multi-criteria decision-making for onshore wind farm site selection in Brazil. Lucas Garbellini, Shangjun Ke, Srinivasa Raghavendra Bhuvan Gummidi, Di Dong, Morten Birkved, Guotian Cai, and Gang Liu. Abstract. Transactions in Energy and Sustainability 1– 25. 2026.
DOI:10.1177/29768632261445736. journals.sagepub.com/home/tss
Constraint factors and exclusion buffers considered in the present study.

I	Constraint factors CF_i	Parameters P_i	Justification	Category
1	Mean wind speed	≥4.49 m/s, ≥8.76 m/s	Minimum and median values derived from statistical analysis (two wind energy scenarios are explored)	Technical
2	Existing wind turbines	≥750 m[a]	Based on value found in literature(Gupta, 2016)	Technical
3	Distance to the power line	≥150 m	Based on value found in the literature and Brazilian law.	Technical
4	Distance to environmental protection areas	≥500 m	Based on Brazilian law and in according to values found in the literature.	Environmental
5	Water bodies and streams	≥500 m; ≥200 m[b]	Based on Brazilian law and values found in the literature.	Environmental
6	IBAs	≥300 m	Based on value found in the literature.	Environmental
7	Distance to Indigenous territory	≥500 m	Based on environmental protected area national regulation.	Social/environmental
8	Distance to urban settlements	≥2000 m	Based on literature predominant values (no distinction was made about urban areas sizes)	Social/economic
9	Distance to roads	≥500 m	Based on value found in the literature.	Economic
10	Distance to airports	≥3.15 km	Based on statistical analysis, aligned with values found in the literature	Economic
11	Distance to ports	≥500 m	Minimum value adopted for safety (buffer distance from ports were not applied in prior studies)	Economic
12	Distance to railways	≥300 m	Based on value found in the literature	Economic
13	Altitude	≤1439 m	Based on maximum value observed in statistical analysis	Technical
14	Slope	≤20%	Based on maximum values observed in the statistical analysis	Technical

To further illustrate the relevance of some of the social constraint factors considered in this study, 0.47% of Brazil's population consists of Indigenous peoples, encompassing 305 ethnicities living in urban, rural and isolated communities (Cunha, 2022). These communities play an important role in conserving biodiversity and promoting the regrowth of native forests (Alves-Pinto et al., 2022). However, they face continuous pressure from several political and economic interest groups, making it essential to ensure their territorial rights (Baragwanath and Bayi, 2020; Brannstrom et al., 2017). Similar contributions to environmental protection are also observed among the quilombola settlements (Oviedo and Bursztyn, 2016), native communities descended from enslaved Africans who resisted the slavery regime. The catalogued communities of this social group are included in the constraint factors within urbanized settlements.

However, the incorporation of social constraint areas is only first step toward a socially sustainable renewable energy transition in Brazil. Achieving this goal demands a justice-oriented approach. As revealed by the referred studies and thoroughly discussed by Lenoir-Improta and Di Masso (2021), **the expansion of wind energy in Brazil often reproduces colonial patterns of development, privileging external investors and marginalizing local populations**. It is necessary not only to guarantee public inclusion in energy debates, but also to ground those debates in a collective awareness of the power asymmetries between Global North and South. Furthermore, efforts should focus on establishing governance frameworks for the development of energy infrastructure and policies that ensure a fair distribution of benefits and respect for territorial identities.

From an environmental sustainability perspective, RE projects should adopt a systems approach that extends beyond compliance with the constraint factors considered in this study.

Response from MLavelle: If the applicants indicate separation distances of 4 times diameter from residences, while maintaining no noise effects or flicker, why are wind turbines excluded from urban areas?

Reference 2026 : A Structured Techno-Economic and Socio-Regulatory Comparison of Onshore, Fixed-Bottom Offshore, and Floating Offshore Wind Energy Systems. Mohsin AliKoondhar, Samandar KhanAfridi, Theyab

Assessment of structural design and operational performance characteristics of onshore

Aspect	Onshore wind
Voltage output (simulated)	Peak voltage reaches 39.5 V at a wind velocity of 8.2 m/s.
Turbulence impact	Surface roughness and obstacles introduce variability in wind speeds, while turbulence intensity remains lower than offshore.
Turbine size	Uses smaller turbines with simpler designs to enable easier installation and upkeep, generally at hub heights of ~100 m.
Wind speed	Lower and more variable, with average hub-height wind speeds of ~5–8 m/s.
Capacity factor	Usually 30%–40%, with performance strongly dependent on site-specific wind conditions.
Power output (simulated)	Peak power attains 1.9 W under a wind velocity of 8.2 m/s.
Energy output	Turbines rated 2–4 MW produce comparatively lower energy output.
Geographic challenges	Surface roughness and obstacles result in variable wind conditions, emphasizing the importance of optimal sitting.
Scalability	Deployment potential is restricted by land-use constraints and community acceptance issues.
Seasonal variation	Pronounced seasonal fluctuations demand comprehensive wind profiling and system optimization.
Levelized cost of energy (LCOE)	LCOE is roughly $50 per megawatt-hour.

4 | Discussion of Technical and Operational Challenges Associated With Onshore, Fixed-Bottom, and Floating Offshore Wind

4.1 | Onshore Wind Energy

Although onshore wind energy is the most technologically mature and cost-effective wind technology, it faces persistent technical and operational challenges that increasingly influence project feasibility. One major technical issue is wind turbulence and shear caused by complex terrain, forests, and built environments. These effects increase cyclic loading on blades, towers, and drive train components, accelerating fatigue damage and raising maintenance requirements over the turbine lifetime.

Cold climate operation introduces additional challenges such as icing, which reduces aerodynamic efficiency and increases structural loads. From an operational standpoint, grid integration has become a critical concern in regions with high onshore wind penetration. Transmission bottlenecks, curtailment, and insufficient grid flexibility can significantly reduce effective energy output. Furthermore, land acquisition and access logistics particularly in mountainous or remote areas—raise construction complexity and cost. Social acceptance remains one of the most

influential non-technical barriers, as visual impact, perceived noise, and land-use conflicts often prolong permitting processes and create regulatory uncertainty.

Reference 2015 : Observed Thermal Impacts of Wind Farms Over Northern Illinois. Lauren M. Slawsky, Liming Zhou, Somnath Baidya Roy, Geng Xia, Mathias Vuille and Ronald A. Harris. Sensors 2015, 15, 14981-15005; doi:10.3390/s150714981

The 2025 Operating Turbines in Illinois have a c80 m hub-height with rotor diameters of about 80 m & an electrical power output capacity of c1.5 Mw to 2Mw before 2015 & far less than 7.2Mw. These turbines do not operate continuously over 12 month periods.

Applicant Reference: Vortex Blog: wakes and blockage

The importance of taking into account wake and blockage effects when assessing wind farm energy production.
Elies Campmany

Since DNV published the consequences of neglecting blockage and its impact on energy production, and Orsted presented an update of its long-term financial targets taking into account the blockage and wake effects, these two effects have become one of the hottest topics in the wind industry. The recent Wind Europe Workshop held in Dublin dedicated two sessions to this topic.

Wake Effect

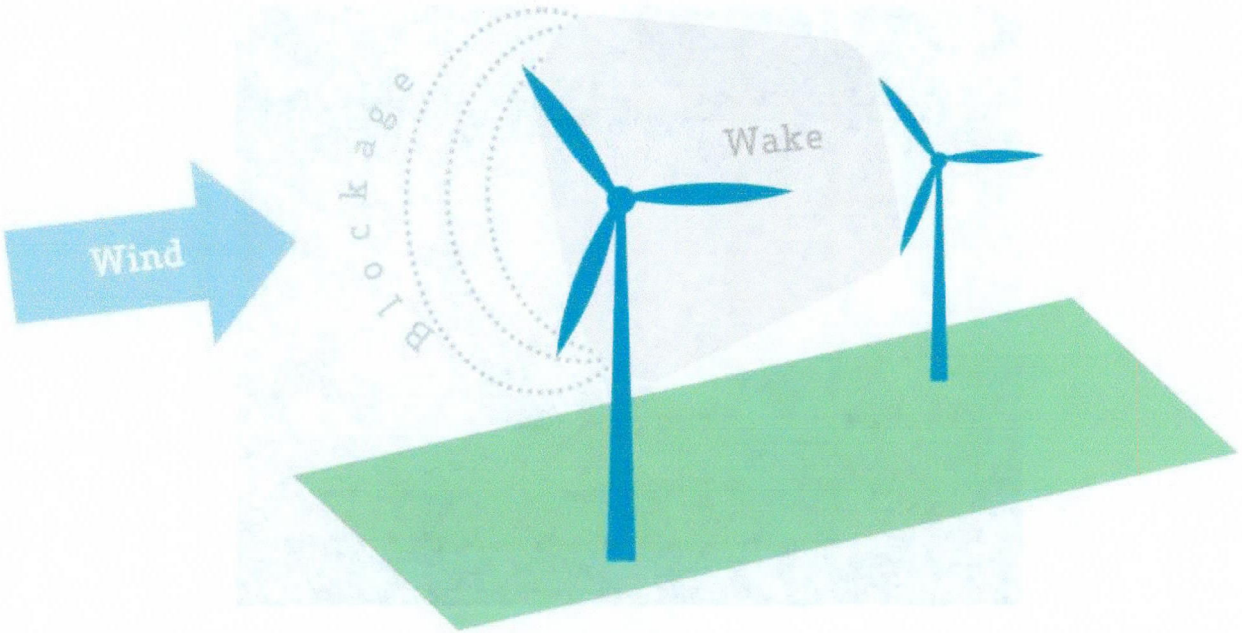
The wake effect refers to the phenomenon where wind turbines create a region of slower wind speeds and increased turbulence downstream from their rotor blades. As wind passes through a turbine, some of its kinetic energy is converted into mechanical energy for electricity generation, resulting in a reduction in wind speed behind the turbine. **This disturbed area, known as the wake, not only experiences reduced wind speeds but also increased turbulence.**

This effect can impact the efficiency and energy output of turbines located downwind, as they receive less kinetic energy from the wind. The increased turbulence within the wake can cause additional mechanical stress on these downstream turbines, potentially leading to higher maintenance needs and a shorter operational lifespan. Because of these impacts, the wake effect is a crucial consideration in the design and layout of wind farms. **Proper spacing between turbines is necessary to minimize the negative effects on overall energy production and turbine durability.** Additionally, in areas with multiple wind farms, the wake from one farm can influence the performance of neighboring farms, making comprehensive planning even more important.

Blockage Effect

The blockage effect of a wind turbine refers to the disruption of airflow caused by the presence of the turbine, resulting in a decrease in wind speed and an increase in pressure upstream of the rotor. As wind approaches the turbine, it slows down due to the obstruction presented by the rotor, creating a high-pressure zone directly in front of the turbine. To conserve mass and momentum, some of the wind flow is diverted around the turbine, which can cause an increase in wind speed on the sides of the rotor.

This decrease in wind speed directly in front of the turbine, caused by the blockage effect, can influence turbine performance. The high-pressure zone in front of one turbine can impact the performance of neighboring turbines, particularly those situated directly upstream, affecting the overall layout and efficiency of wind farms. Understanding and mitigating the blockage effect is crucial for optimizing the efficiency of wind farms.

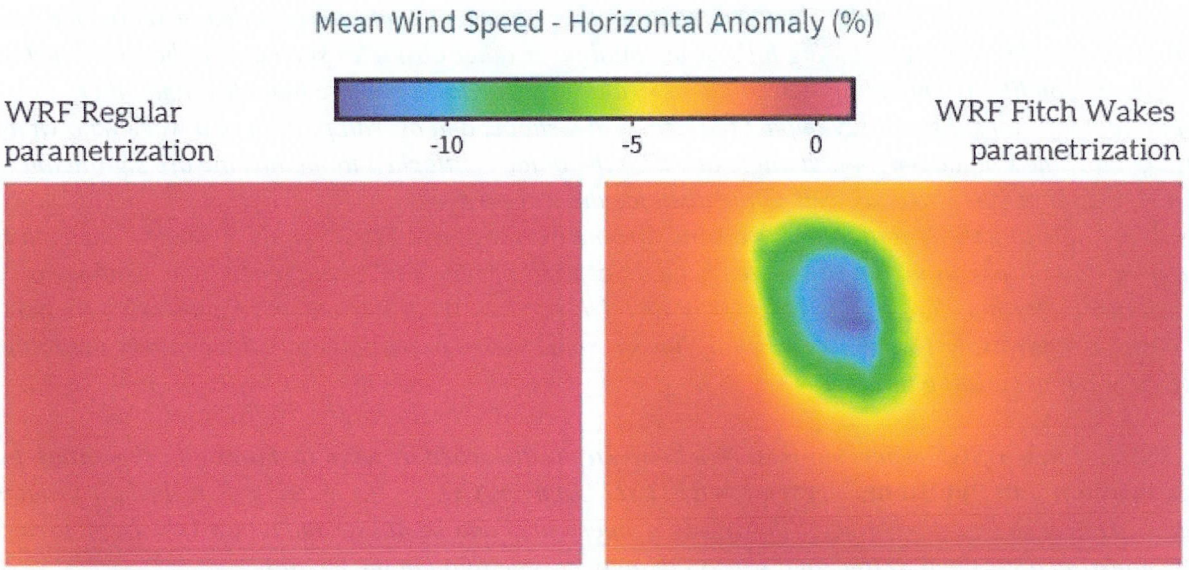


A scheme of the wake and blockage effect. The first turbine disrupts the airflow, so the second turbine will have a lower power output and more turbulence. The blockage produces a deceleration of the flow upstream of the turbine.

The Fitch Scheme

Computational Fluid Dynamics (CFD) tools provide detailed insights into the aerodynamic interactions between wind turbines and their environment, making them good candidates for studying the effects of wakes. However, they are not the only option. The **WRF model** includes a wind turbine drag parameterization scheme that represents sub-grid effects of specified turbines on wind and TKE fields: the Fitch Scheme.

In the **Fitch scheme**, wind turbines are modeled as sinks of momentum and sources of TKE. This parameterization does not consider the rotation of rotor blades, so it is not recommended for high-resolution simulations (higher than 3 times the rotor diameter). Therefore, it is useful in offshore sites, where the horizontal variability is smaller than in onshore sites, and for simulations with a spatial resolution of 1 km.





Reference 2016 : Wake Effects, Wind Rights, and Wind Turbines: Why Science, Constitutional Rights, and Public Policy Issues Play a Crucial Role, Kimberly E. Diamond. William & Mary Environmental Law and Policy Review Volume 40 (2015-2016) Issue 3 Article 5 May 2016

When wind wakes generated from wind turbines on an immediately adjacent neighbour's property extend over a downwind neighbour's land, that land will experience wake-related adverse impacts. A general description of wind wakes and wake effects is as follows. The term "wind wake" is derived from the wakes moving ships leave behind them in the water. Specifically, there is a v-shaped Kelvin wake that spreads out behind a ship, starting from the ship's hull. A turbulent wake bisects the Kelvin wake, creating a zone of churning, choppy water in a corkscrew-like pattern down the middle of the Kelvin wake. Similar to ships, utility-scale wind turbines create wakes from wind passing through them. Wakes, with respect to wind turbines, refer to the wind speed deficit and reduced energy content wind possesses after leaving a particular utility-scale wind turbine. Once wind flows through a turbine, the volume of air downwind from it has a reduced wind speed and increased turbulence compared to wind flowing in the free stream, or, rather, wind that is travelling at its natural velocity that another obstruction has not impeded or redirected (such as a house, barn, tree, complex terrain including hills or mountains, or other obstacles such as another wind turbine). While atmospheric conditions, including seasonal temperature fluctuations, relative humidity, and other environmental factors, can substantially impact the size, scale, shape, and overall pattern of a wake (known as a "wake rose"), a turbine's blade length and angle at which the blade is attached to the turbine are significant factors in the size and magnitude of the wake, as well as the distance the wake travels.

Scientists still are debating the length to which a wind turbine wake extends. However, the scientific community generally agrees that a wake from a utility-scale commercial wind turbine can extend a minimum distance of eight to ten times such turbine's rotor diameter. In fact, Texas Tech University's Wind Science and Engineering Center conducted a recent study using Doppler radar that shows turbine wakes persisting up to fifteen times the rotor diameter of the wake-generating turbine.

Reference 2022 : *A new USGS report shows a link between air disturbed by wind turbines and vegetation patterns*
By Communications and Publishing September 26, 2022 ***Denver, CO****. — The trails of disturbed air produced by wind turbines—known as wakes—can alter downwind temperatures and humidity, and a new U.S. Geological Survey study has demonstrated for the first time that wakes can impact vegetation in the vicinity.*

The study's insight into the effects of wakes from wind turbines on vegetation is an important first step to understanding how wind energy affects terrestrial ecosystems. Wind energy is rapidly and globally expanding, with five-fold increases since 2010 and predictions of up to 10-fold growth over the next 30 years.

"We are just beginning to understand how the wakes from wind turbines affect both the terrestrial and offshore environment," said USGS Research Ecologist, Jay Diffendorfer, "The next step will be to better understand where and why these effects occur."

In the study, scientists modeled wake and non-wake zones around 17 wind facilities across the United States, to test if wakes influenced vegetation condition, which was measured using data from USGS's Landsat satellites. The study was

designed to isolate the effects of turbine wakes from other factors that could affect vegetation condition around wind facilities, such as new roads or agriculture.
These wake-induced changes in vegetation condition were found for part or all of the growing season at 10 of the 17 facilities studied. Researchers found that wakes can have both positive and negative effects on vegetation greenness, a measure that is often used in remote sensing to assess vegetation density and crop health, and that the magnitude of the change in greenness depended primarily on earlier precipitation. The changes observed at some facilities were consistent with levels that other studies found can affect breeding bird clutch size, species richness, and ungulate abundance.
As wind energy expands, understanding where and when wind turbines positively or negatively affect vegetation may aid in future decisions about where to site wind energy infrastructure. For example, careful placement may benefit agriculture or grazing while minimizing unwanted reductions to the vegetation greenness in the vicinity.
Widely acknowledged environmental impacts include wildlife deaths from turbine collisions, habitat loss, and behavioural avoidance of wind facilities by some species (Allison et al 2019*).*
A newly emerging, potential environmental impact may be the effects of turbine wakes ('wakes') on microclimates and vegetation. Wind turbines generate wakes as they remove energy from wind resulting in lower wind speeds and increased turbulence. These wakes are large enough to reduce energy generation at downwind facilities (Lundquist et al 2019*). They can also change air, surface, and soil temperatures, as well as humidity (Zhou et al* 2012*, Armstrong et al* 2016*, Xia et al* 2016*, Rajewski et al* 2020*), but not always (Moravec et al* 2018*). Field-collected and remotely-sensed surface temperature data show wakes can cause nighttime warming up to 1.5 °C–1.9 °C (Rajewski et al* 2013*, Smith et al* 2013*) and cool daytime temperatures (Rajewski et al* 2013*, Xia et al* 2016*), although these effects vary with wind conditions and season.*
Reference Number 110 : Wind turbine wakes can impact down-wind vegetation greenness Jay E Diffendorfer, Melanie K Vanderhoof and Zach H Ancona United States Geological Survey, Geosciences and Environmental Change Science Center, Denver, CO 80225, United States of America *Environ. Res. Lett.* 17 (2022) 104025
https://doi.org/10.1088/1748-9326/ac8da9 26 September 2022
Global wind energy has expanded 5-fold since 2010 and is predicted to expand another 8–10-fold over the next 30 years. Wakes generated by wind turbines can alter downwind microclimates and potentially downwind vegetation. However, the design of past studies has made it difficult to isolate the impact of wake effects on vegetation from land cover change. We used hourly wind data to model wake and non-wake zones around 17 wind facilities across the U.S. and compared remotely-sensed vegetation greenness in wake and non-wake zones before and after construction. We located sampling sites only in the dominant vegetation type and in areas that were not disturbed before or after construction. We found evidence for wake effects on vegetation greenness at 10 of 17 facilities for portions of, or the entire growing season. Evidence included statistical significance in Before After Control Impact statistical models, differences >3% between expected and observed values of vegetation greenness, and consistent spatial patterns of anomalies in vegetation greenness relative to turbine locations and wind direction. Wakes induced both increases and decreases in vegetation greenness, which may be difficult to predict prior to construction. The magnitude of wake effects depended primarily on precipitation and to a lesser degree aridity. Wake effects did not show trends over time following construction, suggesting the changes impact vegetation greenness within a growing season, but do not accrue over years. Even small changes in vegetation greenness, similar to those found in this study, have been seen to affect higher trophic levels. Given the rapid global growth of wind energy, and the importance of vegetation condition for agriculture, grazing, wildlife, and carbon storage, understanding how wakes from wind turbines impact vegetation is essential to exploit or ameliorate these effects.

Reference 2020 : Effect of wind turbine wake turbulence on offshore helicopter operations in and around wind farms. *HFDM analysis and consultation with helicopter operators.* April 2020 . Ministry of EZK and Rijksdienst voor Ondernemend Nederland (RVO).
"A better understanding of the effects of wind turbine wake turbulence on helicopters could reduce the uncertainty in the current recommended distances and could help in defining adequate wind turbine stop-procedures.
" The only relevant and valid document produced by CASA is related to the National Airports Safeguarding Framework12. Guideline D13 to this framework entitled Managing the Risk to Aviation Safety of Wind Turbine Installation (wind farms) / Wind monitoring Towers addresses the issues in the withdrawn AC as well as obstacle issues and, in brief, turbulence. The guideline states that wind turbine turbulence may be "noticeable" up to 16 rotor diameters from the turbine. The document
continues, "At this time, the effect of this level of turbulence on aircraft in the vicinity is not known with certainty".

The Wake effect on bird navigation in the context of the proposed site being located in the centre of the Lough Corrib/Clare River SPA/SAC, creates a turbulent air flight barrier for birds up to a height of c800m OD, over a 4km width & over a 40km Wake & its effects on foraging, fragmentation & habitat loss are not identified. The proposed site location is located in the centre of the Lough Corrib/ Clare River SAC/SPA/Natura 2000 site.

Reference : Mitigating Wind Turbine Radar Interference: USA Wind Energy Technologies Office
The U.S. Department of Energy's (DOE) Wind Energy Technologies Office (WETO) supports interagency efforts to identify and deploy technology and process improvements to mitigate impacts of wind farms on radars. DOE undertakes this work along with the Department of Defense (DOD), the Department of Homeland Security (DHS), the Federal Aviation Administration (FAA), the National Oceanic and Atmospheric Administration (NOAA), and the Bureau of Ocean Energy Management (BOEM).
As wind development continues to grow and expand to new areas of the country, the likelihood that some turbines will be located within the line of sight of radar systems also increases. Wind turbines can cause interference for radar systems because their large towers and moving blades reflect electromagnetic radiation.

Reference 2023 : Segmented Gurney Flaps for Enhanced Wind Turbine Wake Recovery. Nirav Dangi, Koen Boorsma, Edwin Bot, Wim Bierbooms, and Wei Yu. https://doi.org/10.5194/wes-2023-90 Preprint. **Discussion started: 23 August 2023**

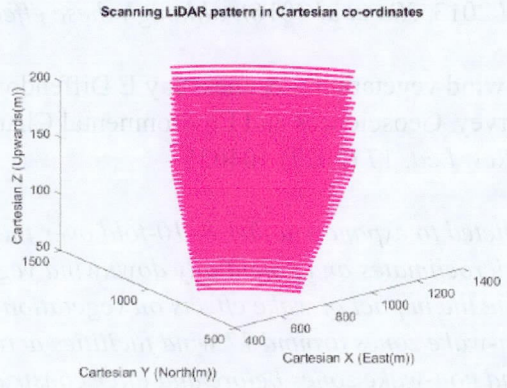


Figure A1: Scanning LiDAR pattern (Cartesian co-ordinates)

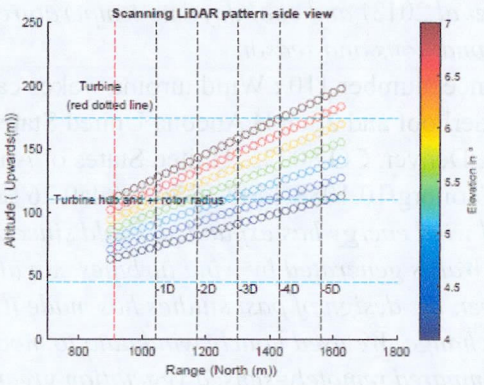


Figure A2: Scanning LiDAR pattern side view

Reference : Costs and consequences of wind turbine wake effects arising from uncoordinated wind energy development J. K. Lundquist, K. K. DuVivier, D. Kaffine and J. M. Tomaszewski. Department of Atmospheric and Oceanic Sciences, University of Colorado Boulder, Boulder, CO, USA. National Renewable Energy Laboratory, Golden,CO, USA. University of Denver Sturm College of Law, Denver, CO, USA. Department of Economics, University of Colorado Boulder, Boulder, CO, USA.e-mail: Julie.Lundquist@colorado.edu Nature Energy | **www.nature.com/natureenergy**
Optimal wind farm locations require a strong and reliable wind resource and access to transmission lines. As onshore and offshore wind energy grows, preferred locations become saturated with numerous wind farms. An upwind wind farm generates 'wake effects' (decreases in downwind wind speeds) that undermine a downwind wind farm's power generation and revenues.
Here we use a diverse set of analysis tools from the atmospheric science, economic and legal communities to assess costs and consequences of these wake effects, focusing on a West Texas case study. We show that although wake effects vary with atmospheric conditions, they are discernible in monthly power production. In stably stratified atmospheric conditions, ***wakes can extend 50+ km downwind****, resulting in economic losses of several million dollars over six years for our case study. However, our investigation of the legal literature shows no legal guidance for protecting existing wind farms from such significant impacts.*

Reference 2024 : Gone with the wind? Wind farm-induced wakes and regulatory gaps Eirik Finserås, Ignacio Herrera Anchustegui, Etienne Cheynet, Cristian Guillermo Gebhardt, Joachim Reuder . Elsevier, Wind Policy 159(2024) 105897. https://doi.org/10.1016/j.marpol.2023.105897

"Wind farm-induced wakes can propagate dozens of kilometres, decreasing the power production and the fatigue lifetime of wind turbines between neighbouring farms.
Recent studies indicate that farm wakes can propagate downwind for distances ranging from ***30 km to 55*** *km , with even longer wakes observed under specific flow conditions.*
Wind turbine wakes correspond to the area downstream of wind turbines associated with a reduced mean wind speed and increased turbulence.
The wakes propagate downstream of wind turbines, and as air with higher velocity from above is mixed downward into the wake, the velocity deficit decreases. This process, known as wake recovery, is strongly influenced by the thermal stratification of the atmosphere, which refers to the vertical layering of air with different temperatures and affects air mixing.
In contemporary OWFs, wind turbines are commonly placed at distances of 6–10 times their diameter. For cutting-edge North Sea offshore turbines with a rotor diameter of 164 m, this results in spacing ranging from 1.0 km to 1.6 km between turbines. While increasing the distance between turbines helps reduce wake effects, it can also raise the cost of energy production due to the efficiency loss.

Reference 2023 : The wind farm pressure field. Ronald B. Smith, Earth and Planetary Science Department, Yale University, New Haven, CT, 06520, USA. European Academy of Wind Energy. https://doi.org/10.5194/wes-2023-56
The disturbed atmospheric pressure near a wind farm arises from the turbine drag forces in combination with vertical confinement associated with atmospheric stability. These pressure gradients slow the wind upstream, deflect the air laterally, weaken the flow deceleration over the farm and modify the wake recovery.
In a stably stratified atmosphere, the lifting of the air caused by farm drag creates gravity waves aloft whose pressure field acts back on the lower atmosphere.

Reference : Impacts of wind farms on surface air temperatures Somnath Baidya Roy and Justin J. Traiteur. Department of Atmospheric Sciences, University of Illinois, 105 South Gregory Street, Urbana, IL 61820.
Utility-scale large wind farms are rapidly growing in size and numbers all over the world. Data from a meteorological field campaign show that such wind farms can significantly affect near-surface air temperatures. These effects result from enhanced vertical mixing due to turbulence generated by wind turbine rotors.

Reference : Wind turbines and horse husbandry in France. Translated from french by : Karen DUFFY - Agata RZEKĘĆ - Gwenaëlle GRANDCHAMP-RENARD
A wind turbine produces neither infectious nor chemical agents, but does produce physical phenomena. There are four types of physical effects :
- Acoustic vibration phenomena, i.e. audible sound and infrasounds produced by the movements of the blades and the electric generator.
- Ground vibrations.
- Electromagnetic fields resulting from converting the mechanical power of the wind to an electric current, and the transfer of this current.
- Parasitic electrical current, induced by the electromagnetic fields, but also linked to current leakage, to couplings between electrical and mechanical elements, and faulty earthing.

Horses are not as sensitive to infrasounds as humans, or even as cattle (Heffner and Heffner, 1983) Scale of sound frequencies in several animal species and in humans (according to Heffner (1998))

Animal species	**Low frequency limit** (Hz)	**High frequency limit** (Hz)	**Ideal sensitivity** (dB)	**Ideal frequency** (Hz)
Cattle	23	37 000	-11	8 000
Human	20	20 000	-10	4 000
Pigs	42	40 500	9	8 000
Horses	**55**	**33 500**	**7**	**2 000**
Cats	55	79 000	-10	8 000
Dogs	67	44 000	-1	8 000
Laboratory rats	530	70 500	0	8 000
Laboratory mice	900	79 000	5	15 000

The persistence of audible sounds does not appear to affect animal behaviour, unlike some people suffering from hyperacusis.

However, infrasound remains controversial in the equine sector. In an expert study conducted in Portugal, there was a suspicion of consequences on joint tissue in Lusitano horses (Branco *et al*, 2005). The results of this expert study have however not been confirmed by the Lisbon University veterinary thesis (Costa, Pereira e Curto 2012) which analysed the afore mentioned cases

Ground vibrations

Ground vibrations are produced by the wind turbine itself, like any building with foundations and wind. The transmission of vibrations through the ground depends on the nature and structure of the ground they go through. The mechanical waves through the ground, produced by wind turbines, are essentially surface vibrations (Saccorotti G. *et al*, 2011). There is very little data regarding the level of the vibrations for local residents, produced by wind turbines. The few studies conducted show that when further than 300 metres (Lubw, 2016) to 700 metres away from a wind turbine (internal study by Cerema), the vibrations merge into the backgound noise of the site (vibration speeds below 0,07mm/s).

Electromagnetic fields

The study of electromagnetic fields revolves around three themes:

- Behaviour and neurophysiology
- Zootechnical and sanitary impact
- Cellular and physiological impact

Behaviour and neurobiology

There is little information regarding perception of electromagnetic fields, and our knowledge is mainly related to wildlife. Likewise, there is no data as to whether electromagnetic fields produced by various structures (wind turbines, high voltage power lines…) have an influence on perception. There are no effects noted on the behaviour of farm animals, only on laboratory animals (rats and mice).

Zootechnical and sanitary impact

With regard to cattle, the results of experiments conducted in the field differ from those of experiments in a controlled environment. In an experimental environment, a decrease in the quantity of milk produced and in the percentage of fat was noticeable, as was an increase in the quantity of feed ingested. The field studies showed no changes.

With regard to poultry, electromagnetic fields presented a teratogenic effect (affecting the embryo, and causing malformation) with a window effect (non-linear effect, i.e. the negative effect of electromagnetic fields is lesser for the weaker and the stronger fields).

Cellular and physiological impact

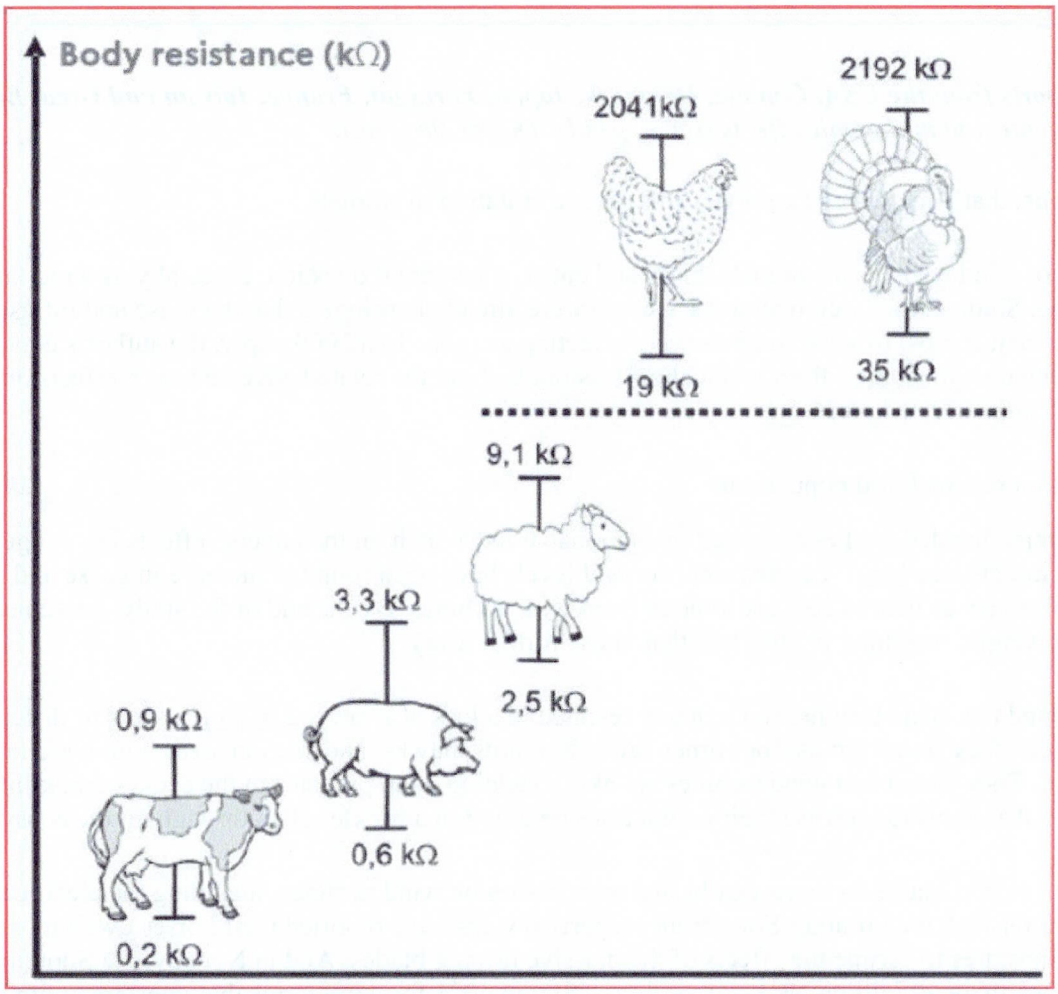
Studies conducted *in vitro* show a genotoxic effect (capacity to compromise the structure or the functioning of the genome) of electromagnetic fields. Moreover, these fields amplify the action of chemical products which have an effect on DNA. Cells submitted to electromagnetic fields are more sensitive to oxidative stress, i.e. there is a higher count of DNA lesions, therefore more frequent cell death. Electromagnetic fields also have an effect on the circadian cycle («the internal clock » of an organism) by modifying the release patterns of melatonin, or through other mechanisms yet to be discovered. However, electromagnetic fields have no effect on immunity and physiological stress (ways in which the organism copes with real or presumed aggression).

Parasitic current

Parasitic current is derived either from electromagnetic fields, or from electrical current (cables…). Parasitic currents can cause different types of voltage :

- **Contact voltage** (contact with a metallic element such as a drinking trough) ⇒ the current goes through the animal and back to earth though the legs.
- **Pace voltage** ⇒ Current goes from the front legs to the rear legs.

The sensitivity of animals depends on the electrical resistance of the species, of the individual and on living conditions.



Animals are more sensitive than humans. Parasitic currents cause pain, leading to physiological stress which can modify behaviour (avoidance, refusing to drink, memory and training issues…) and the state of health (weight loss, decrease in immunity, higher risk of gastric ulcers and colic, genetic alterations in the long term…). An animal's sensitivity to parasitic current can be increased due to its living conditions.

A horse stabled in a building with a lot of metallic structures and/or in a box with damp bedding, is more at risk of being a conductor of parasitic current.

To summarize

Wind turbines produce sounds and infrasound, vibrations, electromagnetic fields and parasitic current

To date, only parasitic currents are a real issue for horses, but vigilance is required nevertheless, due to our lack of knowledge.

Reference Number 42 : An Assault on Lakeland Wildlife and Animals, Wind Concerns in Home, Elk Point/St. Paul, Wildlife and Birds. March 9, 2023

Recent studies are definitive: wind turbines wreak havoc on many animals, bats, and fowl that are forced to live among them.

In a landmark court decision in France,[1] evidence was presented showing that exposure to IWTs (industrial wind turbines) is associated with an increased risk of AHEs (adverse health effects).

This analysis concludes that living or working near IWTs can result in AHEs in both people and animals:

"Wind turbines and adverse health effects: Applying Bradford Hill's criteria for causation", (2021) Dumbrille et. al., journals.lww.com

Regarding animals, the study concluded:

- ***Reports of negative effects on animals, which are known not to show any nocebo effect and which live close to wind turbines, resulted not only in stress reactions, but also in negative effects on fertility, development and reproduction.***

Reference : ***Reports from the USA, Canada, Denmark, Japan, Portugal, France, Taiwan and Great Britain indicated teratogenic and mutagenic effects*** *(see Appendix Dumbrille et al.).*

In layman's terms, that's malformed embryos and genetic mutation in animals.

Health impacts of wind turbines on animals, birds and bats is a perennial question, especially as wind farms proliferate around the globe. Studies from well over a decade ago were already harbingers that the noise and infrasonic (low inaudible range frequencies) of wind turbines were affecting animals. In a 2009 paper, the author's concluded that "There is growing documentation from medical professionals about the related adverse health effects on humans and animals living within affected areas.

Startling costs to insect and bird populations

There are over three hunded studies compiled by National Wind Watch on the adverse effects in a range of animals, birds, bats, and insects (see here). For instance, cortisol levels have been found to increase in geese and ground dwelling animals when as near as half a kilometer from wind turbines. By the end of the study, geese nearest the turbine had lost weight, weighing in 10% less than those further away.

'Researchers found that wind turbines in Germany resulted in a loss of about 1.2 trillion insects of different species each year. In India, they found almost four times fewer buzzards, hawks, and kites in areas with wind farms—a loss of about 75 percent. They found that wind turbines are akin to adding a top predator to the ecosystem, killing off birds, but allowing small animals to increase their populations resulting in a trickle effect throughout the ecosystem.

Cattle farmers have laid blame for mass deaths and other issues on wind turbines, including the electrical currents induced by them through the ground.[7] Equestrian property owners have reported their horses dwelling at the far reaches of their pastures to escape the effects of the massive turning blades. And in Norway, the Supreme Court awarded herdsmen there 90 million NOK (10 million USD) in 2021 for wind farms that interfered with their livelihoods:

> The animals steer clear of the turbines because they are disturbed by their view and noise. On top of that, in the coldest months large chunks of icy snow can be thrown into the distance as the blades turn. It is dangerous for humans and animals alike.
>
> **Leif Arne Jåma, "Indigenous Sámi Win Landmark Case against Wind Power Company, Nov. 4, 2021; earthisland.org**

While buildings and cats claim hundreds of millions of bird deaths each year, the proliferation of wind farms is only making matters worse. Studies show as many as 1.17 million birds are killed by wind turbines in the United States alone each year — a number that will only increase with the rapid spread of massive wind farms. While that's far less than deaths by cats, vehicles, communication towers, etc. what is notable and concerning is that it is large migratory species that are being affected.

> The results of this ground-breaking study are really eye-opening — the buildout of wind energy is already having a negative cumulative impact. There are more than 10,000 wind turbines scattered throughout the Whooping Cranes' migratory pathway. We now know that too many of these turbines are eliminating important migratory stopover habitat for this Endangered species.
>
> **Joel Merriman, Director of the Bird-Smart Wind Energy Campaign at American Bird Conservancy, April 1, 2021; ESA**

And German zoologists are raising the alarm that millions of bats are slaughtered each year because of these industrial wind projects..

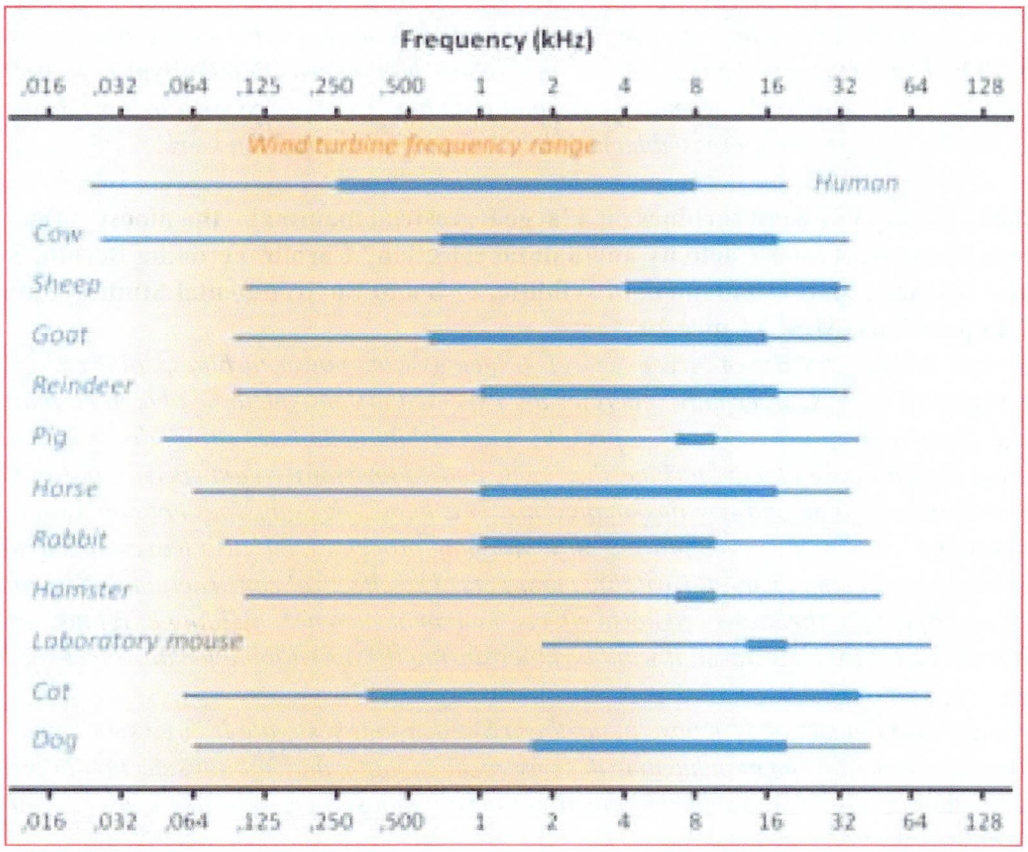
Still, this article has merely grazed the scope of environmental harm these massive industrial warm farms are causing to wildlife (and, of course, people). Which is why it is almost incomprehensible that the province of Alberta may permit two wind farm projects to be built along the North Saskatchewan River near Elk Point, Alberta — a major

recreational and wildlife corridor, fishing paradise, migratory path, and horse and cattle sanctuary, highly populated with rural residences.

Reference 2012 : The impacts of wind power on terrestrial mammals. A synthesis. JAN OLOF HELLDIN, JENS JUNG, WIEBKE NEUMANN, MATTIAS OLSSON, ANNA SKARIN, FREDRIK WIDEMO. report 6510. August 2012. SWEDISH ENVIRONMENTAL PROTECTION AGENCY. ISBN 978-91-620-6510-2. ISSN 0282-7298

Animal hearing

Mammalian hearing is not that unlike human hearing. Humans can hear sound in the frequency range 20–20 000 Hz. Cattle have a hearing range of 23–35 000 Hz, with an extraordinary sensitivity around 8 000 Hz (Heffner & Heffner 1983). Horses have a slightly narrower hearing range, 55–33 500 Hz, with maximum hearing in the range 1000–16 000 Hz (Heffner & Heffner 1983). Pigs' hearing range is more toward ultrasound; frequency response is 42–40 500 Hz, with extra sensitive range at 250– 16 000 Hz (Heffner & Heffner 1990). The hearing range of goats is 78–37 000 Hz, with a maximum sensitivity around 2000 Hz (Heffner & Heffner 1990). Reindeer hearing range extends from 70–38 000 Hz (Flydal et al. 2001). The most prominent frequency range of the aerodynamic sound created by wind turbines is 63–4 000 Hz (Naturvårdsverket 2010). Accordingly, all of the above mentioned species overlap in hearing with the frequency range of wind turbine noise, suggesting that farm animals will readily hear this sound. The similarities with the human hearing range suggest that animals should perceive the sound of wind turbines in rather the same way as humans do.



Reference 2015 : The effect of varying distances from the wind turbine on meat quality of growing-finishing pigs, Małgorzata Karwowska, Jan Mikołajczak, Zbigniew Józef Dolatowski, Sylwester Borowski. *Ann. Anim. Sci., Vol. 15, No. 4 (2015) 1043–1054 DOI: 10.1515/aoas-2015-0051*

This study was conducted to assess the effect of rearing pigs at three different distances from a wind turbine (50, 500 and 1000 m) on the physicochemical properties and fatty acid composition of loin and neck muscles. The experiment was carried out on 30 growing-finishing pigs, derived from Polish Landrace × Polish Large White sows mated to a Duroc × Pietrain boar. The results obtained during the noise measurement showed that the highest level of noise in the audible and infrasound range was recorded 50 m from the wind turbine. Rearing pigs in close proximity to the

wind turbine (50 m) resulted in decreased muscle pH, total heme pigments and heme iron as well as reduced content of C18:3*n-3* fatty acid in the loin muscle. Loins of pigs reared 50 m from the wind turbine were characterized by significantly lower iron content (6.7 ppm g–1) compared to the loins of pigs reared 500 and 1000 m from the wind turbine (10.0–10.5 ppm g–1). The concentration of α-linolenic acid (C18:3*n-3*) in loin and neck muscles decreased as the distance from the wind turbine increased. Avoiding noise-induced stress is important not only for maintaining meat quality but also for improving animal welfare

Reference 2018 : Out of sight of wind turbines—Reindeer response to wind farms in operation. Anna Skarin, Per Sandström, Moudud Alam, *Ecology and Evolution.* www.ecolevol.org 2018;8:9906–9919. 27 July 2018

To meet the expanding land use required for wind energy development, a better understanding of the effects on terrestrial animals' responses to such development is required. Using GPS-data from 50 freely ranging female reindeer (Rangifer tarandus) in the Malå reindeer herding community, Sweden, we determined reindeer calving sites and estimated reindeer habitat selection using resource selection functions (RSF). RSFs were estimated at both second-(selection of home range) and third-order (selection within home range) scale in relation to environmental variables, wind farm(WF) development phase (before construction, construction, and operation), distance to the WFs and at the second-order scale whether the wind turbines were in or out of sight of the reindeer. We found that the distance between reindeer calving site and WFs increased during the operation phase, compared to before construction. At both scales of selection, we found a significant decrease in habitat selection of areas in proximity of the WFs, in the same comparison. The results also revealed a shift in home range selection away from habitats where wind turbines became visible toward habitats where the wind turbines were obscured by topography (increase in use by 79% at 5 km). We interpret the reindeer shift in home range selection as an effect of the wind turbines per se. Using topography and land cover information together with the positions of wind turbines could therefore help identify sensitive habitats for reindeer and improve the planning and placement of WFs. In addition, we found that operation phase of these WFs had a stronger adverse impact on reindeer habitat selection than the construction phase. Thus, the continuous running of the wind turbines making a sound both day and night seemed to have disturbed the reindeer more than the sudden sounds and increased human activity during construction work.

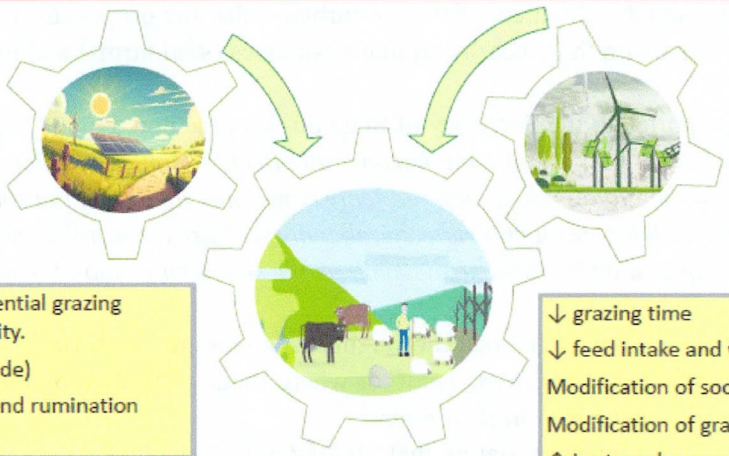
Reference 2021 : Impacts of wind turbines on a large terrestrial mammal – the moose – Does the presence of wind power turbines affect moose activity and habitat selection? Carolin Veronika Berndt. Swedish University of Agricultural Sciences, SLU Department of Wildlife, Fish and Environmental Studies Management of Fish and Wildlife Populations (M.Sc.) Umeå 2021

Across Europe and Sweden, the use of 'green' energies, such as wind power turbines, solar energy or hydropower is increasing. The growth of those alternative energies are expected to continue to be able to mitigate the effects of the climate change. Despite the positive effects, especially wind turbines can have severe direct impacts on wildlife species. Whereas the influence of wind turbines has been studied for many volant species, the impacts on terrestrial mammals are still understudied and remains ambiguous. This knowledge gap does not only result in an underrepresentation of mammal's needs in wind park planning processes, but also leaves unclarities about the impact on species' fitness, which is important for wildlife managers. The effects of constructional work of wind turbines on species comprises especially the increased noise effects, human occurrence, building of related infrastructures (e.g. roads), and direct habitat loss. However, if wind turbines during the operational period affect species in a similar way remains vague.

Here, I used an existing dataset of 31 moose In northern Sweden to Investigate If three small wind parks affect a large mammal – the moose – in movement behaviour in sense of step length, and habitat selection in proximity of wind turbines. Furthermore, I used a step selection function to test if moose were selecting steps towards wind turbines or away from them.

Moose decreased their step length in proximity to the wind turbines and selected proportionally more forest habitats in relation to their availability, when their core area was in average closer to wind turbines than those which had their core area in average more than 5 km away from a wind turbine. Furthermore, moose surprisingly selected in average steps towards wind power turbines instead of away. However, the individual variation in selection strength was relatively high. Those partly contradictory results suggest an impact of wind turbines in some behavioural responses of moose. Further research is needed to clarify the magnitude of wind turbines impact on moose and other terrestrial mammals.

Reference 2024 : Investigating the welfare impacts of wind turbines and solar panels on grazing livestock. August 2024. Isabel Blanco-Penedo. Javier Álvarez-Rodríguez. Yolanda Mena. Carlos Palacios Riocerezo. DOI: 10.13140/RG.2.2.26545.60008. Conference: WAFL 2024



↑discriminative and preferential grazing capacity when ↑ grass quality.
↓ heat stress (access to shade)
↑ resting time lying down and rumination
↑ possibility of scratching.

↓ grazing time
↓ feed intake and weight gain
Modification of social behaviour
Modification of grazing behaviour and habitat use.
↑ in stress hormones

Summary of the effects of wind energy on livestock species. The list only includes factors whose effects on livestock species are documented (adapted from Helldin et al. 2012). *Reliability (from 1: Studies are lacking to 4: The knowledge base is sound and provides a reliable assessment).

Impact factor	Reliability* (1-4)	Effect (negative)	Spatial scope	Temporary Scope
Disturbances during construction	2	Moderate	Minor	Short-Long
Noise/visual disturbances from operating turbines	3	Weak	Minor	Long
Disturbances caused by utility traffic	2	Weak	Minor	Long
Habitat changes	2	Weak-Moderate	Minor	Long/Permanent
Corridor power lines and soil conductivity	1	Moderate	Minor	Long
Electromagnetism	2	Weak	Minor	Long

Proposal of impact assessment points, measures to be carried out and risk thresholds described.

Impact	Sensors and measurements	Risk threshold
Noise/visual damage from operating turbines	Sound measurements with sound level meter at a height of 1 m above the ground	Noise <85 dB (decibels) (Royal Decree 159/2023).
	Distance of the animals from the wind turbines/solar farms	
Electromagnetism	Magnetic field meters at a height of 1 m, from solar turbines/plates (and their power lines) up to 200 m away(2)	Magnetic field <1 mG (milligauss) (McCallum et al., 2014).
Habitat changes under the turbines/solar panels	Analysis of livestock grazing circuits	Reduced grazing and reduced nutritional value of vegetation under and around the facilities.
	Occupation of space	
	Distribution of daily behavioural activities and stereotypies	

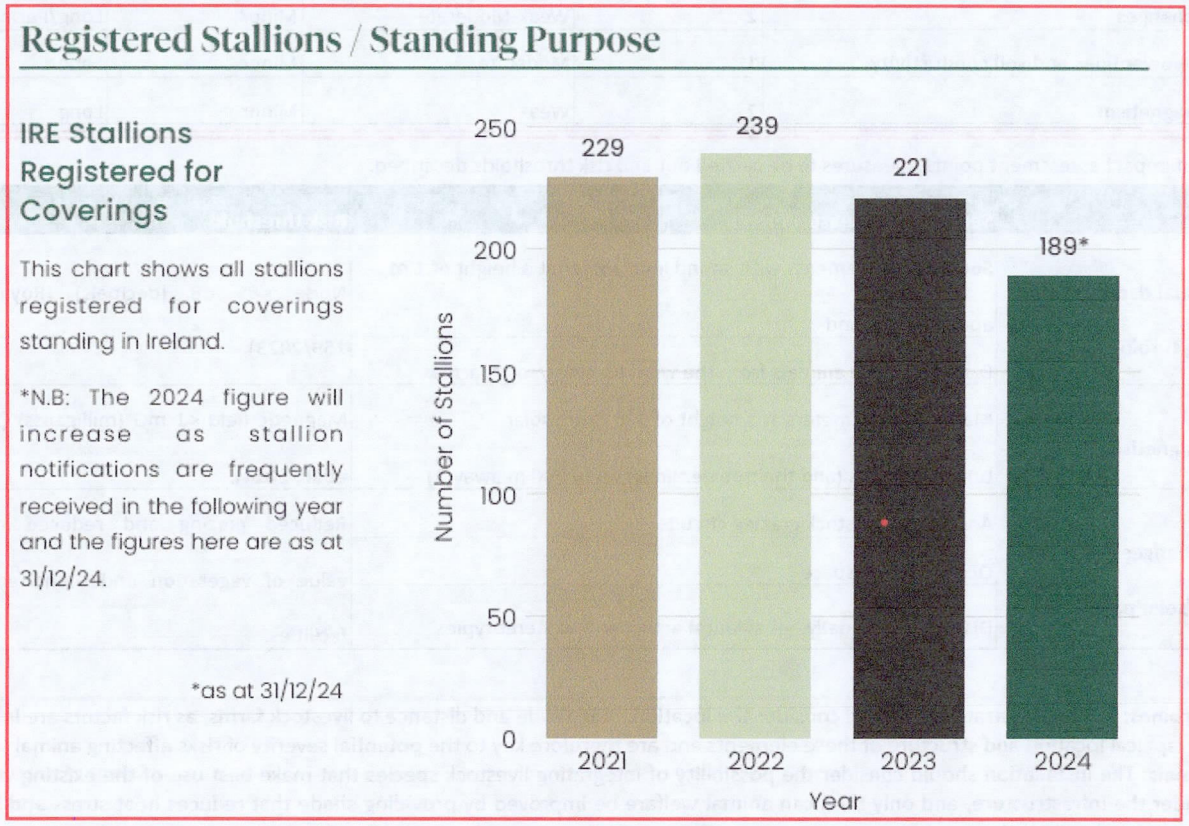
Wind turbines: Mitigation strategies should consider the location, magnitude and distance to livestock farms, as risk factors are inherent to the geographical location and structure of these elements and are therefore key to the potential severity of risks affecting animal welfare.
Solar panels: The installation should consider the possibility of integrating livestock species that make best use of the existing vegetation cover under the infrastructure, and only then can animal welfare be improved by providing shade that reduces heat stress and increases forage quality and grazing time.

Reference : Racehorses & Stud farms

Renewable Energy Developments have to be balanced with equine facilities & this requires informed policy frameworks. Recent statements from Planning Authorities indicate the growing tension between renewable energy expansion and the protection of rural sensitive agricultural sectors, which includes racehorses & stud farms. Thoroughbred horses, horse racing & the industry itself are an integral part of our national identity. Ireland is

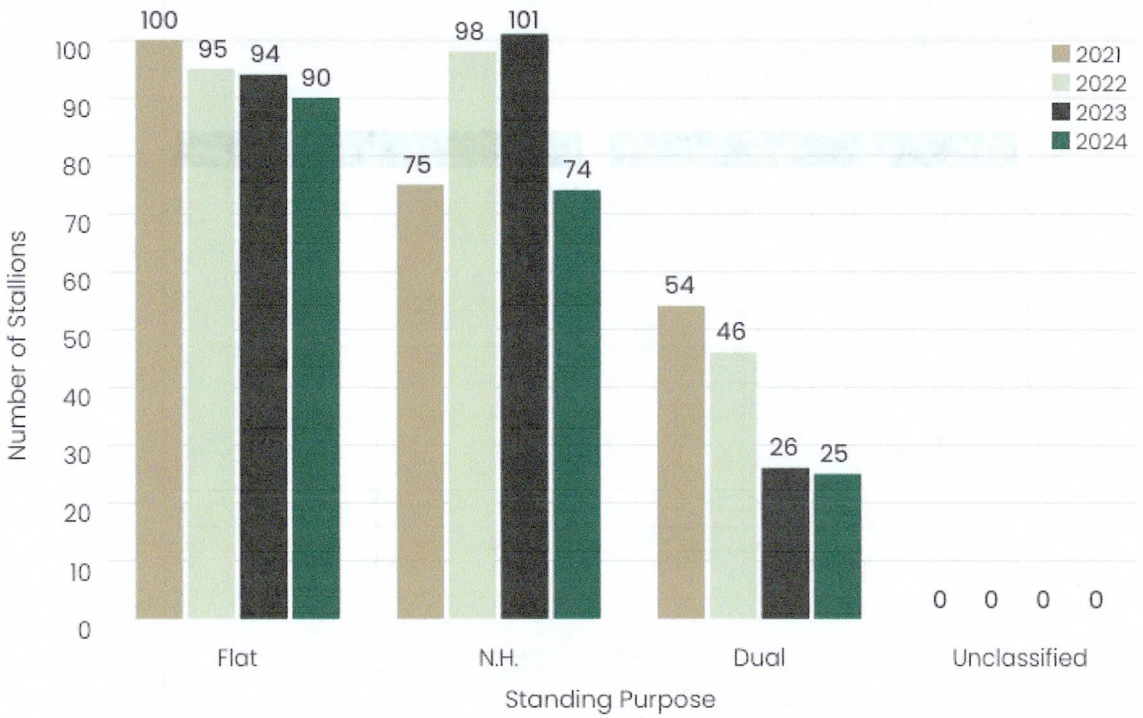
recognised as the world horse industry leader. Ireland is the third largest producer of thoroughbred foals in the world. Only the USA & Australia have more foal births. Ireland exceeds the combined totals of the UK & France.
The UK's Secretary of State for Communities & Local Government acknowledged, in one of the reasons given for refusing permission for a proposed development of 9 wind turbines, that the proposed development would have a potential significant adverse impact on three nearby equine businesses (stud farms) and that "*considerable weight should be attached to this.*"
The Planning Inspector who reported to the Secretary of State on this case noted that "*There are three particular aspects of wind turbines that have a very significant detrimental effect on horses & riders that compromises their safety. Firstly, the movement of the blades when they suddenly come into view from the road, the gallops or a paddock. Secondly, the shadow flicker which has been known to spook a horse. Lastly, the noise from a group of very large turbines, particularly at start up and on a crowded site such as the southern group of 6, could have a very serious effect.*"
The Planning Inspector's report acknowledged that thoroughbred horses are "high *value, highly strung & volatile*" and that "*where turbines would suddenly appear in the view*" or where shadows thrown by turbines are visible "*there is the potential for spooking the highly strung & volatile horses.*"
The Planning Inspector's report continued by stating that "*Whilst not every horse would be startled & as a result injures itself or its rider, some would. In my view this happening would exist over and above the normal risks these stables experience in dealing with this type of horse. These horses represent a significant investment. Thus, every horse owner who uses these stables & every potential client will believe that their valuable investment will be at risk and as such will go elsewhere. The horse racing industry is highly competitive and one where perception and reputation are significant drivers in choosing a trainer and yard. Thus, it strikes me as inevitable that the businesses would decline and given the particular impact of the windfarm would unlikely be replaced with anything similar.*"

Reference *2024*: *Weatherby's Fact Book: The tables indicate a serious decline in the Stud farm industry & Windfarms will exacerbate this decline.*



IRE Stallions Standing Purpose

The proportion of stallions standing for National Hunt purposes was higher than those standing for Flat purposes in 2022 and 2023, compared to 2021 when there were 11% less stallions standing for National Hunt purposes than for the Flat. We expect further stallion registrations for 2024 as noted above.



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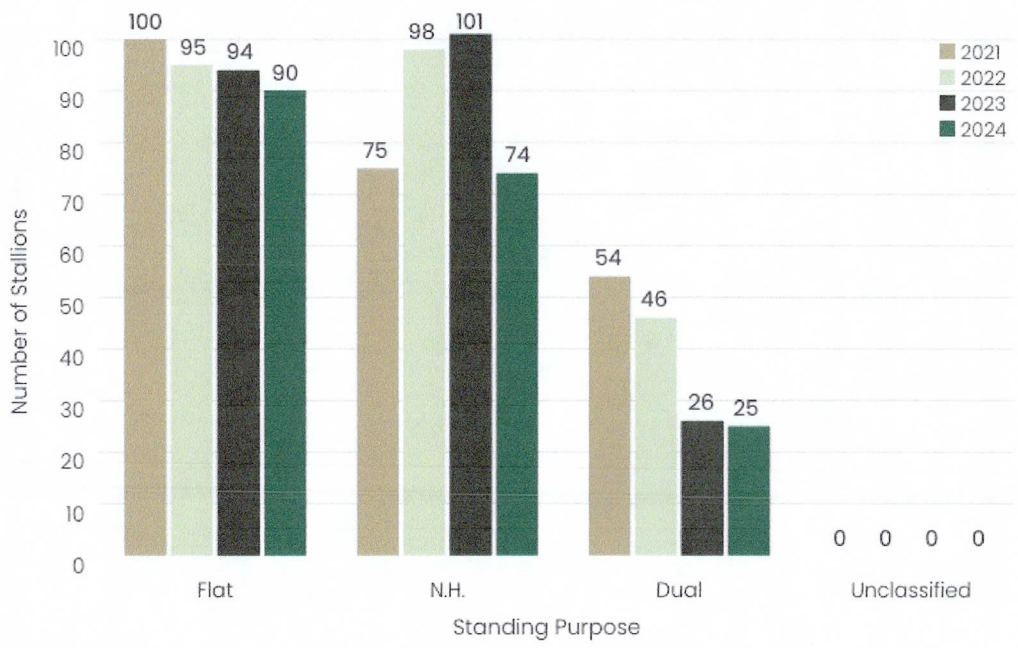


Breeders by County

This table shows the distribution of the 6,354 breeders of Thoroughbreds between 32 Irish Counties. It also highlights the number of mares owned and number of foals produced by those mares. The largest number of individual breeders are found in County Cork, but the largest concentration of mares are in County Kildare.

Included in this data is a figure for breeders not resident in an Irish county, but which have breeding stock permanently domiciled in Ireland. This has been categorised as "Other".

County	Breeders	Mares	Foals
Co. Cork	810	1,611	1,021
Co. Tipperary	799	1,783	1,088
Co. Kildare	707	1,936	1,170
Co. Wexford	555	1,040	601
Co. Meath	440	1,033	575
Co. Kilkenny	425	1,080	662
Co. Waterford	254	609	340
Co. Limerick	242	574	343
Co. Galway	203	368	187
Co. Down	181	367	220
Co. Westmeath	180	713	479
Co. Wicklow	148	351	192
Co. Laois	145	251	138
Co. Carlow	137	414	252
Co. Offaly	117	289	165
Co. Dublin	105	182	112
Co. Clare	82	152	82
Co. Roscommon	60	115	59

County	Breeders	Mares	Foals
Co. Armagh	46	68	33
Co. Antrim	44	97	44
Co. Mayo	39	60	27
Co. Kerry	37	64	43
Co. Louth	35	68	37
Co. Tyrone	33	53	25
Co. Longford	23	38	19
Co. Monaghan	22	28	16
Co. Cavan	19	27	13
Co. Sligo	11	17	9
Co. Fermanagh	9	15	6
Co. Donegal	8	11	7
Co. Leitrim	8	12	5
Co. Londonderry	8	20	8
Sub Total	*5,932*	*13,446*	*7,978*
Other	422	972	565
Total	**6,354**	**14,418**	**8,543**

Number of IRE Broodmares Owned per Breeder

This table shows the distribution of Irish broodmares between breeders by county, with 92% of breeders owning fewer than 5 broodmares.

Included in this data is a figure for breeders not resident in an Irish county, but which have breeding stock permanently domiciled in Ireland. This has been categorised as "Other".

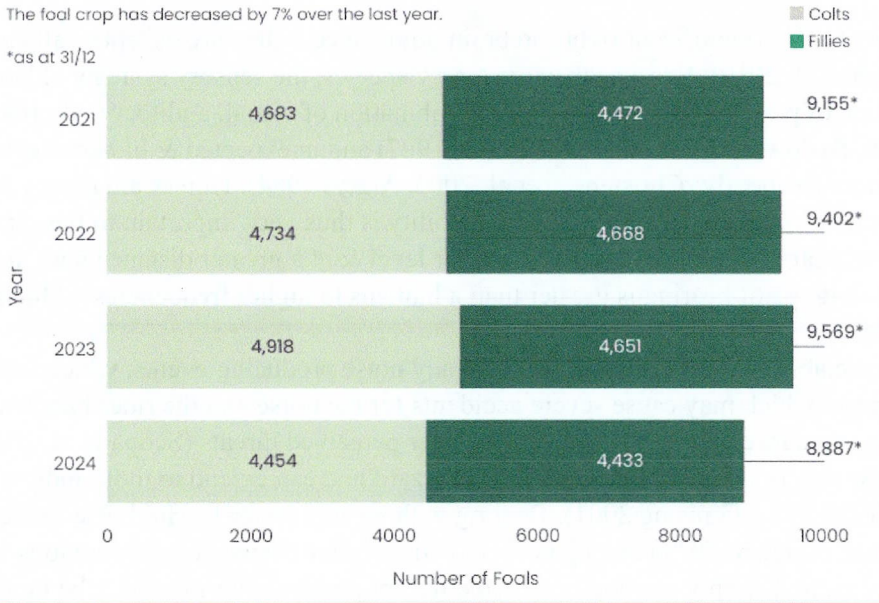
County	1-2	3-4	5-10	11-20	21-30	31+	Total
Co. Cork	669	84	46	7	3	1	810
Co. Tipperary	654	82	42	15	3	3	799
Co. Kildare	556	78	48	16	2	7	707
Co. Wexford	453	68	29	5	0	0	555
Co. Meath	352	48	32	4	2	2	440
Co. Kilkenny	339	47	26	10	1	2	425
Co. Waterford	201	31	16	2	1	3	254
Co. Limerick	193	28	14	5	0	2	242
Co. Galway	173	22	5	3	0	0	203
Co. Down	142	27	10	2	0	0	181
Co. Westmeath	131	24	18	3	0	4	180
Co. Wicklow	120	13	12	2	0	1	148
Co. Laois	125	9	10	1	0	0	145
Co. Carlow	113	15	3	2	0	4	137
Co. Offaly	85	21	8	2	1	0	117
Co. Dublin	92	9	3	0	1	0	105
Co. Clare	65	11	6	0	0	0	82
Co. Roscommon	46	10	4	0	0	0	60

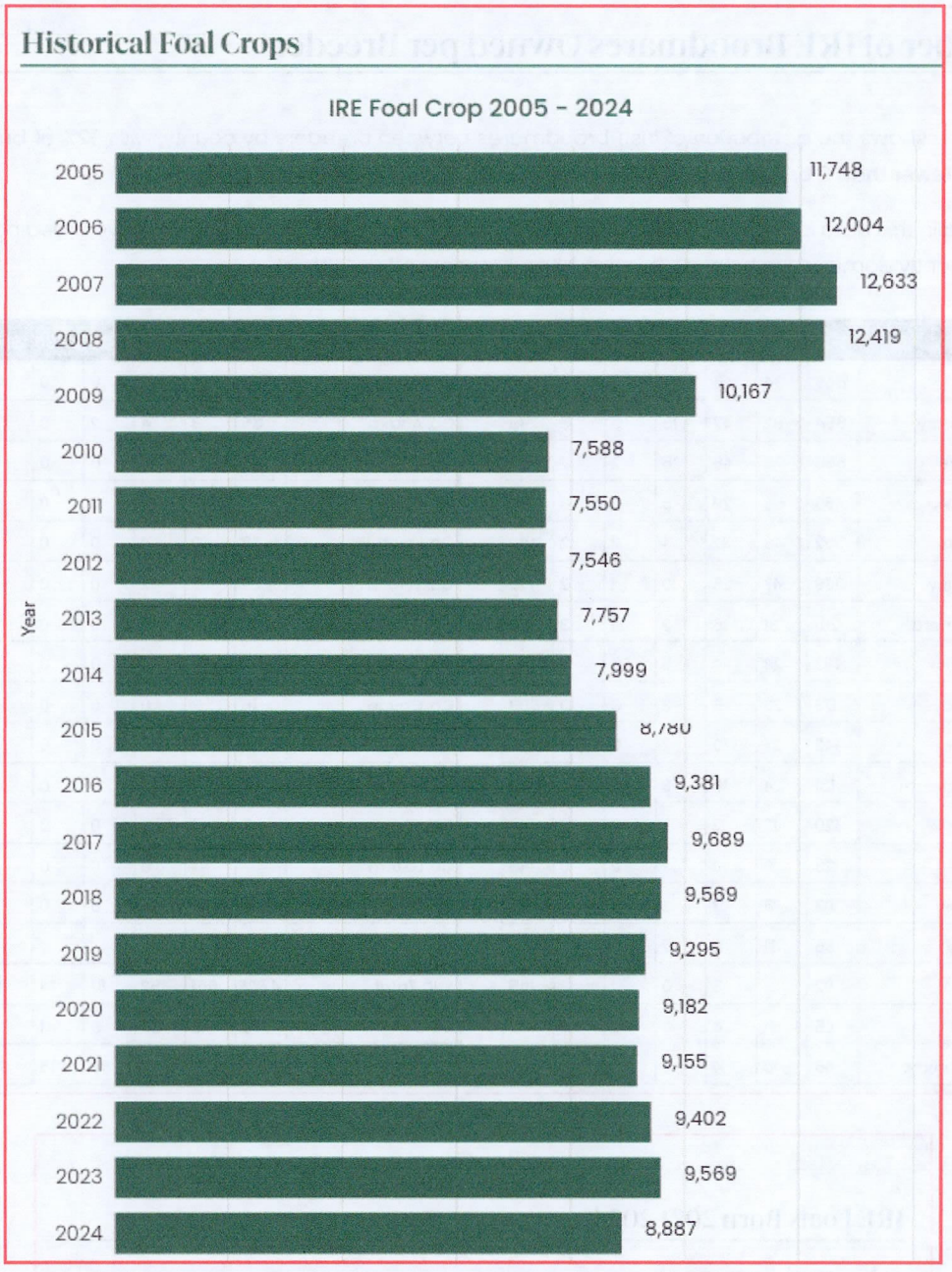
County	1-2	3-4	5-10	11-20	21-30	31+	Total
Co. Armagh	41	3	2	0	0	0	46
Co. Antrim	35	3	4	2	0	0	44
Co. Mayo	36	2	1	0	0	0	39
Co. Kerry	31	4	2	0	0	0	37
Co. Louth	28	3	4	0	0	0	35
Co. Tyrone	29	2	2	0	0	0	33
Co. Longford	21	1	1	0	0	0	23
Co. Monaghan	21	1	0	0	0	0	22
Co. Cavan	16	3	0	0	0	0	19
Co. Sligo	9	1	1	0	0	0	11
Co. Fermanagh	8	0	1	0	0	0	9
Co. Donegal	8	0	0	0	0	0	8
Co. Leitrim	7	1	0	0	0	0	8
Co. Londonderry	6	0	2	0	0	0	8
Sub Total	***4,805***	***651***	***352***	***81***	***14***	***29***	***5,932***
Other	333	43	36	8	1	1	422
Total	**5,138**	**694**	**388**	**89**	**15**	**30**	**6,354**

IRE Foals Born 2021-2024

The foal crop has decreased by 7% over the last year.

*as at 31/12





Horses have been shown to have significant right forebrain dominance – they are exceptionally adept at processing sensory stimuli (Johnson et al. 2019). Because they are a prey species, the sensory systems of horses have evolved to enable a prompt detection of potential danger through a combination of visual, auditory and olfactory cues (Christensen et al. 2006, Saslow 2002, Tierartzliche Praxis 1997) and unexpected & hitherto unknown noises cause rapid flight reactions more frequently (Christensen et al. 2005, Algers 1984). Horses are most easily scared by noise that arises outside their field of binocular vision. Hearing ability is thus very important to the survival for horses over the centuries and a horse's ears can pick up sound at a lower level & at a greater distance than that detected by humans (Saslow, 2002). A horse's range of hearing is greater than a humans to higher frequencies >33kHz while the range for humans is under 20kHz.

Horses can show unpredictable anxiety behaviours during any noise producing events, which include sweating, trembling, escape attempts, which may cause severe accidents for the horse and the rider/handler. More than 84% of horses show immediate avoidance and/or attempts to flee after perceived threats (Scopa et al. 2018).

Injury to riders/handlers, etc., is a significant occupational hazard and can extend to thousands of accidents with associated fatalities (Holler 1984, Gimsing 2001). Dealing with an anxious or fearful horse exacerbates this risk. There is a high rate of incidence of injury (26%) among horses rated as either anxious or very anxious in the face of noise and/or light related flashes, and simply moving horses to adjacent paddocks was found to be ineffective in 37% of cases (Gronqvist 2016) Noise has also been shown to elicit restlessness, vocalisation & colic/gastro-intestinal disturbances (Dai et al. 2020)

"Noise aversion" or "noise anxiety" are terms used when an animal overreacts to noise. Unpredictable noise causes the greatest fear reactions. These noises can have long lasting effects and have been reported to adversely affect food intake, growth and production rates (Broucek 2014. Tracy et al. 2007. Head et al. 1993).
Severe noise anxiety is reported to cause serious welfare consequences, impacting both the physiology and behaviour of the horse (Riva et al. 2022). Very anxious horses showed signs of noise reactivity and their reactions did not improve with time (they do not habituate with time). Very severe injuries can occur as a result of the unpredictable & very severe anxiety. Riva et al. have also shown that the effects of noise-related anxiety can persist for hours/days after the noise event. It is noteworthy that compared to visual and olfactory stimuli, unexpected unknown noises can cause rapid flight reactions.
Highly sensitive mares & newborn foals are particularly vulnerable to environmental stressors. O'Connor & Walsh (2021) emphasised that pregnant mares exhibit heightened sensitivity to noise and light fluctuations, which may interfere with gestation & increase the risk of premature birth or behavioural distress. Smith et al. (2020) reported that foals exposed to elevated noise levels during early development showed signs of sleep disruption, increased startle responses, and reduced social bonding behaviours. Green et al. (2021) noted that neonatal horses are especially susceptible to visual flicker and tonal noise, which can impair rest cycles and contribute to development instability. Chronic exposure to such stimuli may result in heightened stress responses, altered behaviour, and compromised physiological stability as evidenced by Jones et al (2019). They also noted increased agitation, visual stress, reduced rest patterns and avoidance behaviours in horses exposed to nearby wind farms.
Many management strategies are used to try to reduce the effects of noise and have been shown to be ineffective (Gronquvist, 2016). Placing horses in stables is unsatisfactory as those in single stables exhibit even stronger reactions to unknown stimuli with an increased risk of accidents and adverse effects on welfare, which can include long-term behavioural abnormalities (Lesimple et al. 2020). Sedation can often give disappointing results and cause undesirable side effects (Dai et al. 2020) & long-term sedation and or stabling is impractical & inhumane.
2025 Planning Authority Statements underscore the growing tension between renewable energy expansion and the protection of sensitive agricultural sectors, including equine studfarms. An Bord Pleanala (2025) reported that of the 69 energy cases reviewed in the period 2023 – 2024, several windfarms were refused as a result of objections citing proximity to studfarms. In several decisions, the Board cited concerns over elevated noise levels and their potential impact on equine welfare. The Board emphasised the need to balance strategic infrastructure development with environmental and agricultural sensitivities.
It is noted that ABP 23-225138 on appeal from Tipperary County Council 07/111 refused planning permission for a biogas & biodiesel production facility at Castleblake, Rosegreen, County Tipperary for the following reason:
"*The site of the proposed development is located in open countryside in an area of national importance for the bloodstock industry alongside a major horse training establishment. It is the policy of the planning authority, as set out in the current South Tipperary Development Plan, to support the equine industry. It is also the policy of Government to support the equine sector. It is considered that the proposed development of this large scale industrial type facility at this location, employing the particular technology on the scale proposed, having regard to its nature, scale and visual impact, would be incompatible with equine related activities in the vicinity and would be prejudicial to the viability of the equine industry in this area(including undermining confidence therein). Notwithstanding the desirability of providing such facilities, it is considered that the proposed development would seriously injure the amenities of the area and property in the vicinity, would be incompatible with the surrounding land uses, and would, therefore, be contrary to the said Development Plan objectives and to national policy and to proper planning and sustainable development of the area.*"
"The equine industry and in particular the bloodstock industry is a highly competitive commercial industry, which needs a high quality in relation to environmental standards and what could best be described as a clean image. The area of County Tipperary has developed a niche industry comparable with other bloodstock areas as for example Newmarket & Kentucky with major financial benefits to the area and any consideration of permitting development must have consider policy ENV11, for proposals for non-agriculture related development."
The Planning Inspector Derek Daly noted that it could be necessary and appropriate to invoke the Precautionary Principle *"as we are not talking about just any agricultural operation, but one of the international leaders, a business that carries Ireland's reputation in the bloodstock industry and one which the local economy benefits well beyond the level were it to be on only local, or minimal standing."*
The Planning Inspector's report also noted that it should be a consideration in the planning process if one successful enterprise of benefit to an area's economy is placed at risk by a development, which is not by its nature locationally tied to the area. The Planning Inspector stated that "*the onus is on any new development in the rural area and in*

particular non-agricultural development, which for reasons already outlined is not specifically locationally dependent to a rural area to demonstrate that it will not have a negative impact on the viability of existing stud farms or stables and that it is reasonable to consider the development in this context."

References:

- Equine stereotaxic population average brain atlas with neuroanatomic correlation. Johnson, P.J., Janvier, V., Luh, W.M., Fitzmaurice, M., Southard, T., Barry, E.F. (2019) Frontiers in Neuroanatomy, 13,89.
- Responses of horses to novel visual, olfactory and auditory stimuli. Christensen, J.W., Keeling, L. J., & Nielsen, B.L. (2005). Applied Animal Behaviour Science, 93(1-2) 53-65.
- Understanding the perceptual world of horses. Saslow, C.A., (2009). Applied Animal Behaviour Science, 78(2-4), 209-224.
- Responses of horses to sensory stimuli. Tierartzliche Praxis Ausgabe Grosstiere Nutztiere, 25(5) 362-365.
- A note on behavioural responses of farm animals to ultrasound, Algers, B., (1984) Applied Animal Behavioural Science, 13(4), 369-373
- Physiological outcomes of calming behaviours support the resilience hypothesis in horses. Scopa, C., Palagi, E., Sighieri, C., Baragli, P. (2118) Scientific Reports, 8, 17501.
- Occupational risks of horse handling, Holler, A.C., (1984). American Industrial Hygiene Association Journal, 45(1). 34-38.
- Horse related occupational injuries 1992 – 1999. Gimsing. S., (2001) Ugeskr Laeger, 163(43), 5982 – 5985.
- The management of horses during fireworks in New Zealand, Gronqvist, G., Rogers, C., Gee. E., (2016). Animals, 6(20), 1-12.
- Use of detomidine oromucosal gel for allevation of acute anxiety and fear in horses (2020): A pilot study. Dai, F., Rausk, J., Aspegren, J., Huhtinen, M., Cannas, S., Minero, M. Frontiers in Veterinary Science. 7, 573309.
- The impacts of noise anxiety on behaviour and welfare of horses from UK and US owner's perspective. Riva, M.G. Dai, F., Huhtinen, M., Barbieri,S., Dalla Costa, E., (2022). Animals 12(10), 1319
- Behavioural and production responses of dairy cows to noise. Broucek, J (2014) Slovak Journal of Animal Science, 47(2), 111-123
- Behavioural responses of feral goats to helicopters. Tracey, J.P., Fleming, P.J.S (2007) . Applied Animal Behaviour Science, 108m (1-2), 114 -128.
- Milk yield, milk composition, and behaviour of Holstein cows in response to jet aircraft noise before milking. Head, H.H., Kull, R.C., Campos, M.S., Bachman, K.C., Wilcox, C.J., Cline, L.L., Hayen, M.J. (1993). Journal of Dairy Science, 76(5), 1558-1567.
- Environmental stressors and equine health. O'Connor. P,. Walsh. B., (2021). Veterinary Ireland Journal. 11(4), 210-218.
- Noise and light pollution impacts on equine physiology. Smith. J,. O'Connor. P., Walsh. B., (2020). Journal of Equine Science. 28(2). 89-101.
- Wind turbine impacts on livestock behaviour: A case study of equine responses. Green. A., Byrne. S., Nolan. F., (2021). Journal of Agricultural Environment Studies. 42(2), 101-118.
- Sensory sensitivity in horses: Implications for welfare. Jones. R., McBride. S., Mills. D., (2019). Equine Veterinary Journal. 51(3), 345-352.
- Housing conditions and breed are associated with emotionality and cognitive abilities in riding horses. Lesimple. C., Fureix. C., LeScolan. N., Richard-Yris. M.A., Hausberger. M., (2011). Applied Animal Behaviour Science. 129(1), 92-99.

Reference: Variation no. 2 Mayo County Development Plan: Soils & Geology

"Peat Soils

Peatland biodiversity is threatened by habitat loss and fragmentation, which occur when natural habitats are altered or degraded by land use changes. This affects both the quality of the habitat and the species it supports. Development on peatlands such as bogs, fens, and heaths can harm natural heritage.

Additionally, peatlands are vital carbon sinks, storing much of Ireland's carbon in their soils. Activities like wind turbine construction can dry out peat soils, disrupting carbon storage and increasing carbon dioxide emissions.

The conservation of raised bogs in County Mayo is vital to maintaining the overall range and integrity of this unique habitat. Many peat soil areas outside designated conservation sites function as important wetlands, offering significant biodiversity value and contributing to natural flood risk management.

Given the heightened risk of peat desiccation and the associated loss of carbon storage capacity, such soils are considered unsuitable for wind energy development in Mayo. It is therefore appropriate to exclude these areas at the planning policy stage, ensuring that renewable energy infrastructure is directed toward more suitable and sustainable locations."

Reference 2024 : Emerging evidence links wind power plants to changes in vegetation, soil, and hydrology. This may contribute to ecosystem degradation, which has been defined as '*[…] a persistent decline in the structure, function, and composition of an ecosystem compared to its former state*' (Society of Ecological Restoration, 2024).
Literature was retrieved on 25 July 2024, from Web of Science, Scopus, and ProQuest. For Tethys, a faceted search strategy was used to retrieve all references listed under land-based wind and linked to habitat change as a stressor and the physical environment as a receptor. The initial search yielded a total of 1477 references. All references were imported into the EndNote reference manager (The EndNote Team, 2013), and duplicates removed automatically. Studies were excluded when they: (1) were not in English, (2) did not focus on onshore wind energy, (3) lacked relevance to vegetation, soil, or hydrology, (4) focused on wildlife disturbance, or (5) were not available as full text. This process resulted in 70 references meeting the criteria for inclusion. Following initial selection, a backward and forward reference search was conducted using the Web of Science citation map, identifying 18 additional studies that met the inclusion criteria. In total, 88 studies were included in this review.
Negative impacts on vegetation dynamics can result from vegetation clearings prior to construction, vehicle movement in construction areas (Christol et al., 2021), or wake effects caused by wind turbine blade movement (Diffendorfer et al., 2022; Li et al., 2016). For example, the development of wind power plants has been linked to deforestation (Balotari-Chiebáo & Byholm, 2024; Diffendorfer & Compton, 2014; Enevoldsen, 2018) and declines in overall native vegetation cover (Cetin et al., 2022; Guan, 2023; Turkovska et al., 2021). The associated vegetation loss can be substantial, with individual wind turbines contributing to the clearance of up to 3000 m2 of vegetation (Shen et al., 2017). On the project level, the vegetation loss could be as much as 25% of the whole project area (Balik et al., 2017).

Environmental impacts
Vegetation dynamics
Remote sensing studies have confirmed negative impacts on vegetation cover. Qin et al. (2022) found that 59% of 319 wind power plants across the United States exhibited reduced vegetation growth within their main operation area. Other researchers reported decreases in the Normalized Difference Vegetation Index (NDVI), indicating reduced vegetation cover and greenness after wind power plant construction in coastal regions (Aksoy et al., 2023), alpine ecosystems (Ma et al., 2023), and grasslands (Song et al., 2023; Tang et al., 2017). Xia and Zhou (2017) also found a decrease in NDVI after wind power plant construction, although their results were not statistically significant. Lastly, Diffendorfer et al. (2022) observed both increases and decreases in vegetation greenness within the growing season.

Plant community composition
Several studies have examined the impacts of onshore wind energy development on plant community composition. While Ji et al. (2023) documented an increase in species diversity around wind turbines in meadow grasslands, Fraga et al. (2009) found that species diversity was decreased inside the main operation area of a wind power plant within a blanket bog. A long-term study by Urziceanu et al. (2021) found that plots disturbed by wind turbines contained less than 40% of the inventoried rare, endemic, and threatened species of the characteristic steppe vegetation. Losses of endemic species as a result of wind power development were also recorded in mixed-grass prairies (Davis et al., 2018), mires with wet heath vegetation (Fagúndez, 2008), and deserts (Keehn & Feldman, 2018).

Soil erosion
When vegetation is cleared during the construction phase of a wind power plant, bare soil becomes susceptible to erosion from wind and rainfall (Nazir et al., 2020). Peatlands, when drained for safer wind turbine placement, pose a significant risk of carbon loss through erosion (Smith et al., 2014), which can be intensified by the drying of surface soils, depending on season and wind direction (Wang et al., 2023). Additionally, the construction of access roads for wind power plants can trigger peat slides, contributing to further soil loss (Dykes, 2022). In the Karaburun region of Turkey, researchers recorded a total loss of approximately 18,000 tons of soil organic carbon between 2000 and 2019, likely caused by wind energy development (Pekkan et al., 2021). When planning the siting of wind power plants in Chile, it was suggested that the associated soil erosion could increase soil loss by as much as 50% (Martí et al., 2023).

Studies conducted in the Yunnan province of China imply that soil loss may even increase by over 1000% when accounting for factors like vegetation damage and rainfall (Ma et al., 2023).

Soil physical properties

Soil physical properties encompass factors such as soil texture, structure, density, temperature, and water- holding capacity (Sanchez, 2019). The construction of onshore wind power plants can alter soil physical properties through activities like excavation, road construction, and the building of related infrastructure (Christol et al., 2021). These disruptions can cause the loss of native soils, topsoil disturbance, and microtopographic changes. They can also lead to soil compaction (Chen et al., 2019), which tended to be highest near wind turbines and decreased with distance (Xie et al., 2014). Furthermore, alterations in ground-level microclimate and soil temperature have been measured (Armstrong et al., 2016), along with changes in nutrient content (Chen et al., 2019; Luo et al., 2021) and soil salinity (Chen et al., 2019). Ji et al. (2023) also studied the influence of wind power plant operation on soil carbon content but found no significant impacts. The effects from decommissioning are expected to be similar to the ones from construction, which is why turbine pads and underground powerlines are often left in situ to minimize further soil disturbance (Welstead et al., 2013).

Water availability

Onshore wind energy development can affect an ecosystem's water availability via changes in microtopo-graphy and soil physical properties (Christol et al., 2021). Gunn et al. (2002) found that during the construction of an access road for a wind power plant in a peatland, the organic topsoil layer was 6L. SEIFERT ET AL. compacted, causing water to collect on the upslope side. The water availability can also be reduced actively by inserting ditches to regulate water flow and drain the soil for safer wind turbine placement, which is common practice in peatlands (Murray, 2012). Ditches can be inserted temporarily during construction to regulate surface runoff caused by earthwork activities and to prevent wind turbine pads from being uplifted, or permanently to regulate increased runoff caused by road construction (Stunell et al., 2009). It was suggested that the effects of drainage for wind energy development can far exceed conservative land use estimates and need to be backed up by continuous long-term studies on hydrological impacts (Ramchunder et al., 2009; Renou-Wilson & Farrell, 2009). In addition to drainage, some studies found impacts of wind power plants on local precipitation. Jawaheer et al. (2018) observed a decrease in precipitation one year after the construction of the Roches Noires wind power plant in Mauritius. Similarly, Pryor et al. (2018) found a decrease in summer precipitation caused by wind power plant operation, though the effect was not statistically significant. These findings are contradicted in a study by Fiedler and Bukovsky (2011), who used a regional climate model to demonstrate a significant increase in precipitation resulting from wind power plant operation.

Water quality

Studies on water quality have predominantly centered around wind power plants in peatlands, where peat degradation can contribute to reduced water quality by mobilizing metals and pollutants stored in the peat (Evans et al., 1999). The establishment of wind power plants was linked to increases in water turbidity and nutrient contents (Stunell et al., 2009), as well as dissolved organic carbon content (Ramchunder et al., 2009) in downstream aquatic habitats. The concentration of dissolved organic carbon and suspended sediments was higher in streams disturbed by wind power plants compared to undisturbed reference streams (Grieve & Gilvear, 2009; Heal et al., 2020; Lindsay & Bragg, 2005; van Niekerk, 2012; Waldron et al., 2009). At the Whitlee wind power plant in Scotland, researchers measured increased macronutrient concentrations (Zheng et al., 2018) and export rates (Murray, 2012) following wind power plant construction on peatland. Another study conducted on peatland reported significant impacts on pH and alkalinity (Millidine et al., 2015). However, studies conducted in a Karst environment found no impacts on groundwater quality (Valente et al., 2022).

Consideration of mitigation and restoration

The majority of studies (41 studies) focused exclusively on impacts, while fewer considered the subsequent need for mitigation (24 studies) or restoration (23 studies). This was especially apparent in empirical research, where more than half of the studies (35 out of 62 studies) focused exclusively on impacts, while only few acknowledged the subsequent need for mitigation (16 studies) or restoration (11 studies). In contrast, only 6 of the 26 non-empirical studies focused exclusively on impacts, while the majority addressed the need for mitigation (8 studies) or restoration (11 studies). Another emerging trend was the low concern for restoration in studies that analyzed vegetation impacts. The share of vegetation studies was 58% in the studies exclusively focusing on impacts, and 55% in those mentioning mitigation.

This trend was reversed in the restoration group, where most studies concerned soil-related impacts (45%), but only 30% concerned impacts on vegetation, despite the overall dominance of vegetation studies in the reviewed literature. For hydrological studies, no clear trend was observed regarding their consideration of mitigation and restoration.

Discussion

Highlights

This literature review analyzed 88 studies on the impacts of onshore wind energy on vegetation, soil, and hydrology. Empirical studies were more common than non-empirical studies. They primarily focused on vegetation dynamics and highlighted both positive and negative effects, such as increased biomass in grasslands and deserts, but significant vegetation loss in forests. For impacts on soil and hydrology, empirical evidence remained limited. Few studies included direct field-based measurements of soil compacted, causing water to collect on the upslope side. The water availability can also be reduced actively by inserting ditches to regulate water flow and drain the soil for safer wind turbine placement, which is common practice in peatlands compaction or hydrological alterations, and only a small subset monitored long-term recovery. Moreover, most empirical research lacked standardized methods or site replication, making it difficult to generalize findings across studies. Importantly, nearly half of the studies focused solely on identifying impacts, while few acknowledged the subsequent need for mitigation or restoration. This trend was reversed for non- empirical studies. This imbalance highlights the need to more actively consider how environmental impacts can be mitigated and how degraded ecosystems can be restored in the context of onshore wind energy.

Reference Number 182 : 2024/1991 Regulation (Eu) 2024/1991 Of The European Parliament And Of The Council of 24 June 2024 on nature restoration and amending Regulation (EU) 2022/869

CHAPTER II

RESTORATION TARGETS AND OBLIGATIONS

Article 4

Restoration of terrestrial, coastal and freshwater ecosystems

1. Member States shall put in place the restoration measures that are necessary to improve to good condition areas of habitat types listed in Annex I which are not in good condition.

Such restoration measures shall be put in place:

(a) by 2030 on at least 30 % of the total area of all habitat types listed in Annex I that is not in good condition, as quantified in the national restoration plan referred to in Article 15;

(b) by 2040 on at least 60 % and by 2050, on at least 90 % of the area of each group of habitat types listed in Annex I that is not in good condition, as quantified in the national restoration plan referred to in Article 15.

7. Member States shall put in place restoration measures for the terrestrial, coastal and freshwater habitats of the species listed in Annexes II, IV and V to Directive 92/43/EEC and of the terrestrial, coastal and freshwater habitats of wild birds falling within the scope of Directive 2009/147/EC that are, in addition to the restoration measures referred to in paragraphs 1 and 4 of this Article, necessary to improve the quality and quantity of those habitats, including by re-establishing them, and to enhance connectivity, until sufficient quality and quantity of those habitats is achieved.

8. The determination of the most suitable areas for restoration measures in accordance with paragraphs 1, 4 and 7 of this Article shall be based on the best available knowledge and the latest scientific evidence of the condition of the habitat types listed in Annex I to this Regulation, measured by the structure and functions which are necessary for their long-term maintenance, including their typical species, as referred to in Article 1, point (e), of Directive 92/43/EEC, and of the quality and quantity of the habitats of the species referred to in paragraph 7 of this Article, making use of information reported under Article 17 of Directive 92/43/EEC and Article 12 of Directive 2009/147/EC, and where appropriate taking into account the diversity of situations in various regions as referred to in Article 14(16), point (c), of this Regulation.

9. Member States shall ensure, by 2030 at the latest, that the condition of habitat types is known for at least 90 % of the area distributed over all habitat types listed in Annex I and that by 2040, the condition of all areas of habitat types listed in Annex I is known.

10. The restoration measures referred to in paragraphs 1 and 4 shall consider the need for improved connectivity between the habitat types listed in Annex I and take into account the ecological requirements of the species referred to in paragraph 7 that occur in those habitat types.

11. Member States shall put in place measures which shall aim to ensure that the areas that are subject to restoration measures in accordance with paragraphs 1, 4 and 7 show a continuous improvement in the condition of the habitat types listed in Annex I until good condition is reached, and a continuous improvement of the quality of the habitats of the species referred to in paragraph 7, until the sufficient quality of those habitats is reached.

12.Without prejudice to Directive 92/43/EEC, Member States shall, by the date of publication of their national restoration plans in accordance with Article 17(6) of this Regulation, endeavour to put in place necessary measures with the aim of preventing significant deterioration of areas where the habitat types listed in Annex I to this Regulation occur and which are in good condition or are necessary to meet the restoration targets set out in paragraph 17 of this Article.

13.With regard to paragraphs 11 and 12 of this Article, outside Natura 2000 sites, Member States may, in the absence of alternatives, apply the non-deterioration requirements set out in those paragraphs at the level of each biogeographical region of their territory for each habitat type and each habitat of species, provided that the Member State concerned notifies its intention to apply this paragraph to the Commission by 19 February 2025 and fulfils the obligations set out in Article 15(3), point (g), Article 20(1) point (j), Article 21(1) and Article 21(2), point (b).

Article 11

Restoration of agricultural ecosystems

4.Member States shall put in place measures which shall aim to restore organic soils in agricultural use constituting drained peatlands. Those measures shall be in place on at least:

(a) 30 % of such areas by 2030, of which at least a quarter shall be rewetted;

(b) 40 % of such areas by 2040, of which at least a third shall be rewetted;

(c) 50 % of such areas by 2050, of which at least a third shall be rewetted.

Member States may put in place restoration measures, including rewetting, in areas of peat extraction sites and count those areas as contributing to meeting the respective targets referred to in the first subparagraph, points (a), (b) and (c).

In addition, Member States may put in place restoration measures to rewet organic soils that constitute drained peatlands under land uses other than agricultural use and peat extraction and count those rewetted areas as contributing, up to a maximum of 40 %, to meeting the targets referred to in the first subparagraph, points (a), (b) and (c).
Restoration measures that consist in rewetting peatland, including the water levels to be achieved, shall contribute to reducing greenhouse gas net emissions and increasing biodiversity, while taking national and local circumstances into account.

Where duly justified, the extent of the rewetting of peatland under agricultural use may be reduced to less than required under the first subparagraph, points (a), (b) and (c), of this paragraph by a Member State if such rewetting is likely to have significant negative impacts on infrastructure, buildings, climate adaptation or other public interests and if such rewetting cannot take place on land other than agricultural land. Any such reduction shall be determined in accordance with Article 14(8).

The obligation for Member States to meet the rewetting targets set out in the first subparagraph, points (a), (b) and (c), does not imply an obligation for farmers and private landowners to rewet their land, for whom rewetting on agricultural land remains voluntary, without prejudice to obligations stemming from national law.

Member States shall, as appropriate, incentivise rewetting to make it an attractive option for farmers and private landowners and foster access to training and advice to farmers and other stakeholders on the benefits of rewetting peatland and on the options of subsequent land management and related opportunities.

ANNEX I

TERRESTRIAL, COASTAL AND FRESHWATER ECOSYSTEMS – HABITAT TYPES AND GROUPS OF HABITAT TYPES REFERRED TO IN ARTICLE 4(1) AND (4)

The list below includes all terrestrial, coastal and freshwater habitat types listed in Annex I to Directive 92/43/EEC referred to in Article 4(1) and (4), as well as six groups of those habitat types, namely 1) wetlands (coastal and inland), 2) grasslands and other pastoral habitats, 3) river, lake, alluvial and riparian habitats, 4) forests, 5) steppe, heath and scrub habitats and 6) rocky and dune habitats.

1. GROUP 1: Wetlands (coastal & inland)

Mires, bogs and fens	
Habitat type code as referred to in Annex I to Directive 92/43/EEC	Habitat type name as referred to in Annex I to Directive 92/43/EEC
7110	Active raised bogs
7120	Degraded raised bogs still capable of natural regeneration
7130	Blanket bogs
7140	Transition mires and quaking bogs
7150	Depressions on peat substrates of the *Rhynchosporion*
7160	Fennoscandian mineral-rich springs and springfens
7210	Calcareous fens with *Cladium mariscus* and species of the *Caricion davallianae*
7220	Petrifying springs with tufa formation (*Cratoneurion*)
7230	Alkaline fens
7240	Alpine pioneer formations of the *Caricion bicoloris-atrofuscae*
7310	Aapa mires
7320	Palsa mires
Rivers and lakes	
3110	Oligotrophic waters containing very few minerals of sandy plains (*Littorelletalia uniflorae*)
3120	Oligotrophic waters containing very few minerals generally on sandy soils of the West Mediterranean, with *Isoetes* spp.
3130	Oligotrophic to mesotrophic standing waters with vegetation of the *Littorelletea uniflorae* and/or of the *Isoëto-Nanojuncetea*
3140	Hard oligo-mesotrophic waters with benthic vegetation of *Chara* spp.
3150	Natural eutrophic lakes with *Magnopotamion* or *Hydrocharition* — type vegetation
3160	Natural dystrophic lakes and ponds
3170	Mediterranean temporary ponds
3180	Turloughs

ANNEX V

COMMON FARMLAND BIRD INDEX AT NATIONAL LEVEL

Description

The common farmland bird index summarises population trends of common and widespread birds of farmland and is intended as a proxy to assess the biodiversity status of agricultural ecosystems in Europe. The national common farmland bird index is a composite, multispecies index that measures the rate of change in the relative abundance of farmland bird species across selected survey sites at national level. That index is based on specially selected species that are dependent on farmland habitats for feeding or nesting, or both. National common farmland bird indices are based on species sets that are relevant to each Member State. The national common farmland bird index is calculated with reference to a base year when the index value is typically set at 100. Trend values express the overall population change in the population size of the constituent farmland birds over a period of years.

List of species used for the common farmland bird index in the Member States

Ireland

Carduelis carduelis - Goldfinch
Columba oenas – Stock Dove
Columba palumbus – Common Wood Pigeon
Corvus cornix – Hooded Crow
Corvus frugilegus - Rook
Corvus monedula - Jackdaw
Emberiza citronella - Yellowhammer
Falco tinnunculus - Kestrel
Fringilla coelebs - Chaffinch
Hirundo rustica –Barn swallow
Chloris chloris - Greenfinch
Linaria cannabina - Linnet
Motacilla alba – White Wagtail
Passer domesticus – House sparrow
Phasianus colchicus – Ring-necked Pheasant
Pica pica - Magpie
Saxicola torquatus - Stonechat
Sturnus vulgaris - Starling

ANNEX VII

LIST OF EXAMPLES OF RESTORATION MEASURES REFERRED TO IN ARTICLE 14(16)

(1) Restore wetlands, by rewetting drained peatlands, removing peatland drainage structures or de-poldering and discontinuing peat excavation

(12) Assist migration of provenances and species where it may be needed due to climate change.

(22) Improve connectivity across habitats to enable the development of populations of species, and to allow for sufficient individual or genetic exchange as well as for species' migration and adaptation to climate change.

Reference number 183 : Client: European Commission, DG Environment. Impact assessment study to support the development of legally binding EU nature restoration targets Undertaken as part of Contract 07.0202/2019/SER/806106/ENV.D.2. *Supporting the Evaluation of the EU Biodiversity Strategy to 2020 and Followup* .Rotterdam, 06 June 2023.

Figure 2-1 Share of terrestrial surface area by broad ecosystem type in the EU and UK

Note: 1) Marine ecosystem are not included and represent the most extensive ecosystem type in the EU (5.8 million km²); 2) The percentages only add to 98.5% and the remaining 1.5% include some important smaller ecosystems relevant to this Impact Assessment, in particular coastal wetlands

Source: EU Ecosystem Assessment Summary for policy makers[25]. Original source: Corine Land Cover, European Environment Agency, 2018.

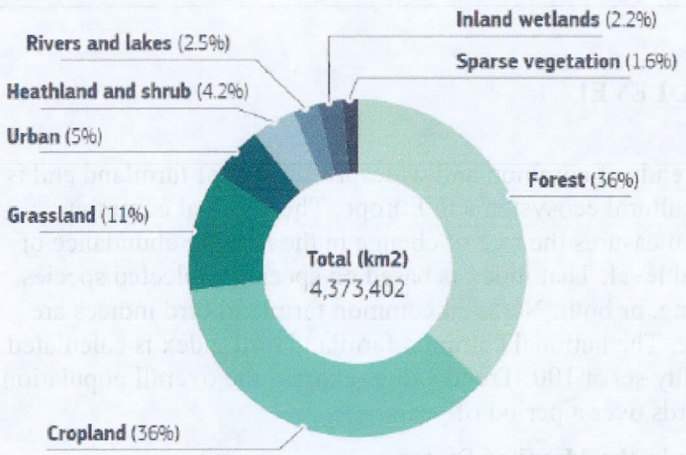
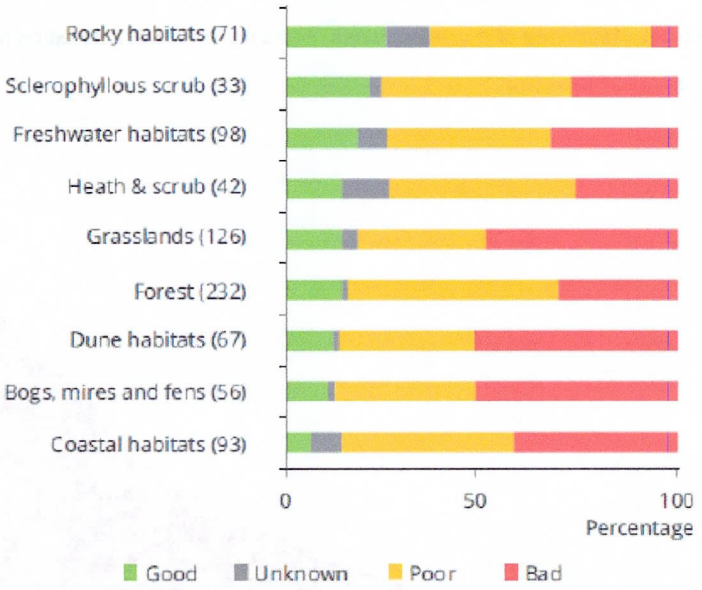


Figure 2-2 Conservation status per habitat group at the EU level

Source: Taken from EEA (2020) State of nature in the EU, Results from reporting under the nature directives 2013-2018. EEA Report No.10//2020.



	• Synergies with related EU initiatives, e.g. LULUCF, Farm to Fork strategy.	
	General *Corresponding to the general objective of the Biodiversity Strategy for 2030.*	Specific Corresponding to the proposal for legally binding restoration targets
Policy and Legal Context	• European Green Deal • EU Biodiversity Strategy • Existing legislation to protect and restore biodiversity and ecosystems such as the Bird and Habitats Directive, Water Framework Directive and the Marine Strategy Framework Directive • Related EU initiatives, e.g. Farm to Fork, revision of the LULUCF Regulation • Strong public interest in nature restoration.	
Problem	General problem: Biodiversity loss and ecosystem degradation	Specific problem: Largely insufficient ecosystem restoration in the EU. Need for more ambitious nature restoration to reverse biodiversity loss, as nature protection alone is insufficient.
Drivers	Main direct drivers of biodiversity loss and ecosystem degradation: • Changes in land and sea use; • Over-exploitation of natural resources; • Climate change; • Pollution; • Invasive alien species.	Specific policy and legislative drivers of insufficient ecosystem restoration in the EU: • Voluntary approaches have been ineffective • Gaps in existing legislation • Lack of comprehensive approach • Funding challenges • Political commitment and ownership by Member States
Objectives	General objective Reverse biodiversity loss so that: • Europe's biodiversity is on the path to recovery by 2030; • All of the EU's ecosystems are restored and resilient by 2050; • Implement the Biodiversity Strategy for 2030).	Specific objectives: To restore degraded ecosystems across the EU, in particular those that have the most potential to remove and store carbon and prevent and reduce the impact of natural disasters. Operational objectives: • Introduce time-bound, measurable, legally binding targets to enable restoration of ecosystems across the board and in a way that addresses the main ecosystem types. • Establish a governance and implementation structure to enable this restoration and ensure that restored ecosystems do not deteriorate. • Set out requirements for effective monitoring, planning, financing and capacity.
Policy Options	Option 1: Baseline scenario Option 2: Overarching legally binding target for ecosystem restoration Option 3: Legally binding targets for specific ecosystems, habitats or (groups of) species Option 4: Hybrid of legally-binding ecosystem-specific targets with an overarching objective	

Figure 4-1 Projected restoration effort (extent) based on Eftec et al and remaining gap to 15-40-100% HD Annex I targets

Note: This figure assumes that Eftec et all only identified 25% of actual restoration action in the then EU28, and the total effort towards the targets reflects the best-estimate total area of degraded Annex I habitats in the EU27 based on the last conservation status reporting under the EU Habitats Directive (Art 17 reporting)[50].

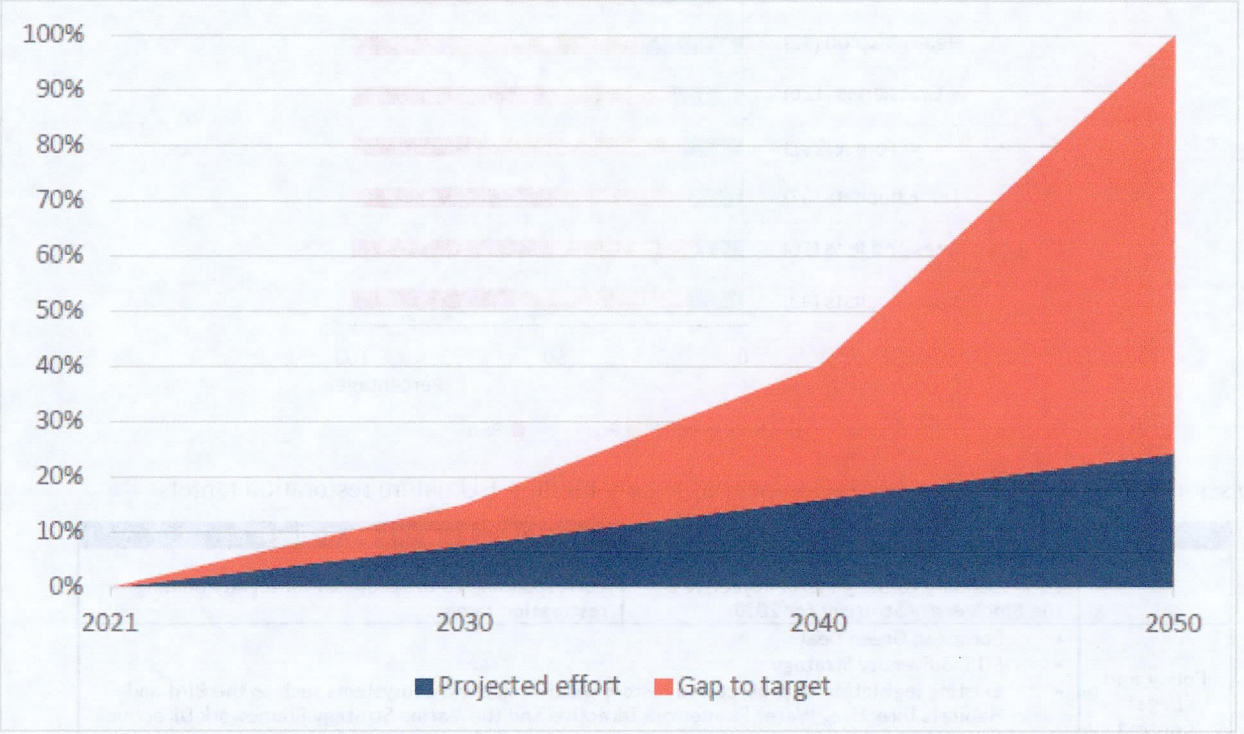


Table 5-1 Potential Ecosystem-specific Targets for Restoration in Step 1 of Stepwise Approach

SELECTED TARGETS FOR STEP 1
WETLANDS (incl. Peatlands, marshlands & coastal wetlands)
- Restore all HD Annex I wetland habitat area to good condition, with all necessary restoration measures completed on 30 % (or 15 %) of degraded areas by 2030, 60 % (or 40 %) by 2040 and 100 % by 2050.
- *For peatlands only*: Re-wetting at least 25 % of HD Annex I peatland habitat area degraded due to drainage by 2030, 50 % by 2040 and 100 % by 2050 so that the water table is at, or with 15cm of the surface. - Recreate 30 % (or 15 %) of additional habitat area required to achieve favourable conservation status of HD Annex I wetland habitats by 2030, 60 % (or 40 %) by 2040 and 100 % by 2050. - Restore and re-create the area as necessary to enhance the conservation status of species listed in Annex II, IV and V of the Habitats Directive as well as wild birds associated with wetlands in view of achieving their favourable conservation status by 2050, with at least 30 % achieved by 2030 and at least 60 % by 2040.

Table 6-1: Overview table of likely dimensions impacting on the prioritisation of certain ecosystem types over others in implementing an overarching target

Key: Blue=Criterion is likely to encourage restoration of this ecosystem within an overall target; Orange=Criterion may have a moderate or mixed effect in encouraging restoration of the ecosystem; Red=Criterion may discourage restoration of this ecosystem within an overall target.

Please note: The scope of this impact assessment also includes pollinators and soils which, due their cross-cutting nature, were not included as a separate ecosystem in this table. Their restoration needs would however need be integrated in the implementation of the overarching target under different ecosystem types.

Ecosystem	Ecosystem extent	Technical feasibility	Need for coordinated international action	Cost per hectare	Benefit:Cost ratio	Opportunity cost/ stakeholder resistance	Contribution to climate mitigation and adaptation	Contribution to disaster prevention and protection	Overall assessment
Peatlands and wetlands	Low	Re-wetting of most drained semi-natural peatland is straightforward, full restoration of highly degraded	Moderate	Moderate per hectare costs	Good B:C ratios	Low for Annex 1 habitats	Exceptionally high potential for carbon storage and sequestration, improved water retention can also contribute to adaptation	High in flood prone catchments where reversing drainage reduces run-off rates and downstream flooding	Likely to be a priority for restoration for those MS with degraded peatlands, given strong climate mitigation benefits.
		peatland is difficult							

Table 6-2 Overview table of all ecosystem-specific target options screened in and assessed for this Impact Assessment study

Ecosystem	Target	Intended impacts			
		Biodiversity	CC mitigation	CC adaptation	Ecosystem services (other)
Inland wetlands and peatlands	The full recovery of Habitats Directive Annex I peatlands to good ecosystem status (i.e. favourable conservation status), including through the following: • Re-wetting at least 25% of HD Annex I peatland habitat area degraded due to drainage by 2030, 50% by 2040 and 100% by 2050 so that the water table is at, or with 15cm of the surface. • Restore all HD Annex I peatland habitat area to good condition, with all necessary restoration measures completed on 15% / 30% of degraded areas by 2030, 40% / 60% by 2040 and 100% by 2050 • Re-create the area necessary to achieve Favourable Conservation Status of HD Annex I peatlands at national biogeographical level by 2050, with 15% / 30% achieved by 2030 and 40% / 60% by 2040, and 100% achieved by 2050.	*****	*****	****	****
	Marshes- to maintain, restore and re-create marshlands as necessary to achieve the favourable conservation status of species associated with marshlands listed in Annex II, IV and V of the Habitats Directive, and the secure status of wild birds associated with marshlands, by 2050, with at least xx% achieved by 2030 and at least xx% by 2040.	****	*****	*****	****
	Peatland converted to cropland- Reduce the area of managed or drained organic soils that are losing carbon by 15% by 2030, 40% by 2040 and 100% by 2050.	***	*****	****	****

Table 6-7 Estimated benefits for each ecosystem under the two scenarios

Overview of benefits for the preferred option - until 2070 (Present Value)				
	Scenario A (15-40-100% targets for 2030-2040-2050)		Scenario B (30-60-100% targets for 2030-2040-2050)	
Restoration of ecosystem type	Carbon benefits in EUR million	Benefits from all ecosystem services (including carbon) in EUR million	Carbon benefits in EUR million	Benefits from all ecosystem services (including carbon) in EUR million
Peatlands	10 629	38 702	13 042	47 488

Reference number 184 : WD(2022) 167 final Part 1/12 Commission Staff Working Document Impact Assessment Accompanying the proposal for a Regulation of the European Parliament and of the Council on nature restoration Brussels, 22.6.2022

Table I: Restoration needs of habitats listed in Annex I of the Habitats Directive based on reporting by Member States (2013-2018). Romania is excluded because its reported Annex I areas exceed the terrestrial area of the country. Source: EEA.

Ecosystem based on Annex I types *(N° of Annex I habitat types)*	Surface[1] Annex I habitats in km²	Condition in km² & %			Overall restoration needs in km²	
		Good	Not good	Unknown	Area re-establishment (min/max)	Improvement in condition (min/max)
Wetlands[2] (inland & coastal) *(28)*	174 400	62 950 36%	27 100 16%	84 300 48%	3 131 6 910	27 100 111 400
Forests[3] *(69)*	357 952	162 300 45%	79 210 22%	116 444 33%	3 487 8332	79 210 195 000
Agro-habitats and grasslands[4] *(35)*	177 442	84 150 47%	31 180 18%	62 100 35%	2 431 8 798	31 180 93 000
River, lakes, alluvial and riparian habitats[5] *(32)*	96 480	52 970 55%	21 560 22%	21 950 23%	894 2 743	21 560 38 000
Heath & scrub[6] *(21)*	78 582	43 420 55%	6 590 8%	28 600 36%	405 928	6 586 35 000
Rocky and (Coastal) & dunes *(41)*	65 135	30 048 46%	6 619 10%	28 500 44%	355 1 458	6 619 35 100
Total Terrestrial	**949 990**	**435 838** **46%**	**172 259** **18%**	**341 894** **36%**	**10 703** **29 169[8]**	**172 255** **505 500[9]**
				Total restoration terrestrial:	**182 985 – 536 669 km² [10]**	
Marine[7] *(4)*	240 030	36 810 15%	34 830 15%	168 390 70%	1 622 3 424	34 828 203 200
				Total restoration marine:	**36 450 – 206 624 km² [11]**	

Table II: Overall restoration needs, by Member State, of habitats listed in Annex I of the Habitats Directive, based on reporting by Member States (period 2013-2018) under Art.17 of the HD – EU27 (excluding Romania for data quality reasons). Source: EEA.

Member State	Member State surface in km²	Overall restoration needs (all ecosystems) in km² TERRESTRIAL				Overall restoration needs in km² MARINE
		Area re-establishment (min/max)	Area improvement (min/max)	Total restoration area (min/max)	% of MS territory (min/max)	(min/max)
Ireland	70 699	313 / 640	5 180 / 5 657	5 493 / 6 297	7.8 / 8.9	3 014 / 24 542

Table III: MINIMUM restoration needs, by Member State and by Annex I habitat, based on reporting by Member States (period 2013-2018) under Art.17 of the HD – EU27. Source: EEA.

		MINIMUM ecosystem areas (km²) for restoration (improvement + re-establishment)						
	MS area (km²)	Wetlands	Rivers & lakes	Grasslands & agri	Forests	Heath & scrub	Rocky & dunes	Terrestrial
IE	70.699	3.753	928	692	19	54	47	5.493

Table IV: MINIMUM restoration needs, by improvement/re-establishment, by Member State and by Annex I habitats, based on reporting by Member States (period 2013-2018) under Art.17 of the HD – EU27. Source: EEA.

Condition: area reported in 'not-good' condition: in need of improvement. Zeros often reflect that most areas have been reported as 'unknown condition'

Additional: for re-establishment: based on minimum Favorable Reference Areas.

	MINIMUM ecosystem areas (km²) for restoration (improvement and re-establishment)												
	Wetlands		Rivers & lakes		Grasslands		Forests		Heath & scrub		Rocky & dunes		
	condition	Additional	condition	Additional	condition	addition al	condition	addition al	condition	addition al	condition	addition al	Terre-strial
IE	3.527	226	928	0	611	82	19	0	54	0	42	4	5.493

Reference Number 185 : Scottish Government, Scottish Natural Heritage, SEPA (2017) Peatland Survey. *Guidance on Developments on Peatland*

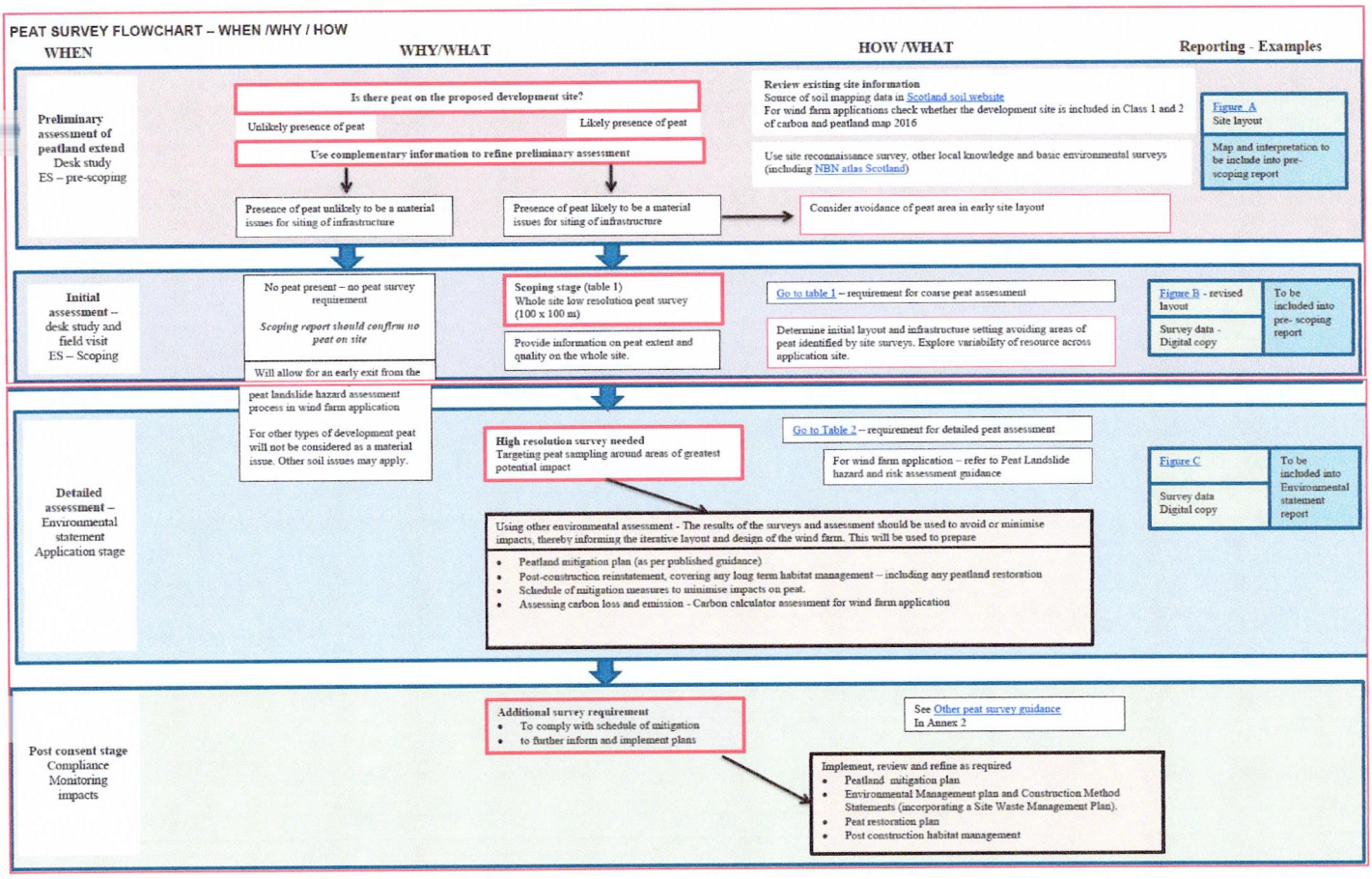


TABLE 1 – PRELIMARY ASSESSMENT OF PEATLAND EXTENT AND CONDITIONS

A field evaluation at low resolution will determine the presence of peat across the whole site. This is usually undertaken at an early stage in the EIA process.

Area coverage	Whole proposed development site
Peat depth survey resolution	Low resolution - Usually 100 m X 100 m on a regular grid pattern across the whole area proposed for development. Greater intensity surveys will not be required for areas that are unlikely to be developed.

A- Information to be sampled and gathered during peat depth survey	B- Other ancillary information to be recorded during field visit	C- Other information collected as part of Environment statement	D- Methodology for peat depth survey	E-Data interpolation
1- Location of each individual sampling point - Grid reference of each sampling point (at least precision to 100 cm) – use of GPS device is essential.	1- Contextual information, including surface drainage conditions	1- Detailed Phase 1 Habitat Survey whole site and National Vegetation Classification (NVC) Survey in locations where infrastructure is proposed which provide identification of Annex I habitats and Ground Water Dependent Terrestrial Ecosystems.	1- Peat depth surveys are usually conducted using peat probes (sometimes referred to as depthing rods). Probes should be long enough to cover the whole peat depth.	1- Detail on the geo-statistical procedure used to generate the estimated peat distribution map from the scattered set of peat depth values (i.e. interpolation using natural neighbor, IDW, Spline function, Kriging using QGIS, ARCGIS or other software)
2- Depth of the peat deposit – all occurrence of peat deposit (even if less than 50cm) should be recorded with at least a 10 cm precision. When no peat deposit is present a value of zero should be entered.			2- More information can be collected using a gouge auger – such as information on peat stratification and localized surface hydrological conditions. (See A-3)	
3- Composition of the soil column / type of peat (fibrous, semi-fibrous or amorphous) / moisture within the soil column where a auger is used instead of peat rods (see additional information in Annex 1)	2- Photography at selected viewpoints to provide a visual context of the spatial data		**E- Information presentation (see section 4, figure A)**	
4- Slope and other pertinent features such as active, incipient or relict instability should be recorded to inform the Peat Landslide Hazard & Risk[1] Assessment that will inform whether these areas should also be avoided.			• Geo-referenced peat depth data provided in a table • Peat distribution map • Peat depth data and interpolated distribution map provided as GIS shape file • Habitat Maps – Phase 1 and NVC	

[1] http://www.gov.scot/Publications/2006/12/21162303/1

TABLE 2 - FURTHER ASSESSMENT OF PEATLAND EXTENT AND CONDITIONS

For areas potentially to be developed to determine where peat is and how deep it is. This is so that developments can be designed to avoid the areas of deepest peat and minimise the impacts on peat and peatland environment, as much as possible.

Area coverage & resolution	Targeted sampling regime tailored to potential development areas within the proposal boundary. Sampling should focus on areas of greatest potential impact from development including:
	• full targeted probing along all tracks, at all turbines/hard standings, turning points and passing places, site compounds, substation, borrow pits and met mast locations
	• detailed survey on a 10m by 10m grid basis around the centre of each proposed turbine base or other infrastructure including borrow pits and proposed temporary storage sites. Need to take account of potential micro-siting limits.
	• Detailed survey at 10 to 50m intervals along proposed track/road locations using 10m right angled offsets. Need to take account of potential micro-siting limits.

A - Information to be sampled and gathered during peat survey	B- Other ancillary information to be recorded during field visit	C- Methodology for peat depth survey	D- Data interpolation and analysis
1- Grid reference of each sampling point (precision at least 50 cm) – use of GPS device is essential.	1- Photography of areas of proposed infrastructure	1- Survey should use hand held GPS device with at least 50 cm resolution. This is used to record and locate sampling points and markers to identify the grid pattern being applied across the site.	1- Detail on the method used to calculate the depth and volume of peat that will be excavated at different locations.
2- Total depth of the peat deposit at each sample point (accurate measurement with at least 5 cm precision – including in areas where peat is less than 50cm, or is absent.)	2- Contextual information and other information that is collected as part of the Environment statement	2- Conduct surveys using an auger to identify the thickness of peat deposits, as well as providing an indication of peat stratification and localised surface hydrological conditions. Peat probes are not sufficient for collecting samples at depth.	2- Detail of any geo-statistical procedure used to generate the estimated peat distribution map from the scattered set of peat depth values (i.e. interpolation using natural neighbor, IDW, Spline function, Kriging using QGIS, ARCGIS or other software)
3- Description of the soil core column including texture, depth and moisture content. These should be provided using recognised field assessment protocols (see additional info below about *Soil survey of Scotland Peat survey methods*)	3- Results of detailed habitat and vegetation surveys including Phase 1 Habitat Survey across the whole site and National Vegetation Classification (NVC) Survey in locations where infrastructure is proposed, which will provide identification of Annex I habitats and Ground Water Dependent Terrestrial Ecosystems	3- Soil augers or Russian peat samplers/corers, capable of extracting peat samples for carbon analysis, bulk density measurements and the degree of decomposition are required. Surveys should be undertaken by suitably skilled surveyors. This should be capable of reaching total core depth, and extension rods should be used where required. The minimum number of samples should reflect the diversity of habitats (4 samples in most cases). Selected samples should be representative of peat in areas where development is planned. The results can be checked against nationally derived estimates of bulk density and total carbon content to ensure accuracy.	
4- Peat bulk density samples for laboratory analysis		4- Samples collected should be carried back for laboratory assessment in labeled, air and water tight containers (or polypropylene bags) prior to analysis.	**Information presentation (see section 4, figures B and C)**
5- Details of peatland characteristics such as surface vegetation cover density, vegetation type, artificial drainage features, signs of historic and current erosion (gullies, rills or hags) and peat stability on slopes. Note some of this may have been undertaken as part of any habitat survey.		5- Additional habitat survey sampling protocol based on quadrats to describe the vegetation. Phase 1 and NVC guidance[9,10] should be used to provide a representative survey across the site. This should be undertaken by suitably qualified ecologists.	• Tabulated survey results - Geo-referenced and including all information collected at each sampling / survey points • All map of peat distribution map should include an overlay all proposed infrastructure locations • Interpolated map should include location and depth of surveyed points as an overlay. • Peat depth data point and interpolated distribution map provided as GIS shape file • Average peat depth and maximum peat as required in the Carbon Calculator assessment • Volume of excavated peat to inform the Peat Management Plan • Drawings and tables demonstrating how and where peat will be re-used • Calculations relevant to peat hazard and risk assessment

Annex 1 - Additional information – extract of Soil survey of Scotland Scottish Peat survey methods

Relevant sections of the 1964 Soil Survey of Scotland Scottish Peat Survey methods[2] methodology shown below will inform the conduct of an appropriate site survey to determine peat stock and condition on site. Note S.I unit must be used.

Soil survey of Scotland Scottish Peat survey methods

Section 1 to 2 no included

Section 3 - FIELD WORK

a) to c) not included

d) Surface firmness estimation

It is necessary to make some estimate of the bearing capacity of the bog surface as this will influence the type of machines recommended for initial and subsequent exploitation. Modem bog tractors have a ground pressure of less than 2 lb. per square inch but the total pressure applied is also affected by the character and density of the vegetation and whether the tractor carries or pulls its loads. A miller or rotavator for instance imparts a forward push to a tractor.

An average man standing on one foot applies a pressure to the ground of between 5 and 6 lbs. p.s.i. and this fact is used to estimate the bearing capacity. The following symbols are used to denote the pressure the ground will stand.

Firmness of surface (P)

P0 = Surface too soft to walk on

P1 = Surface just passable

P2 = Surface fairly firm

P3 = Surface firm

As an example, Table 1 shows data from White Moss, Mainland, Orkney.

P0		P1		P2		P3		Total number of observations
No	Percent	No	Percent	No	Percent	No	Percent	
0	-	1	16.7	3	50.0	2	33.3	6

In practice these data mean that some 83 per cent of the bog could be developed with mechanical equipment without much difficulty. On 17 per cent of the area some care would be required but this softer part would be expected to become firmer as drainage began to have a consolidating effect.

Table 2 shows to some extent the relationship between the surface moisture content (for the stratum 0-20 in. (0-0.5 m)) and the estimated bearing capacity.

P-value / Moisture content (%)	P1	P2	P3
Average (range)	93.8 (92.4-94.7)	92.2 (86.5 -94.5)	89.0 (79.4-92.2)

(No data for areas rated P0)

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[2] Soil Survey of Scotland Scottish Peat Surveys, 1964. http://www.gov.scot/Topics/Business-Industry/Energy/Energy-sources/19185/17852-1/CSavings/PS1964

Although the differences in terms of percentage water in the peat appear small, it is important to note that a 1 per cent increase in water content at or near the figure of 90 per cent which is common for peat, results in a decrease in solids content of 10 per cent and the peat becomes appreciably more fluid and less able to bear applied pressure without collapse.

e) Observations on the vegetation

The plants growing within a radius of 49 to 66 ft (15-20 m) round each bore hole are recorded, as are the boundaries between well-defined plant communities which are noted during traverses across the bog.

f) Observations on the peat

i. *Botanical* origin

The range of vegetable remains easily identifiable in the field is strictly limited and laboratory analyses of the many hundreds of samples taken in anyone season would be vastly time-consuming. However, it is usually possible to ascertain the main peat-forming species in the field and this is done for all samples examined.

The universal peat formers found in both Blanket and Raised Basin Bogs are species of *Sphagnum.* Also found in most bogs are the remains of *Eriophorum vaginatum,* the leaf-sheaths of which contain fine fibres which are extraordinarily resistant to the processes of decomposition, and small twigs of *Callana vulgaris* which are generally found in the upper strata. The usual type of peat found in the lower horizons of Basin Bogs is a mixture of the remains of *Carex* species with smaller amounts of *Phragmites, Typha, Equisetum* and *Menyanthes,* all or some of which are usually present. Wood remains are frequent, even in areas which are now treeless such as Shetland. The commonest wood is *Betula* but *Pinus* is not uncommon and it is probable that *Salix, Alnus* and Cory*lus* occur more often than they are recognised. Field identification of wood fragments is somewhat uncertain.

ii. Degree *of humification* - von POST SCALE

The degree of humification of peat samples is estimated in the field according to the method devised by the Swedish botanist L. von Post.

A small amount of peat is squeezed in the hand and the water and! or peat exuded indicates, by its colour and consistency, the degree to which the peat has undergone humification or, more correctly, a type of decomposition which includes breakdown under anaerobic conditions. This is one of the most important observations to be made on the peat and, because it is entirely subjective, one of the most difficult to make with a minimum of error. As far as possible, the same person makes all such observations and experience counts for a great deal. It is necessary to make allowance for moisture content, oxidation of the surface horizons and for the botanical origin of the peat. Obviously for example, pieces of wood do not squeeze between the fingers and yet the matrix in which the wood fragments are embedded may be very highly humified. A very dry peat may appear to be less well humified than it actually is and vice versa. Attempts have been made by various workers to develop an objective method for the estimation of degree of humification but without conspicuous success.

The von Post scale ranges from 1 to 10, the higher the number the higher the degree of humification. The full scale is as follows:

DEGREE OF HUMIFICATION - von POST SCALE

H1	Completely undecomposed peat free of amorphous material. On squeezing, clear colourless water is pressed out.
H2	Nearly undecomposed peat, free of amorphous material, yielding only yellowish brown water on pressing.
H3	Very slightly decomposed peat, containing a little amorphous material. On squeezing, muddy brown water but no peat passes between the fingers. Residue is not pasty.
H4	Slightly decomposed peat containing some amorphous material. Strongly muddy brown water but no peat passes between the fingers. Residue is somewhat pasty.
H5	Moderately decomposed peat containing a fair amount of amorphous material. Plant structure recognisable though somewhat vague. On squeezing, some peat but mainly muddy water issues. Residue is strongly pasty.
H6	Moderately decomposed peat with a fair amount of amorphous material and indistinct plant structure. On pressing, about one third of the peat passes between the fingers. Residue is strongly pasty, but shows the plant structure more distinctly than in unsqueezed peat.
H7	H7 Strongly decomposed peat with much amorphous material and faintly recognisable plant structure. On squeezing, about one half of the peat is extruded. The water is very dark in colour.
H8	Strongly decomposed peat with much amorphous material and very indistinct plant structure. On squeezing, two thirds of the peat and some water passes between the fingers. Residue consists of plant tissues capable of resisting decomposition (roots, fibres, wood, etc.).
H9	Practically fully decomposed peat with almost no recognisable plant structure. Nearly all the peat squeezed between the fingers as a uniform paste.
H10	Completely decomposed peat with no discernible plant structure. On squeezing, all the peat, without water, passes between the fingers.

Mean H-values are calculated for each bog and its sub-areas if required and also for each 20 in. (0.5 m.) layer from the surface to the bottom. The variation with depth is shown graphically in the Bog Reports. The usual pattern is for the H-value to increase more or less steadily with increasing depth unless the origin of the peat changes drastically. When *Carex* peat occurs near the bottom of a deposit, the degree of humification generally falls to a value similar to that found in the upper layers of the bog.

Peats of low degrees of humification are those commonly described as "light" or "brown" and are used as moss litter and in horticulture. The highly humified "black" or "blue" peats comprise good fuel types. In recent years horticulturalists have been less insistent on having the very light peats since rather darker qualities have been found equally useful for many purposes.

Inspection of humification data from the surveys shows that the extremes of the von Post scale are rarely encountered (i.e. H1 and H10). The majority of samples lie about the centre of the scale with small shifts of the average towards the lower or higher values depending upon whether the peat in the bog is of a fuel or a moss litter type.

iii. Fibre

The fibre content of each peat sample is estimated visually and the amounts of the two types (classified 'fine' or 'coarse') are noted on a scale ranging from 0 to 3 as shown below. Accurate quantitative determinations are made later on bulk samples in the laboratory as described in section 4(f).

Fine fibres, mainly derived from *Eriophorum spp.* (F)

F0 = Nil
Fl = Low content
F2 = Moderate content
F3 = High content

Coarse fibres, mainly rootlets (R)

R0 = Nil
Rl = Low content
R2 = Moderate content
R3 = High content

iv. Wood

Wood remains, especially if they are large and resistant, may conceivably cause a certain amount of difficulty during the exploitation of a bog. An attempt is therefore made when sampling to assess the extent of wood. It is estimated on a scale ranging from 0 to 3 as detailed below.

Wood remains (W)

W0= Nil
Wl = Low content
W2 = Moderate content
W3 = High content

Extensive wood remains of a type that might prove a serious obstacle to exploitation are not frequent but bogs with this feature have been surveyed in Sutherland and Aberdeenshire.
In Blanket Bogs, impenetrable wood is found mainly in sheltered valleys; in Raised Basin Bogs it tends to occur at the margins of the deposits.

v. Other *observations*

When peat is freshly sampled and before it darkens by oxidation, note is taken of its colour, stratification, the presence of visible mineral matter and any other features of interest.

Section 4 - OFFICE AND LABORATORY WORK

a) not included

b) Calculation of the volume of raw peat

This calculation is based on the area of deep peat and the average depth in that area. If the bog is divided into sub-areas, the volume of peat in each sub-area is calculated separately. The accuracy of the calculation depends largely upon the accuracy of the calculation depends largely upon the accuracy of the calculated average depth. In this connection the Scottish Statistical Office has carried out Standard Error calculations on the depth measurements for some bogs and, for example, in the Moss of Cree, Wigtownshire survey, found the S.E. to be ± 0.0971. There is a high degree of probability that the true average depth lies within the limits: calculated average depth plus or minus twice the S.E. In this case therefore the true average depth is probably within the range 10.64-11.92 ft. (3.246- 3.634 m.) and the true volume of peat will lie between 17.8 and 19.9 million cu. yd. (13.6-15.2 million cu. m.). (Survey results indicate an average depth of 11.3 ft. (3.44 m.) and a volume of 18.8 million cu. yd. (14.4 million cu. m.)).

The calculation of the exact volume of peat is not the most important task in a bog survey. It must be established which part or parts of a deposit may be most economically developed and for what purposes. The data should also indicate which of the several possible methods would be the choice in particular circumstances. It should also be noted that, although the total amount of peat present in a bog may be fairly accurately estimated, it is usually the case that not all this material could be exploited because of various factors, the most important of which is the variation in depth due to changes in level of the bog floor. In practice not more than approximately 70 per cent of the total volume could be utilised in the majority of deposits.

An example of data from one of the surveys is given in Table 3.

Sub-area	Area of deep peat (over 20 in. (0.5m)		Average depth		Volume of raw peat	Solids	
	acres	hectares	Feet	meter	Millions of cubic metres	Percent	Millions of tons
I	2,342	948	13.5	4.1	37.38	8.1	3.03
IA	215	87	9.8	3.0	3.15	7.2	0.23
II	917	371	9.2	2.8	10.21	9.3	0.95
III	1,275	516	7.5	2.3	14.69	8.7	1.28
IV	1,883	762	8.2	2.5	16.45	9.3	1.58
total	6,632	2,684	-	-	81.86	-	7.07

(1 cu. m = 1.308 cu. yd)

c) Moisture and solids contents

Earlier surveys of many Scottish bogs by the International Survey Company, a British Company which worked in conjunction with Peco Ltd., were not sufficiently detailed to allow an accurate estimation of the moisture content to be made. The current series of surveys has shown that these early estimates of moisture content tended to be rather low.

The estimation of moisture content entails considerable work which must be done within a short time of the samples being collected in order to avoid error by evaporation and mechanical loss. The number of samples to be taken is a matter of judgment, bearing in mind the degree of accuracy required, the time available for field work and the capacity of the laboratory. No rigid routine is followed.

d) Bulk density

The bulk density of the peat solids, including ash, is determined in the laboratory as follows:-

i. the sample is completely dried and ground to pass a 1 mm. screen.
ii. the ground sample is put into a graduated container and exposed to a standard number of controlled taps on a tapping machine.
iii. the volume after compaction is noted and, related to the weight, gives the bulk density in g. per cc.

A certain degree of correlation can sometimes be demonstrated between the degree of humification, the bulk density and the calorific value but comparisons are subject to the probable error introduced by the subjective estimation of the degree of humification.

e) Ash content

The content of ash in peat is an extremely variable factor and is in no sense diagnostic.
It is useful to know the ash content of any particular peat in that it may have some bearing on the suggested utilisation of the bog but it can be so greatly affected by numerous outside agencies that its value as a factor in classification is virtually nil. For example, coastal bogs exposed to on-shore winds tend to be high in ash due to the long-continued deposition of wind-borne sand and spray; valley bogs also tend to have high ash contents because of the continual inflow of ron-off from the surrounding slopes carrying mineral particles eroded from these slopes. Peat areas subject to flooding are frequently grossly contaminated with mineral matter deposited by flood water, often in distinct strata visible to the eye.

f) Fibre content

Large samples are taken for laboratory estimation of fibre content, each being a mixture of peat from all levels of one bore hole. Each sample is washed through sieves to remove the finely divided material and the fibrous residues are dried and weighed. The results are expressed as a percentage of the total solids content which is separately estimated on another similar sample.
The data shown in Table 4 are collected from a number of bog reports.

Table 4 – Fibre content

Name of deposit and location	Classification of bog peat	Fibre (per cent of total solids)		
		Fine	Coarse	Total
Achaim, Caithness	Blanket	7.3	8.6	15.9
Altnabreac, Caithness	Blanket	11.75	2.6	14.35
Kame, Shetland	Blanket	4.5	12.2	16.7
Garror, Perthshire	Raised Basin	3.7	12.9	16.6
Mindork, Wigtownshire	Raised Basin	4.9	13.2	18.1
Cranley, Lanarkshire	Raised Basin	5.9	8.8	14.7

It should be mentioned that the fibre content varies considerably from place to place even within one bog area. The data obtained are, therefore, only a guide to the amount of fibre present.

Section 5 ASSESSMENT OF DATA

a) drainage

All data relevant to the drainage possibilities of a bog are collected during the survey and include information on water levels, outfalls, catchment areas and any deep basins or "pockets" in the floor of the bog which might pose special problems in the drainage of the bottom should the peat be removed.
Existing ditches are examined and are mapped if in reasonable condition and capable of future use. Non-functioning ditches are noted but not recorded in detail.
Tentative drainage schemes suggested for a particular bog usually include a layout of at least the main ditches for the bog itself and an assessment of the work that would be required to carry run-off to the nearest convenient outlet.

Reference Number 186 : The extent of windfarm infrastructures on recognised European blanket bogs. Guaduneth Chico, T. Clewer, N. G. Midgley, P. Gallego-Anex, P. Ramil-Rego, J. Ferreiro, E. Whayman, S. Goeckeritz & T. Stanton. Scientific Reports | (2023) 13:3919 | https://doi.org/10.1038/s41598-023-30752-3

Peatland environments are the Earth's largest terrestrial carbon store and have the potential to act as carbon sinks. However, the development of windfarms on peatlands is affecting their morphology, hydrology, ground-level climate conditions, carbon functions and vegetation, and long-term consequences still need to be assessed. Blanket bogs are a rare type of ombrotrophic peatland that are typical of oceanic areas with high precipitation and low temperatures. Their distribution has been mapped across Europe, where they are mainly located on hill summits where wind energy potential is higher, making them attractive sites for windfarm developments. The promotion of renewable energy is currently a priority given the environmental and economic drive to increase low-carbon energy production. Establishing windfarms on peatland in pursuit of greener energy, therefore, risks compromising and undermining the green-energy transition. Despite this, the extent of windfarm infrastructures on blanket bogs have not yet been reported at the European scale. This research reports the extent of windfarm infrastructures on recognised blanket bogs, with a geographical focus on Europe, where blanket bogs have been mapped systematically. Under the EU Habitats Directive (92/43/EEC), there are 36 European regions NUTS level 2 with recognised blanket bogs. Of these, 12 have windfarm developments, including 644 wind turbines, 253.4 km of vehicular access tracks and an affected area of 207.6 ha, mainly in Ireland and Scotland where the extent of blanket bogs is also higher. However, despite Spain having under 0.2% of Europe's recognised blanket bogs area, this was the most affected country. In Scotland, a comparison of the recognised blanket bogs under the Habitats Directive (92/43/EEC) with blanket bogs recorded in national inventories indicates that the extent of windfarm developments was higher, with 1,063 wind turbines and 634.5 km of vehicular access tracks. Our results highlight the extent of windfarm developments on blanket bog habitat, both in areas where peatlands are broadly distributed across the landscape, and also in areas where this recognised habitat is particularly rare. There is a pressing need to assess the longterm impacts of windfarms on peatlands to ensure that efforts to meet energy targets result only in carbon sequestration, and do not jeopardise ecosystem services. Blanket bogs represent a particularly vulnerable habitat, the study of which should be prioritised updating national and international inventories to protect and restore this habitat.

Peatland environments are recognised as a potential carbon sink when in either restored or pristine condition.

This terrestrial habitat only covers 2.84% of Earth's land surface, but they represent over 25% of the total terrestrial carbon.

In Europe, only 5.2% of the land is covered by peatlands, where Nordic countries concentred most of this habitat.

There are several peatland classifications based on environmental factors, such as climate, geomorphology and vegetation; however, there is not a single factor classification system.

The hierarchical classification provides a method to study peatlands in relation to the scale of analysis with specific criterion for each level of analysis (e.g. nanotope, microtope, mesotope, macrotope and supertope). This enables the combination of vegetation, landforms, and hydrology to provide a better understanding of the relationships within peatlands environments.

There are two types of bogs based on the water sources and their topographical location; blanket bog and raised bog. The main geomorphological difference is whether they are covering the topography as a located in valleys or around water courses.

Blanket bogs are a rare ombrotrophic (rain-fed) type of peatland commonly found in hyperoceanic conditions with high precipitation (> 1000 mm yr-1), low temperature (< 15 °C) and low seasonal temperature variability; although some exceptions are found in areas with lower precipitation (e.g. The Falkland Islands) highlighting the need of a global classification approach for this habitat. Globally, it has been estimated that blanket bogs cover around 10 million ha mainly in the Northern Hemisphere.

In Europe, the most important and extensive blanket bogs are found in the British Isles with some occurrence in Norway, France, Austria, Sweden, Spain and Portugal (Azores Islands). Blanket bogs usually cover large extensions of the landscape, although they could be covering small areas in certain locations, mainly because of topographical limitations (e.g. high slope). Peat depth can vary from a few centimetres to several metres depending on the climatic conditions and topography.

Notwithstanding the extensive peatland restoration projects (e.g. LIFE programme) and their positive implications for peatland ecosystem services, a large proportion of these blanket bogs are currently in an unfavourable condition.

Blanket bogs with favourable status are only found in France, Sweden and Portugal, where they represent less than 2% of the total extent of recognised blanket bogs across the EU and the UK.

Pressures such as peat extraction for fuel and horticulture, forestry, overgrazing, drainage, burning for recreational activities and anthropogenic infrastructures, have affected the stability of blanket bog habitats for centuries. Current threats frequently included in Habitat Directive conservation status reports for blanket bogs are variable across Europe (Table 1), although agriculture, drainage, and intensive grazing are the most common issues. However, morerecently, windfarm developments, have been highlighted as a concerning pressure for this habitat having impacts on peatland hydrology, ground-level climatic conditions and habitat biodiversity, contributing to vegetation changes and habitat transition. This pressure not only affects the areas where turbines are installed, but also where associated infrastructures, such as tracks, sub-stations and associated facilities are built. Windfarm infrastructures have an impact on the peatland surface affecting the hydrological units, as well as promoting vegetation changes and habitat loss.

The Directive EU 2018/2001 on the promotion of the use of energy from renewable resources aims to promote the use of renewable energy across the EU27 based on Article 194 of the Treaty on Functioning of the European Union, requiring member states to promote energy efficiency and saving. By 2030, at least the 32% of the energy consumed across the EU should be renewable. In 2020, 36% of the EU renewable energy was produced by windfarms, demonstrating the importance of this technology in reducing our carbon emissions. Although the need to expand international renewable energy capacities is clear, it is important that the pursuit of legislative energy requirements and targets does not compromise the aims of alternative environmental legislation. Therefore, a legislative conflict exists between the Habitats Directive and Renewable Energy Directive that must be acknowledged and addressed. Both directives aim to reduce carbon emissions by restoring carbon sinks and promoting renewable energy transitions and, though windfarm development is permitted on Natura 2000 sites or recognised blanket bogs under the Habitats Directive, if they negatively affect the integrity of the site and the impacts cannot be mitigated by additional measures, authorisation for the development should not be granted.Noting the lack of understanding regarding the long-term impacts on the peatland carbon sink function and the fact that windfarms installed on non-degraded peatland would not result in a net long-term carbon benefit, windfarm developments need to be carefully assessed.

Country		Wind and Energy	Intensive grazing	Agriculture	Peat extraction/ cutting	Invasive species	Forestry	Drainage	Abiotic pressures	Tourism / Sport/ Recreation	Infrastructure/ Mining	Air pollution	Climatic Change	Burning	Management of game	Other
Spain	Pressure	M	M	M	H	M								M		
	Threat	M	M	M	H			M					M	M		
Republic of Ireland	Pressure	M	H	H	H		H	M	M					H		
	Threat	M	H	H	H		H	M	M				M	H		
United Kingdom	Pressure	M	H		M	M		H				H	M	H	H	M
	Threat	M	H		M	M		H				H	M	H	H	M
Portugal	Pressure		H	H			H	H	M	M						M
	Threat		H	H			H	H	M	M						M
France	Pressure															M
	Threat			M				M	M			H	H			
Austria	Pressure		H					M		M		M	M			
	Threat		H					M		M		M	M			

Table 1. Pressures and threats on recognised blanket bogs across the EU and UK according to the last habitat assessments. Sweden has not reported this information in their last habitat assessment. H = High, M = Medium.

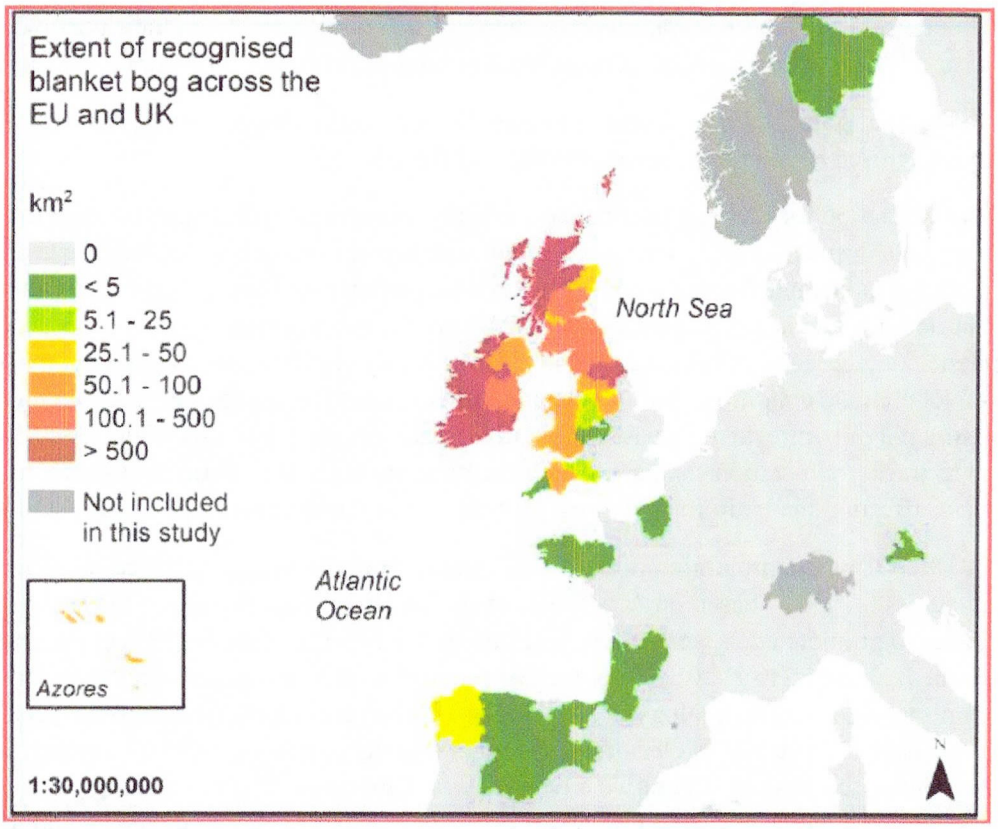
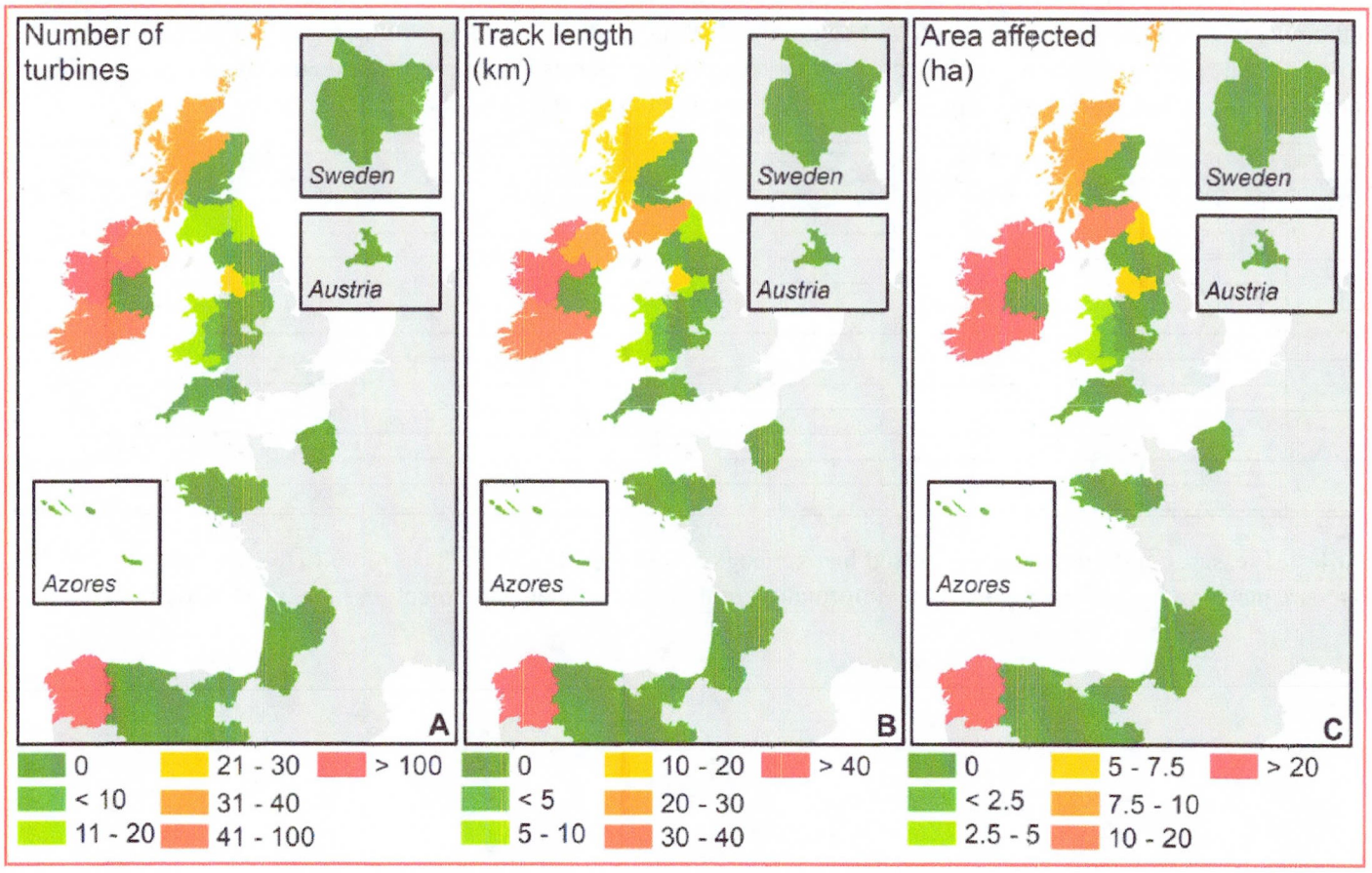
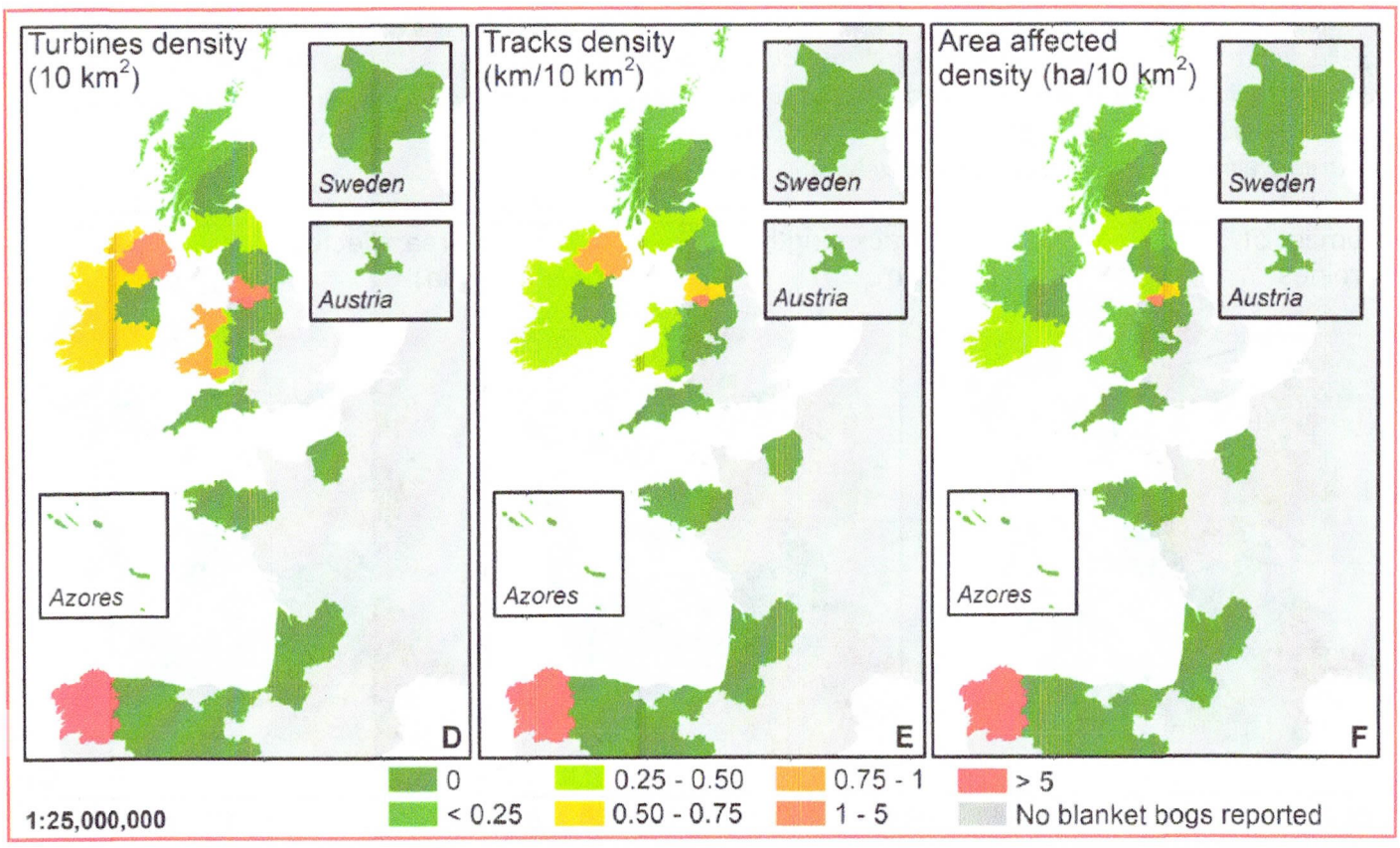


Figure 1. Total extent of the recognised blanket bog by European regions NUTS level 2 based on the Habitats Directive (92/43/EEC) including the last update from the UK before Brexit. Map created in ArcGIS 10.8.1.





the 2013–2018 conservation status report prior to Brexit by European regions NUTS level 232. *Note: Boundaries of the regions have not been added to improve legibility. The political geographical regions do not represent the extent of blanket bogs.* **(A)** Total turbines on blanket bog habitat 7130. **(B)** Tracks length on blanket bog habitat 7130. **(C)** Total area affected by windfarm developments on blanket bog habitat 7130. **(D)** Density of turbines per 10 km2 of blanket bog habitat 7130 by European regions. **(E)** Density of tracks per 10 km2 of blanket bog habitat 7130 by European regions. **(F)** Density of area affected by windfarm developments per 10 km2 of blanket bog habitat 7130 by European regions. *Datasets for blanket bog habitat 7130*: Austria, Portugal, Sweden and France, Scotland; England; Wales; Republic of Ireland and Spain.

Dataset for peatlands (only priority habitat): Northern Ireland. The location of mapped regions in the Azores, Austria, Sweden, and the full extent in Spain is shown in Fig. A (Supplementary materials). Map created in ArcGIS 10.8.1.

Country	Recognised as blanket bog habitat 7130			Recognised as blanket bog habitat 7130 and protected under Natura 2000 network		
	Turbines	Track length (km)	Track area (ha)	Turbines	Track length (km)	Track area (ha)
Spain	252	70.7	46.3	233	65.9	43.7
Republic of Ireland	186	92.2	82.9	24	12.1	9.3
England	72	36.4	28.1	0	0	0
Wales	24	7.8	5.4	0	0.07	0.06
Scotland	55	26.6	25.5	0	1.4	0.9
Northern Ireland	430	203.2	213.9	0	0	0

Table 2. *Windfarm developments on recognised blanket bog habitat 7130 compared with recognised blanket bog habitat within a Natura 2000 site. No relationship between the extent of recognised blanket bog and number of turbines ($p = 0.30$), length of tracks ($p = 0.40$) and total affected area ($p = 0.46$) was found. of Ireland (including Republic of Ireland and Northern Ireland) represents one of the most extensive hotspots for the conflict between windfarm developments and recognised blanket bog habitat. Within the island of Ireland, the northwest (Co. Donegal) is the most affected by windfarm developments by total extent (Fig. 3A–C). When assessing densities (Fig. 3D–F), this area concentrates a high proportion of the total extent of the island's recognised blanket bogs (> 20%) meaning a lower density of windfarm infrastructures. Similar conclusions can be drawn in some areas of the east of the Republic*

of Ireland (Co. Kerry and Co. Mayo) and southwest of Northern Ireland (Co. Fermanagh and Omagh; Fig. 3). Together, these locations represent almost 60% of Ireland's recognised blanket bogs. Beyond these four areas, blanket bogs in central Ireland (Co. Roscommon) had a particularly high density of windfarm infrastructures (Fig. 3D–F). Despite the small extent of recognised blanket bogs across Co. Roscommon (8.5 km2), extensive windfarm infrastructure has been developed across blanket bog in the county.

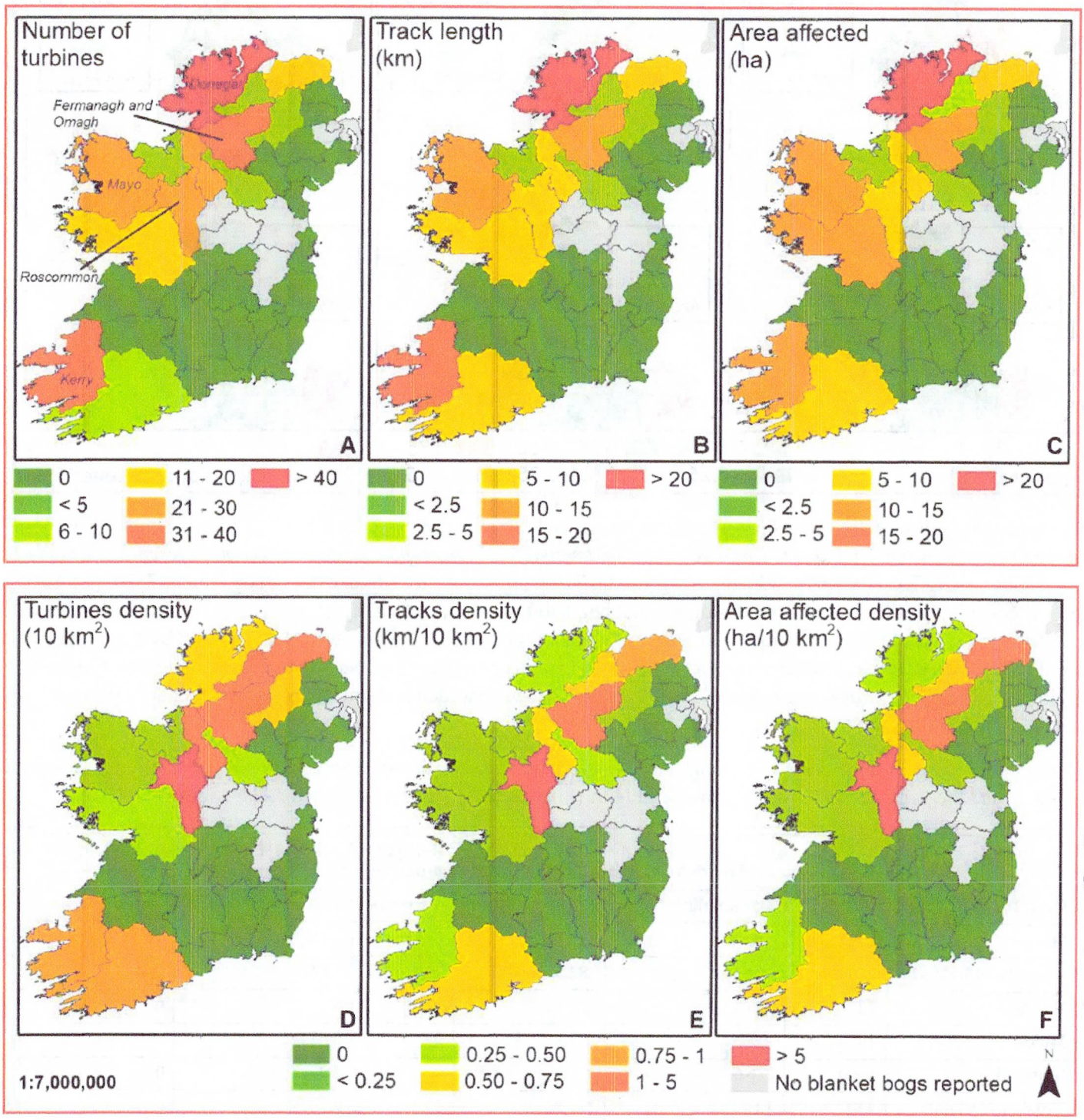


Figure 3. The extent of windfarm developments across the island of Ireland on blanket bog habitat 7130 at county level for the Republic of Ireland and intact or pool complex after blanket bog visual assessment for peatlands on Northern Ireland. (**A**) Total turbines on blanket bog habitat by county. (**B**) Tracks length on blanket bog habitat by county. (**C**) Total area affected by wind farm developments on blanket bog habitat by county. (**D**) Density of turbines by 10 km2 of blanket bog habitat by county. (**E**) Density of tracks by 10 km2 of blanket bog by county. (**F**) Density of area affected by wind farm developments by 10 km2 of blanket bog habitat by county. *Dataset for blanket bog habitat 7130*: Ireland. *Dataset for peatlands*: Northern Ireland. Map created in ArcGIS 10.8.1.

In Scotland, the pressure of windfarm developments on blanket bogs is also evident, where the Scottish Planning Policy considers classes 1 and 2 as areas of significant protection; although, windfarm developments may be possible under some circumstances as is permitted under the Habitats Directive across the EU29. However, to assess the impacts of windfarms on peatlands in a consistent way and evaluate the environmental impact of potential new developments on carbon-rich soils, a carbon calculator has been developed by the Scottish Government. The carbon calculator allows users to estimate the carbon savings of windfarms installed on peatlands, although they highlight the importance of long-term management in relation to the final net carbon calculation. Nonetheless, installing windfarms on non-degraded peatlands has been reported as unlikely to reduce carbon emissions even when the management has been considered carefully and it should be avoided. Therefore, peatlands under classes 1 and 2 considered by the Scottish government as a priority should be excluded from any windfarm developments (currently representing over 16% of onshore turbines, Table 3); especially considering the current policy of increasing onshore windfarms in Scotland.

Long-term research is needed to fully assess the impacts before new windfarm developments are installed.

Country	Total number of turbines	Turbines on blanket bog	% of turbines on blanket bog
Spain	21,574[51]	252	1.2
Republic of Ireland	1896**[47]	186	9.8
England	2138*[52]	72	3.4
Wales	1177*[52]	24	2
Scotland	6322*[52]	55 (protected)	0.9
		1,063 (Class 1 & 2)	16.8
Northern Ireland	1950*[52]	54 (only intact blanket bogs)	2.8
		430 (all priority peatlands)	22.1

Table 3. Total % of turbines on blanket bog (recognised/national inventories) in relation with the total turbines installed by country. *Include wind turbines consented, operational and under construction. **Include proposed, constructed and under construction.

In this novel research, the extent of windfarm developments across all recognised European blanket bogs under the Habitats Directive have been assessed. Large extents of blanket bogs have already been damaged, concentrated in the edge-of-range of this habitat and directly affecting hundreds of hectares of blanket bog across the rest of Europe. The full potential long-term damage to the habitat functionality is still unclear, but scientific evidence supports the negative impacts of windfarm developments on this critical habitat. European blanket bogs need further scientific evidence to demonstrate the real benefit of incentivising the reduction of carbon emissions by installing onshore windfarm infrastructures on peatlands which are causing the degradation of the most important long-term natural carbon sink and storage ecosystems. A strategic restoration plan and appropriate relevant legislation would be beneficial to promote the safeguarding of blanket bogs in the UK after Brexit. An urgent revision and compliance of the legislation regarding the protection of blanket bogs needs to be implemented, especially under the current trend of promotion and increasing legislation on renewable energy to reduce carbon emissions. An improvement of the national inventories across the EU and UK protected area networks is critical to implement the recognition, protection, and restoration of this habitat, in order to guarantee its favourable conservation status and its function as a long-term carbon sink to mitigate climate change.

Land use: EIAR Chapter 8: Soils and Geology concludes that providing the mitigation measures outlined in this report are fully implemented and best practice is followed onsite, it is expected that effects associated with the development of the Wind Farm Site will not be significant. It is recommended that suitable monitoring programmes are implemented in order to ensure that there is rigid adherence both to the CEMP and to the mitigation measures outlined here during construction, operation and decommissioning of the Wind Farm.

Tourism: It is considered that the Proposed Development with regards to tourism effects are considered to be, short term, slight, negative during construction, operational and decommissioning phases. All other aspects of human health (noise, water, air quality, shadow flicker, telecommunications and traffic) are taken into account under NTS sections

for: noise, hydrology and hydrogeology, air quality and climate, shadow flicker, material assets and traffic and transport).

7 BIODIVERSITY

The likely effects on biodiversity associated with the Proposed Development have been assessed in **Chapter 6** of the EIAR.

A detailed understanding of the baseline conditions at the Site has been gained following the collation of desktop information and data sources and ecological field surveys. The ecological field surveys completed at the Site include surveys for habitats, terrestrial mammals, bats and aquatic ecology.

Seven European designated sites occur within a 15 km distance of the proposed wind farm site (these are fully assessed in the AA Screening report and NIS which accompanies the application). The Proposed Development area has hydrological connectivity with two sites, the Lackan Saltmarsh and Kilcummin Head SAC and Killala Bay/Moy Estuary SPA. There are three Natural Heritage Areas (NHAs) within the 15 km radius of the Wind Farm Site, along with a total of ten proposed Natural Heritage Areas (pNHAs).

The proposed Wind Farm site is dominated by agricultural grassland, which varies from Improved or semi-improved agricultural grassland (GA1) to Wet grassland (GS4). Conifer plantation (WD4) is a main habitat in the area and especially in the southwest sector. Hedgerows (WL1) typically form the boundaries of the fields and are often in association with Drainage ditches (FW4). Areas of relatively intact Lowland blanket bog (PB3) occur at the location of wind turbine AT13 at Lackan Hill and also adjoining the abandoned quarry at Castlelackan Demesne (location for AT16). Scrub occurs scattered throughout, with stands of Broadleaved woodland (WD1) occasional. Other habitats which occur over small areas are Disturbed ground (ED) (including abandoned quarry), and Buildings and artificial surfaces (BL3) (including public roads).

While the occurrence of blanket bog, an EU Habitats Directive Annex I listed habitat, within the site of the Proposed Development is of note, the area of bog is rated not more than Local Importance (higher value) as it is a relatively small area (7.65 ha) of shallow bog, which shows signs of past disturbance. No nationally rare or legally protected plant species listed in the 2022 Flora (Protection) Order were recorded from within the Wind Farm Site during the surveys nor are there any past records of such species from the study area.

No invasive species on the Third Schedule list of the European Communities (Birds and Natural Habitats) Regulations 2011-2021 was recorded during the surveys. However, Japanese knotweed has a presence in the general area, with a record from Carrowcor (north of Knockboha Hill) in 2015.

The Wind Farm Site supports a typical mammalian fauna of agricultural pastoral land and coniferous plantation. The Irish hare and all deer species are protected under the Wildlife Acts, as is the pygmy shrew and hedgehog. While the watercourses within the Wind Farm Site are of low value for otter, the larger stretches of rivers downstream of the site and the coastal fringe support this species. Otter is listed on Annex II of the EU Habitats Directive as amended. All mammal species recorded within the Wind Farm Site, or expected to occur, are listed as 'Least Concern' on the Irish Red List. The common frog and the common lizard are protected under the Wildlife Acts, though both are listed as 'Least Concern' on the Irish Red List.

Response from MLavelle:

Reference 2015 : Wind Turbines Cause Chronic Stress In Badgers (*Meles Meles*) In Great Britain, Roseanna C. N. Agnew; Valerie J. Smith; Robert C. Fowkes. *J Wildl Dis* (2016) 52 (3): 459–467.Https://Doi.Org/10.7589/2015-09-231

A paucity of data exists with which to assess the effects of wind turbines noise on terrestrial wildlife, despite growing concern about the impact of infrasound from wind farms on human health and well-being. In 2013, we assessed whether the presence of turbines in Great Britain impacted the stress levels of badgers (Meles meles) in nearby setts.

Hair cortisol levels were used to determine if the badgers were physiologically stressed. Hair of badgers living <1 km from a wind farm had a 264% higher cortisol level than badgers >10 km from a wind farm. This demonstrates that affected badgers suffer from enhanced hypothalamo-pituitary-adrenal activity and are physiologically stressed. No differences were found between the cortisol levels of badgers living near wind farms operational since 2009 and 2012, indicating that the animals do not become habituated to turbine disturbance. Cortisol levels in the affected badgers did not vary in relation to the distance from turbines within 1 km, wind farm annual power output, or number of turbines. We suggest that the higher cortisol levels in affected badgers is caused by the turbines' sound and that these high levels may affect badgers' immune systems, which could result in increased risk of infection and disease in the badger population.

Reference 2017 : Do terrestrial animals avoid areas close to turbines in functioning wind farms in agricultural landscapes? Rafał Łopucki & Daniel Klich & Sylwia Gielarek. Environ Monit Assess (2017) 189: 343 DOI 10.1007/s10661-017-6018-z

The reactions of animals were species specific. Herbivorous mammals (roe deer and European hare) avoided wind farm interiors and proximity to turbines. The common pheasant showed a positive reaction to wind turbine proximity. The red fox had the most neutral response to wind turbines. Although this species visited wind farm interiors less often than the control area, there was no relation between fox track density and turbine proximity.

Terrestrial animals can potentially be affected by wind power development in various ways (Lovich and Ennen 2013), but the empirical evidence suggests a lack of such effects during the operational phase of wind farms or a swift habituation of animals to the disturbance, thus suggesting a limited impact (Helldin et al. 2012; Lovich and Ennen 2013; Łopucki and Mróz 2016; Menzel and Pohlmeyer 1999; Walter et al. 2006; Winder et al. 2014a, b). For this reason, we would expect no effect (neither negative nor positive) of wind turbines on the studied species.

However, our study showed that wind farms can significantly alter habitat use of terrestrial animals not only during the construction phase (Helldin et al. 2012), but also during the operational phase.

In our study, terrestrial animals did indeed use the wind farm areas (tracks of all analyzed species were found close to turbines), which is in accordance with the published literature regarding the different animal species (Helldin et al. 2012; Lovich and Ennen 2013; Rabin et al. 2006; Winder et al. 2014a, b), but the frequency of use of areas near wind turbines was different than the use of land far away from turbines. Our results show that wind farm operations affect terrestrial animals both in wind farm interiors (among the turbines), as well as within at least a 700-m buffer zone around each wind farm. The reaction of the studied animals to wind farms, however, is specific and depends on the species.

Herbivorous mammals

Wind farm interiors were less intensively frequented by roe deer and European hare than control areas. Both species also showed a clear linear decrease of track density with decreasing distance to the turbine. Acoustic factors seem to be the most probable reason for the lower presence of these species in the wind farm areas and with decreasing distance to turbines. Permanent and high noise levels may be bothersome enough for these species to visit less frequently and spend less time there (resulting in lower track density) because the noise may cause metabolic stress and be harmful for animals (Du et al. 2010; Kight and Swaddle 2011). However, it is more likely that herbivorous mammals have difficulty perceiving sounds in noisy environments. Human related noise may restrict the habitat use and movement of species and represent a life-threatening hazard in predator-prey interactions, particularly regarding herbivorous mammals (Barber et al. 2010; Chan et al. 2010; Clevenger and Waltho 2005; Rabin et al. 2006). Both the roe deer and the European hare rely more on hearing than other senses, particularly to avoid danger (Molinari-Jobin et al. 2004) and, thus, are susceptible to such a noise effect. Both are also under high predatory pressure in the Carpathian region (Bombik et al. 2014; Kauhala and Kowalczyk 2011).

Herbivorous mammals generally increase their vigilance in environments that are under a high predatory pressure (Laundré et al. 2001; Wolff and Horn 2003). Avoidance of risky habitats is an important part of their anti-predatory strategy (Aulak and Babińska-Werka 1990; Bongi et al. 2008; Klich and Grudzień 2013) that may lead to some areas being depleted of prey due to vigilance rather than predation (Brown et al. 1999).

For roe deer and the European hare, the proximity of turbines may thus represent a risky habitat due to the animals' impaired ability to hear approaching predators. This phenomenon may be more likely during hours of darkness or low light, when both species are most active during winter (Chapman and Flux 2008; Pépin and Cargnelutti 1994; Wallach et al. 2010). Previous studies (Bergen 2002; Menzel and Pohlmeyer 1999) showed no significant difference in roe deer distribution or habitat use in areas with wind farms compared to reference areas without wind power.

However, neither roe deer nor the European hare were under high predation pressure that could displace them to other habitats (Keuling et al. 2011; Ludwig et al. 2009).

Reference 2021 : Vibrational noise from wind energy-turbines negatively impacts earthworm abundance. 2021, Velilla, Estefania; Collinson, Eleanor; Bellato, Laura; Berg, Matty P.; Halfwerk, Wouter Published in: Oikos DOI: 10.1111/oik.08166. www.oikosjournal.org

Human activities often impact the sensory environment of organisms. Wind energy turbines are a fast-growing potential source of anthropogenic vibrational noise that can affect soil animals sensitive to vibrations and thereby alter soil community functioning. Larger soil animals, such as earthworms (macrofauna, > 1 cm in size), are particularly likely to be impacted by the low-frequency turbine waves that can travel through soils over large distances. Here we examine the effect of wind turbine-induced vibrational noise on the abundance of soil animals. We measured vibrational noise generated by seven different turbines located in organically-farmed crop fields in the Netherlands. Vibratory noise levels dropped by an average of 23 ± 7 Db over a distance of 200 m away from the wind turbines. Earthworm abundance showed a strong decrease with increasing vibratory noise. When comparing the nearest sampling points in proximity of the wind energy turbines with the points furthest away, abundance dropped on average by 40% across all seven fields. The abundance of small-sized soil animals (mesofauna, < 10 mm in size) differed between crop fields, but was not related to local noise levels. Our results suggest that anthropogenic vibratory noise levels can impact larger soil fauna, which has important consequences for soil functioning. Earthworms, for instance, are considered to be crucial ecosystem engineers and an impact on their abundance, survival and reproduction may have knock-on effects on important processes such as water filtration, nutrient cycling and carbon sequestration.

Animals rely on different sensory stimuli to acquire and process information from their environment. The ability to acquire this information is essential for an animal's reproductive success and survival (e.g. finding a mate and detecting a predator) (Dall et al. 2005, Dominoni et al. 2020). Activities tightly linked to human population growth are however interfering with environmental information processing of many animal species, with important population- and community-level consequences (Derryberry et al. 2020, Dominoni et al. 2020, Halfwerk 2020). Sensory pollutants, such as artificial light at night and traffic sounds have been shown to cause negative effects on animal behaviour and physiology, which can translate to reduced survival and reproduction, and ultimately to population declines (Barber et al. 2010, Kight and Swaddle 2011, Francis and Barber 2013).

Human activities are responsible for 50% of the earth's seismic noise levels (Lecocq et al. 2020), but the impact of this sensory pollutant on animals and their communities living in the soil remains largely unknown. However, vibrational noise of natural and anthropogenic sources has been shown to affect mating interactions, predator prey dynamics and competition in different species (Caldwell et al. 2010, McNett et al. 2010, Roberts et al. 2016, Caorsi et al. 2019, Phillips et al. 2020, Velilla et al. 2020). A major contributing source of anthropogenic vibrational noise comes from wind energy turbines, which are mainly found in rural or farming areas and sometimes cover a large land surface. The blades, the rotor and the shafts from wind turbines are supported by a tower that is usually anchored to a heavy concrete and steel rebar platform reaching up to nine meters in depth (Stammler and Ceranna 2016). These platforms are needed to withstand the weight of the turbine, and although they may additionally reduce some of the vibrational noise created by the turbine, they induce vibrations in the soil, mostly in the low frequency range < 500 Hz (Stammler and Ceranna 2016). So far, we have little knowledge on how wind-turbine generated noise affects soil animals.

The potential impact of noise on animals may depend on the overlap between an animal's body size and the spectral distribution of the vibrations that travel through the soil. Vibrations generated by wind energy turbines are typically low in frequency (< 500 Hz) and small-bodied animals (mesofauna, < 10 mm in size) might not be able to perceive, or even experience any strain from these low-frequency waves. Larger soil animals (macrofauna, > 1 cm in size), however, might be able to perceive low-frequency vibrations and can therefore be impacted by turbine noise through a perceptual mechanism. Among macrofauna, earthworms are particularly sensitive to low-frequency vibrations as they use vibrational cues to detect approaching predators (Catania 2008, Farina 2014). Earthworms are crucial ecosystem engineers (Jones et al. 1997) that are well known to influence soil structure, hydrology and nutrient quality as well as plant production (Clements et al. 1991, Van Groenigen et al. 2014, Bertrand et al. 2015). Vibratory noise from turbines may either mask, or mimic vibratory cues produced by approaching predators, such as moles, and earthworms may surface in response (Catania 2008, Dominoni et al. 2020). An increased perception of predation pressure, or decreased response to predatory cues could both lead to a decline in earthworm abundance in areas with high vibrational noise,

consequently affecting soil structure, water infiltration, nutrient cycling, carbon sequestration and more (Blouin et al. 2013, Bertrand et al. 2015).

In the current study we assessed the effect of wind turbine-induced vibrational noise on earthworm abundance, and on the abundance of soil mesofauna. We hypothesized that vibrational noise would have a body-size dependent effect on soil animals and therefore expected a negative impact on earthworm abundance and no direct impact on the smaller mesofauna (although they could still be affected indirectly through an impact on earthworms). To test our predictions, we selected seven turbines stationed in agricultural fields in the Netherlands. We measured vibrational noise induced by wind turbines along a 14 transects and related these noise levels to earthworm and mesofauna abundance.

Earthworm abundance was negatively related to vibrational noise

We found that, on average, the number of earthworms decreased by 40% at the point furthest away from the turbines compared to the closest point to the turbines where we measured (128 m versus 8 m). Our results confirm that earthworm abundance decreased substantially as the amplitude of vibrational noise increased. The maximum amplitude difference over the range at which we surveyed earthworms was on average 13 Db. We therefore predict the impact of vibratory noise to be even bigger when measured over the whole transect, as vibrational noise levels near the base of the turbine are up to 30 Db higher than at our furthest sites (> 200 m from the turbine). We did not survey earthworm densities close to the turbine base as the composition of the soil differed substantially between the nearest points (2 m and 4 m) and remaining points of the transect. While we accounted for variation in soil compaction and crop type, neither of these factors was related to earthworm densities. Soil compaction and crop type also did not co-vary with distance to the wind turbines (Supporting information). Although vibration-specific receptors have not been described for any earthworm species, earthworms can detect tactile stimuli along their entire body (Laverack 1960), and tactile stimulation has been shown to induce activity in the segmental nerves (Laverack 1960, Mill and Knapp 1967). Earthworms also have distinct sensory cell bumps found along their body surface that contain multiciliate sensory cells (Langdon 1895, Knapp and Mill 1971, Gardner 1976, Mill 1982). A combination of sensory cell bumps and tactile sensitivity in earthworms, makes them a good candidate for vibration reception (Mitra 2009).

Sensory pollution consequences

Human-induced sensory pollutants can directly affect organisms through an impact on their perception, physiology and behavior (Brumm and Slabbekoorn 2005, Barber et al. 2010, Kight and Swaddle 2011, Naguib 2013, Velilla and Halfwerk 2019). It is possible that wind turbine-induced vibrational noise masks the vibrational cues of approaching foraging moles, making earthworms in noisy areas more prone to predation (Dominoni et al. 2020). Vibratory noise could also be misleading to earthworms (Dominoni et al. 2020), who may not be able to distinguish between vibratory cues coming from an approaching predator such as a mole, and the subterranean waves from the turbines. As matter of fact, earthworms are well known to be misled by other organisms, including humans who have developed so-called 'worm grunting' techniques that mimic soil vibrations from approaching moles (Catania 2008). Future studies should experimentally test which sensory mechanism is responsible for the patterns we revealed in this study. Alternatively, soil vibrations induced by wind turbines could alter the direct physical environment, e.g. through soil particle sorting or an impact on eartworm tunnel structures, thereby influencing water drainage and other abiotic conditions. Such physical impact should however also impact the mesofauna, which we did not report on our study. However it is clear that more data on the effects of vibrations on soil structure are needed, and vice versa.

Our findings suggest that noise could decrease earthworm densities, and ultimately modify the distribution of species that depend or interact with earthworms (Gutiérrez-López et al. 2010). In our study we did not find evidence for an effect of variation in earthworm abundance on the abundance of smaller soil animals. However, our measurements and observations were carried out in agricultural fields, possibly influencing the effects that earthworms would have under natural wild conditions, or in a different season. Further studies should examine the effect of vibrational noise on earthworm abundance in non-managed fields and its consequences on other soil organisms.

Earthworms play a crucial role in several soil processes including: soil formation, soil structure, water infiltration, nutrient cycling, carbon sequestration, climate regulation and primary production (Blouin et al. 2013, Bertrand et al. 2015). Furthermore, earthworms are known to play an important role in plant production (Baker et al. 2006, Blouin et al. 2013). Therefore, the negative relationship we find between wind turbine noise levels and earthworm abundance could potentially have cascading effects on other soil organisms and processes and should also draw attention to other sources of seismic noise (Lecocq et al. 2020).

The bat landscape association model suggests that the locations for the proposed turbines are situated in habitats ranging from moderate low to moderate high suitability for bats. During bat activity surveys, a total of four species were recorded: soprano pipistrelle, common pipistrelle, brown long-eared and Leisler's bat. During static surveys, a total of five species of bats were recorded: soprano pipistrelle, common pipistrelle, Leisler's bat, brown long-eared bat and Natterer's bat. Several registrations recorded as *Myotis* species were identified only to genus level. The most commonly recorded species were soprano pipistrelle, followed by Leisler's bat and common pipistrelle, with lower levels from other species. All bats recorded are classified as 'Least Concern' on the Irish Red List (2019) and protected under the EU Habitats Directive as amended Annex IV and Wildlife Acts as amended.

Reference 2023 : Bat Apocalypse by Wind Concerns in Home, Wildlife and Birds, August 17, 2023

The destruction of migratory birds by industrial wind turbines has earned them the well-deserved title "bird blenders." But even more alarming is the far more widescale destruction of bat populations, many of them now endangered species.

Studies in both Germany and North America have determined that hundreds of thousands if not millions of bats are being slaughtered now annually by wind turbines. There appear to be two causes of death, the first being blunt force trauma: the bats are hit by the turbine blades, suffering broken arms, wings, and skull bones. The second, believed to be the majority of fatalities, is through what is known as "barotrauma": as a turbine blade spins, it forms pockets of low-pressure air trailing behind the blade. The sudden expansion of the air in nearby bats' lungs causes them to rupture resulting in fatal haemorrhaging. Either is a brutal death.

Unlike birds, it appears that bats are actually drawn toward turbines, either mistaking their tall structure for trees or perhaps because insects and moths, the staple diet of most bats, are drawn to wind farms by the heat they generate.

Certain species are attracted to wind turbines. When we point thermal cameras up and watch bat activity in and around wind turbines, we see bats contacting the structures like the tower, the nacelle, chasing the blades, making swoops and patterns. It's not just bats randomly passing through and happening to get hit by the wind turbine blades; they're spending time and increasing their risk.

Dr. Cris Hein, Senior project lead in the National Renewable Energy Laboratory, November 18, 2022; Cosmos Magazine

With wind energy corporations building increasingly taller turbines, the crisis is only worsening.

As turbine height increases, bat deaths increase exponentially. What we found is a lot of internal haemorrhaging.

Erin Baerwald, Ecologist, University of Calgary; August 26, 2008; Scientific American

Wind turbines kill at least 500,000 bats annually in the U.S., according to Texas-based Bat Conservation International.

"When you start wiping out bat populations like this that are already in decline, the concern isn't just the loss of endangered species but the impact this has on the entire ecosystem," says Wind Concerns Editor-in-Chief, Mark Mallett.

Experts predict that four bat species will lose more than half of their populations due to collisions with wind turbines in the next 15 years if effective conservation actions are not taken soon.

"State of the Bats Expert Elicitation Summary", 2023, batcon.org

Bats play an essential role in pest control, pollinating plants and dispersing seeds. Recent studies estimate that bats eat enough pests to save more than $1 billion per year in crop damage and pesticide costs in the United States corn industry alone. Across all agricultural production, consumption of insect pests by bats results in a savings of more than $3 billion per year. "They also keep moths and caterpillars at bay increasing crop yields," says Professor Fiona Mathews of Exeter University who published a study on wind farm bat casualties. "So it's something that affects us all."

Earlier this year, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) announced that the Hoary Bat, Eastern Red Bat and Silver-haired Bat have been assessed as Endangered in Canada. This listing now means that 5 of the 9 bat species that occur in Alberta have been formally assessed as Endangered.[5]

Moreover, "it is illegal to harm or kill any species of bats in Alberta," which are protected under the Alberta Wildlife Act. Across North America, millions of cave-hibernating bats have died from the disease White-Nose Syndrome, caused by a fungus that grows in caves. This fungus was detected in Alberta in 2022. According to the Alberta government's fact sheet updated in June 2023, "It is important to protect bats and their habitat to ensure they can recover from the disease"

It isn't clear, then, how any future wind turbine projects can be approved without violating this provincial law — unless the province grants a wind energy corporation a permit to essentially continue the slaughter.

Bat casualty

"So if I swing a bat and kill one of these species, I go to prison," says Mallett. "If the wind energy corporations do it, several times a day, they get a free pass. When wind energy is unreliable to begin with, why are governments continuing to allow these environmentally destructive industrial wind plants to continue?"

In order to mitigate bat deaths, some wind companies are turning off their turbines at night or during migratory periods.

We need to remember bats have been around for at least 30 million years and during that time have been able to fly happily without the risk of colliding with a spinning object. If bats are actively attracted to turbines then it might not prove possible to predict this accurately in advance.

Professor Fiona Mathews, Exeter University, Nov 8, 2016, Express

"So how is this a solution for creating reliable energy?" asks Mallett. "This is the point that Premier Danielle Smith has been repeatedly asserting: the power grid needs constant and reliable energy. That's neither wind nor solar at the best of times. And the solution is to make wind energy even less effective? This is nonsensical."

Trudeau's federal government is now demanding that provinces reach so-called "net-zero" emissions by 2035. However, Saskatchewan's leader called the plan "impossible" while Premier Smith warned this would create energy insecurity and is "unconstitutional, irresponsible and utterly out of step with reality."

"So, from where we stand," says Mallett, "we are strongly urging the Premier to simply put an end to wind energy expansion in this province and look for other clean reliable sources that aren't so incredibly harmful, destructive, and divisive. There is absolutely nothing "green" about wind energy. Period."

Wind turbine plants take up huge tracts of land; they require massive amounts of fossil fuel to manufacture, transport, and install; they have a short lifespan; they produce power unreliably; they are toxic and present serious problems in their decommissioning; they kill massive amounts of large migratory birds, bats, and now whales; they use up prime farmland; they destroy pristine landscapes; and they have been proven definitively to harm both human and animal health.

"And now, if we continue to destroy bats which are essential to our ecosystem," says Mallett, "how exactly are we saving the planet?"

Reference 2020 : Post construction bird and bat monitoring at wind farms in Victoria Ver. 1.0 Public report 13th Wind Wildlife Research Meeting 2020. Symbolix

1.2.1 Cumulative estimated mortality rates

We present a table in Section 4.6 of the estimated annual mortality per turbine for each species. This is limited to the species found at three or more sites, as we cannot reliably report combined results for species found at only one or two sites.

• Turbine size influences the mortality estimate, due to differing 'fall zones' for carcasses (Hull and Muir 2010). We estimated per turbine mortality for two size classes.
– Small (SML) turbines have rotor diameter of less than or equal to 103m. Anything larger was classed as Large (LRG).
– At time of writing there were 544 small class turbines and 220 large class turbines in Victoria (Appendix A).

• Between 7 and 10.8 bat mortalities occur per turbine per year in Western Victoria. The rate is not significantly different for different sizes (Section 4.5.1)

• For birds, significantly more mortalities occur at larger turbines. For small turbines, between 3.4 and 4.1 bird mortalities occur per turbine per year. For large turbines, the range varies between 5 and 6.7 per turbine per year.

• Our study suggests that mortalities are higher for White-striped Freetail Bats than any other bat or bird species. Between four to six White-striped Freetails are struck per turbine, and they were discovered at every site in the study. This implies that turbines in Western Victoria strike around as many White-striped Freetails as all birds combined.

Table 5: Twenty-five most documented species during carcass searches (at included sites)

Common name	*No. found*	*No. sites*
White-striped Freetail Bat	*229*	*10*
Gould's Wattled Bat	*77*	*8*
Australian Magpie	*69*	*10*
Unidentified Bird	*45*	*7*
Nankeen Kestrel	*41*	*8*
Raven sp.	*35*	*7*
Wedge-tailed Eagle	*33*	*7*
Eastern False Pipistrelle	*33*	*5*
European Skylark	*33*	*3*
Brown Falcon	*26*	*7*
Large Forest Bat	*16*	*6*
Lesser Long-eared Bat	*15*	*<3*
Little Forest Bat	*13*	*6*
Unidentified Bat	*11*	*6*
Southern Freetail Bat	*10*	*4*
Southern Bent-wing Bat	*8*	*<3*
European Goldfinch	*7*	*5*
Common Starling	*7*	*5*
Welcome Swallow	*6*	*4*
Chocolate Wattled Bat	*6*	*4*
Red-rumped Parrot	*5*	*<3*
Grey-headed Flying-fox	*4*	*<3*
House Sparrow	*4*	*<3*
Magpie-lark	*4*	*<3*
Southern Forest Bat	*4*	*<3*

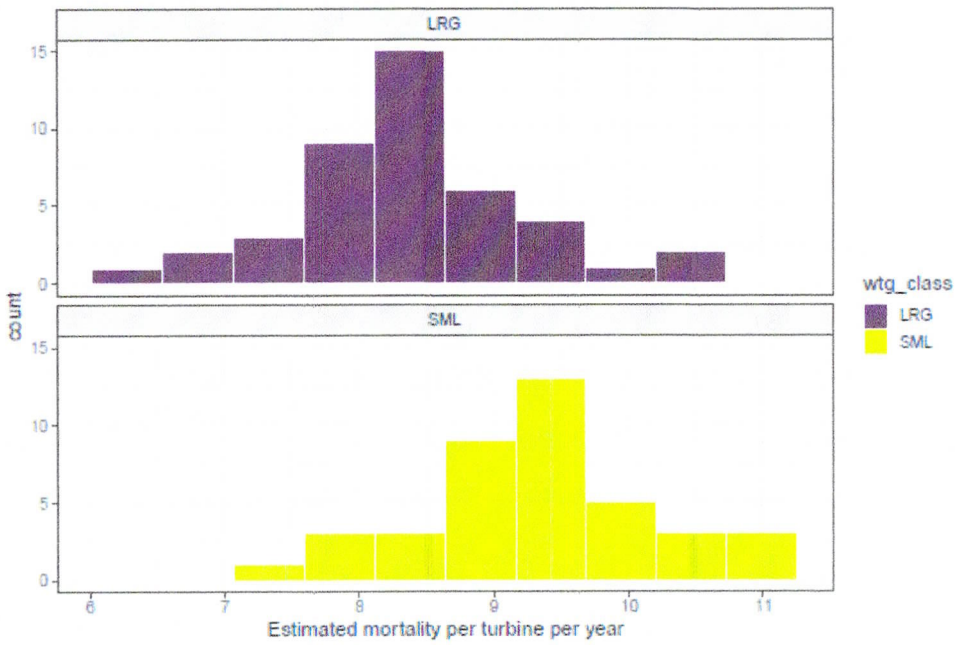


Figure 11: Credible Distribution of Bat Mortalities per turbine year

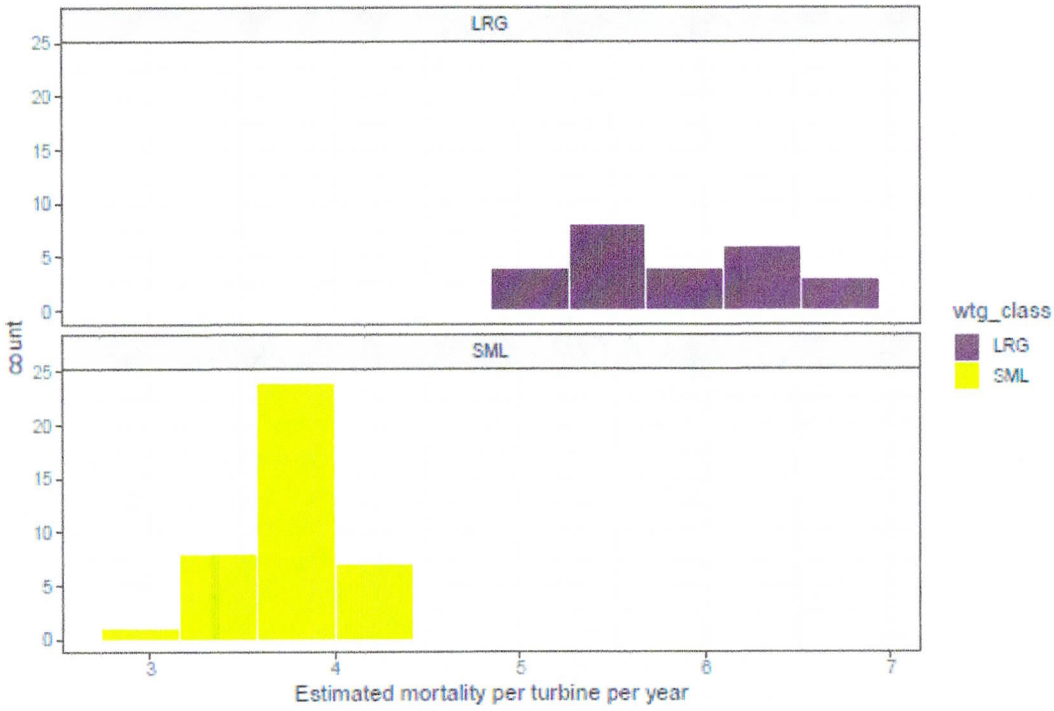


Figure 12: Credible Distribution of Bird Mortalities per turbine year

Reference 2022 : An updated review of Hypothesis regarding bat attraction to wind turbines, Guest, E.E.,Stamps, B.F., Durish, N.D., Hale, A.M., Hein, C.D., Morton, B.P.,Weever, S.P., Frits, S.R. Animals, MDPI, January 2022, 12,343., https://doi.org/10.3390/ani12030343

"Patterns of bat activity and mortalities at wind energy facilities suggest that bats are attracted to wind turbines based on bat behaviour responses to wind turbines. For example, current monitoring efforts suggest that bat activity increases post wind turbine construction, with bats making multiple passes near wind turbines. We separated the attraction hypothesis into five previously proposed explanations of bat interactions at or near wind turbines, including attraction based on noise, roost sites, foraging and water, mating behaviour, and lights, and one new hypothesis regarding olfaction, and provide a state of the knowledge in 2022."

Noise: " Bat echolation calls are among the loudest natural sounds and provide reliable sensory perception for navigating and foraging at night. Evidence of bats using acoustic cues between 3 and 12kHz from distances of up to several hundred metres prompted the idea that noise emitted from wind turbines could be misinterpreted as prey."

Roosting: "It is hypothesised that the tall, stand-alone structure of wind turbines on the landscape could be misinterpreted by bats as trees and viewed as potential roost structures."

Foraging and Water: "Insect density around wind turbines may be positively correlated with bat activity, because bats may perceive wind turbines as a potential food source. The proposed logic for the accumulation of insects near wind turbines includes hilltopping behaviour, insect attraction to the light or heat emitted from wind turbine structures, and insect attraction to wind turbine colour."

Mating: "It is suggested that male and female bats of some species visually orient toward the tallest trees on the landscape for navigation toward mating aggregations. Direct observation through thermal imaging coupled with mortality trends suggest that wind turbines may be used by bats for orientation to potential mating sites."

Lights: "Lights on wind structures or associated infrastructure may directly or indirectly contribute to increased bat activity."

Olfaction: "Recent work using paired thermal video and acoustic recording at Meteorological tower sites documented swarming activity concentrated at various focal points on the Meteriological tower structure, including mechanical anemometers, wind vanes, the top of the tower, and aircraft marker balls."

Reference 2021 : Bats and onshore wind turbines: Survey, Assessment and Mitigation, version August 2021, NatureScot, Natural England, Natural Resources Wales, Renewable UK, Scottish Power Renewables, Ecotricity Ltd., University of Exeter, Bat Conservation Trust (BCT).

"Assessing potential impacts: Wind farms can affect bats in the following ways:

1) *Collision mortality, barotraumas and other injuries.*
2) *Loss or damage to commuting and foraging habitat.*
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4) *Displacement of individuals of populations ."*

Reference 2022 : Conservation: Tracking bats around wind turbines. M. Teague O'Mara, Current Biology 33, R136–R158, February 27, 2023 2022 Elsevier Inc. . https://doi.org/10.1016/j.cub.2022.12.048

Alternative energy is essential for a green future but comes at a high risk for animals. New research shows that forest-based wind turbines may create an ecological trap for bats that typically are repelled by wind turbines.
Like many other tree-roosting migratory bats, common noctules are particularly vulnerable to wind turbine mortality. Common noctules migrate and forage at altitudes commonly occupied by wind turbines. They are the most commonly killed bat species at wind turbine facilities in Germany, and like many bat species worldwide, their populations are declining rapidly. Common noctules will roost in bat boxes, but prefer natural tree cavities such as woodpecker holes for roosting during the day. By placing GPS loggers on common noctule bats that roosted near wind turbine fields in Germany, Reusch and colleagues tracked individual bats over time. This allowed them to test how these bats interacted with wind turbine habitats in and out of forests, both at an individual and population level. Typically, surveys that track bat activity rely on acoustic detectors that record echolocation calls that can then be identified to species or a group of species and give a measure of occupancy and activity for the area. Miniaturized GPS tracking pushes beyond an anonymous, population-level view to understand how individuals arrived at a site, and how the site was selected and used.
Reusch and colleagues found that per night common noctules flew 16 km, covering an area of 11 ± 34 km2, and spent roughly half their time commuting across farmland and meadows to forests where they feed on a wide range of moths, beetles and other insects.

Reference 2022 : Conservation: Tracking bats around wind turbines. O'Mara, M.T., 2022, Current Biology, https://doi.org/10.1016/j.cub.2022.12.048

"Flying animals face the highest risk from wind turbines, as birds and bats seek out the same conditions that make wind generation profitable. These energetically advantageous conditions allow animals to fly cheaply on uplifting winds and thermals or on prevailing winds. The placement of wind turbines in such profitable wind conditions may dramatically endanger migration, commuting and foraging pathways. Preference for these habitats makes bats particularly vulnerable to turbine related mortality, and efforts in . North America have focussed on why and how bats are attracted to wind turbines at night.....This conflict has resulted in millions of bats killed by wind turbines every

year worldwide, including over 300,000 in Germany alone .... Common noctules flew 16km per night covering an area of 11+- 34km2".

Reference 2023 : Wind turbine power and land cover effects on cumulative bat deaths. Aristides Moustakas, Panagiotis Georgiakakis, Elzbieta Kret, Eleftherios Kapsalis. Science of the Total Environment 892 (2023) 164536

Wind turbines (WT) cause bird and bat mortalities which depend on the WT and landscape features. The effects of WT features and environmental variables at different spatial scales associated to bat deaths in a mountainous and forested area in Thrace, NE Greece were investigated. Initially, we sought to quantify the most lethal WT characteristic between tower height, rotor diameter and power. The scale of interaction distance between bat deaths and the land cover characteristics surrounding the WTs was quantified. A statistical model was trained and validated against bat deaths and WT, land cover, and topography features. Variance partitioning between bat deaths and the explanatory covariates was conducted. The trained model was used to predict bat deaths attributed to existing and future wind farm development in the region. Results indicated that the optimal interaction distance between WT and surrounding land cover was 5 km, the larger distance than the ones examined. WT power, natural land cover type and distance from water explained 40 %, 15 % and 11 % respectively of the total variance in bat deaths by WTs. The model predicted that operating but not surveyed WTs comprise of 377.8 % and licensed but not operating yet will contribute to 210.2 % additional deaths than the ones recorded. Results indicate that among all WT features and land cover characteristics, wind turbine power is the most significant factor associated to bat deaths. In addition, WTs located within 5 km buffer comprised of natural land cover types have substantial higher deaths. More WT power will result in more deaths. Wind turbines should not be licensed in areas where natural land cover at a radius of 5 km exceeds 50 %. These results are discussed in the climate-land use-biodiversity-energy nexus.

Bats are long-lived mammals with low reproductive potential and thus high levels of adult individuals survivorship are important for maintaining a viable population (Wilkinson and South, 2002). All European bat species are strictly protected under the Habitats Directive (92 43 EEC, Annex IV) and the national legislation of many countries. Nevertheless, in the absence of specific mandatory regulations, the effect of wind farm installation and operation on bat populations is rarely examined to a sufficient extent in environmental impact assessments. This is in spite of the fact that increased mortality in wind turbines may increase extinction risk for frequently killed species (Frick et al., 2017).

Results indicate deaths are significantly associated to wind turbine power. Power alone explained a third of the variance of bat deaths and it is more lethal than tower height or rotor diameter. Energy, the product of power and time, produced by WT is determined by the size of the turbine (tower height, rotor diameter), and rotor speed (Dixon and Hall, 2014).

To that end decreasing rotor speed would need to be compensated by increasing WT size and vice versa for producing the same amount of energy. Thus, altering WT features will not minimize impacts on bats, as long as the energy produced remains the same or even increases. In addition, having several small or fewer large WT (Dabiri et al., 2015; Krijgsveld et al., 2009) is unlikely to minimize deaths as long as total produced energy remains constant. Avian and bat mortality was reported to be constant per energy unit produced across wind turbine power capacities (Huso et al., 2021), confirming that not simply the size of turbines but power is the factor better explaining deaths. In the same study, the actual energy produced by each WT, but not the nominal power which is the maximum power capacity was found as a more unbiased estimator of wildlife deaths (Huso et al., 2021).

Reference 2021 : Insect fatalities at wind turbines as biodiversity sinks. Voight., C.C., Wiley: Conservation Science and Practice. 15th January 2021. DOI: 10.1111/csp2.366. https//orchid.org/0000-0002-0706-3974

Evidence is accumulating that insects are frequently killed by operating wind turbines..... Current observations suggest that mostly hilltopping, swarming, and migrating insects interact with wind turbines. Recently, the annual loss of insect biomass at wind turbines was estimated for Germany to amount to 1,200tonnes for the plant growth period, which equates to about 1.2trillion killed insects per year, assuming 1mg insect body mass. Accordingly, a single turbine located in the temperate zone might kill about 40million insects per year.

Decline of insect populations may also diminish their ecosystem function, including services like pollination.

After collision, most insects leave a layer of organic detritus on the leading edge of blades. This layer disrupts the laminar airflow, causing a significant drop in power production. Indeed, insect remains that stick to the leading edges of blades during low wind periods can halve power generation during high wind periods..... Aerial insectivores such as bats are well known for searching and hunting insects in proximity to wind turbines.

Reference 2017 : Increasing evidence that bats actively forage at wind turbines. (2017) Foo. C.C., Bennett. V.J., Hale, A.M., Korstian. J.M., Schildt, A.J., Williams. D.A. PeerJ 5: e3986;DOI 10.7717/peerj.3985

Although the ultimate causes of high bat fatalities at wind farms are not well understood, several lines of evidence suggest that bats are attracted to wind turbines. One hypothesis is that bats would be attracted to turbines as a foraging resource if the insects that bats prey upon are commonly present on and around the turbine towers.

Reference 2022 : An updated review of Hypothesis regarding bat attraction to wind turbines, Guest, E.E.,Stamps, B.F., Durish, N.D., Hale, A.M., Hein, C.D., Morton, B.P.,Weever, S.P., Frits, S.R. Animals, MDPI, January 2022, 12,343., https://doi.org/10.3390/ani12030343

"Patterns of bat activity and mortalities at wind energy facilities suggest that bats are attracted to wind turbines based on bat behaviour responses to wind turbines. For example, current monitoring efforts suggest that bat activity increases post wind turbine construction, with bats making multiple passes near wind turbines. We separated the attraction hypothesis into five previously proposed explanations of bat interactions at or near wind turbines, including attraction based on noise, roost sites, foraging and water, mating behaviour, and lights, and one new hypothesis regarding olfaction, and provide a state of the knowledge in 2022."

Noise: " Bat echolation calls are among the loudest natural sounds and provide reliable sensory perception for navigating and foraging at night. Evidence of bats using acoustic cues between 3 and 12kHz from distances of up to several hundred metres prompted the idea that noise emitted from wind turbines could be misinterpreted as prey."

Roosting: "It is hypothesised that the tall, stand-alone structure of wind turbines on the landscape could be misinterpreted by bats as trees and viewed as potential roost structures."

Foraging and Water: "Insect density around wind turbines may be positively correlated with bat activity, because bats may perceive wind turbines as a potential food source. The proposed logic for the accumulation of insects near wind turbines includes hilltopping behaviour, insect attraction to the light or heat emitted from wind turbine structures, and insect attraction to wind turbine colour."

Mating: "It is suggested that male and female bats of some species visually orient toward the tallest trees on the landscape for navigation toward mating aggregations. Direct observation through thermal imaging coupled with mortality trends suggest that wind turbines may be used by bats for orientation to potential mating sites."

Lights: "Lights on wind structures or associated infrastructure may directly or indirectly contribute to increased bat activity."

Olfaction: "Recent work using paired thermal video and acoustic recording at Meteorological tower sites documented swarming activity concentrated at various focal points on the Meteriological tower structure, including mechanical anemometers, wind vanes, the top of the tower, and aircraft marker balls."

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Reference 2023 : Wind turbine power and land cover effects on cumulative bat deaths. Moustakas, A., Georgiakis. P., Kret. E., Kapsalis. E., The science of the Total Environment. (May 2023)

"Wind turbines cause bird and bat mortalities which depend on the wind turbine and landscape features..... wind turbine power is the most significant factor associated to bat deaths.....wind turbines located within 5km buffer of natural land cover types have substantially higher deaths. More wind turbine power will result in more deaths. Wind turbines should not be licensed in areas where natural land cover at a radius of 5km exceeds 50%.

Reference 2022 : Wind turbines without curtailment produce large numbers of bat fatalities throughout their lifetime: A call against ignorance and neglect Christian C. Voigt, Klara Kaiser, Samantha Look, Kristin Scharnweber, Carolin Scholz . Global Ecology and Conservation 37 (2022) e02149

Bats are protected by national and international legislation in European countries, yet many species, particularly migratory aerial insectivores, collide with wind turbines which counteracts conservation efforts. Within the European Union it is legally required to curtail the operation of wind turbines at periods of high bat activity, yet this is not practiced at old wind turbines. Based on data from the national carcass repository in Germany and from our own carcass searches at a wind park with three turbines west of Berlin, we evaluated the magnitude of bat casualties at old, potentially poor-sited wind turbines operating without curtailment. We report 88 documented bat carcasses collected by various searchers over the 20-year operation period of this wind park from 2001 to 2021. Common noctule bats (Nyctalus noctula) and common pipistrelles (Pipistrellus pipistrellus) were most often found dead at these turbines. Our search campaign in August and September 2021 yielded a total of 18 carcasses. We estimated that at least 209 bats were likely killed during our field survey, yielding more than 70 casualties wind turbine or 39 casualties MW in two months. Since our campaign covered only part of the migration season, we consider this value as an underestimate. The 20-year period of the wind park emphasises the substantial impact old turbines may have on bat individuals and populations when operating without curtailments. We call for reconsidering the operation procedures of old wind turbines to stop the continuous loss of bats in Germany and other countries where turbine curtailments are even less practiced than in Germany.

Reference 2023 : The presence of wind turbines repels bats in boreal forests Simon P. Gaultier, Thomas M. Lilley, Eero J. Vesterinen, Jon E. Brommer., Landscape and Urban Planning 231 (2023) 104636

Impacts of wind power on bats are usually evidenced by the recorded fatalities, while other impacts are not well understood or considered during project planning. However, wind turbines may affect use of the surrounding habitats by bats. Little is known about such impact, especially in the European boreal biogeographical region. We studied the consequences of operating wind turbines on the presence and activity of bats in forests. We simultaneously monitored bat acoustic activity at 84 sampling sites placed at 200 m intervals from 0 to 1,000 m (2 recorders per distance class), over four months and at seven Finnish wind farms located in forested habitats. Our results show higher presence and activity at 600 m and further from turbines for Eptesicus nilssonii, and higher presence at 800 m and further for Myotis spp. We also saw an increase in bat activity during midsummer, which may be due to increased use of forest canopy cover during the short nights at this time. These results indicate a potential loss in habitat quality around wind turbines, e.g., a greater number of open areas in forests unfavourable to certain bat species. This lower activity and presence could also be an indication for active avoidance of the wind turbines from the bats. Furthermore, these results are the first of their kind for Eptesicus nilssonii, and for the European boreal biogeographical region. They show undeniable impacts of wind power on bats in Finland, and enforce the requirement for better consideration of bats during the development of such projects in Finland. Similarly, these results show impacts of operating turbines on habitat use by bats, impacts that now must be considered in Europe. We also call for investigation on the causative mechanisms of the observed effect, to better facilitate mitigation.

We estimated the area avoided by bats per turbine, and for all current and planned wind power projects in Finland up to June 2022. Information on wind farms in the country is publicly available on the website of the Finnish Wind Power Association. We used the observed range of avoidance (800 m for E. nilssonii, 1,000 m for Myotis spp.) to determine the area avoided around each turbine by each species or group of species. Then, we calculated the proportion of area impacted by the presence of turbines in Finland, for all current and planned turbines.

Reference 2023 : Forest gaps around wind turbines attract bat species with high collision risk Julia S. Ellerbrok , Nina Farwig, Franziska Peter, Finn Rehling, Christian C. Voigt. Biological Conservation 288 (2023) 110347

The global demand for renewable energy has led to an expansion of wind energy production at forested sites. The deployment and operation of turbines requires the clearing of forest areas, resulting in significant habitat changes. To

assess the consequences of these changes for forest-associated bats, we measured the acoustic activity of three foraging guilds at turbine clearings, adjacent forest edges, and above nearby closed forests. Open-space and edge-space foraging bats were more active at turbine clearings and forest edges than above closed forests. Similarly, narrow-space foraging bats tended to be more active at turbine clearings than above closed forests. Open-space and edge-space foraging bats are known to be at high risk of colliding with wind turbines and their increased activity at forest gaps around turbines may increase casualties for these guilds. Operation of wind turbines in forests may therefore require longer shutdown periods to prevent legally protected bats from colliding with turbines. Although this may impair the energy yield of wind turbines in forests, such preventive conservation measures will ultimately contribute to a sustainable transition from fossil to renewable energy sources which factors in biodiversity conservation.

Temperate forests are important habitats for a wide range of species, among them bats. For example, 90 % of European bat species use forest structures at least temporarily for foraging and roosting (Dietz and Kiefer, 2014; Russo et al., 2016). Specifically, bats require tree cavities and standing deadwood for roosting as well as resource-rich foraging areas, which they use according to strata, structure, and vegetation density (Jung et al., 2012; Müller et al., 2013; Law et al., 2016). When forests are partially cleared for wind turbines, bats can be affected in several ways depending on their foraging and flight behaviour (Denzinger and Schnitzler, 2013; Aldridge and Rautenbach, 1987). Open-space foraging bats are long-range echolocators with pointed wings foraging mostly in spaces with few or no obstacles (Denzinger and Schnitzler, 2013).

They hunt above treetops and in larger clearings, while they avoid dense vegetation and small clearings (Voigt and Holderied, 2012). Thus, open-space foraging bats may explore and use forest gaps associated with wind turbines in forests. Edge-space foraging bats are mid-range echolocators, which are specialized on hunting prey close to background objects (Denzinger and Schnitzler, 2013). Hence, they are often found at forest edges (Kirkpatrick et al., 2017), which are created when forest patches are clear-cut for wind turbines. Finally, narrow-space foraging bats are short-range echolocators with rounded wings that facilitate foraging in forest understorey (Denzinger and Schnitzler, 2013). Although narrow-space foragers can fly outside of forests (Heim et al., 2018), they mostly occur in the forest interior and might therefore suffer from the creation of forest gaps for wind turbines. In conclusion, open-space and edge-space but not necessarily narrow-space foraging bats can be expected to increase their activity where forest gaps are created for wind turbines.

Fatalities of bats after collisions with wind turbines are a known global problem (O'Shea et al., 2016; Thaxter et al., 2017). Bat casualties at wind turbines are not equally distributed across species.

In Europe, for example, 95 % of bats found dead under wind turbines belonged to 6 out of 11 assessed genera (Nyctalus, Vespertilio, Pipistrellus, Hypsugo, Miniopterus, Tadarida; Dürr, 2022). Accordingly, bat species from these genera are commonly recognized as high-collision risk species (Rodrigues et al., 2014), which is associated with their ability to fly at the operation range of wind turbines (Reusch et al., 2022, 2023; Roeleke et al., 2016; Roemer et al., 2017).

Noticeably, all bat species recognized as high-collision risk species at wind turbines are members of the open-space or edge-space foraging guild, while bat species of the narrow-space foraging guild are usually considered to be at low risk of colliding with wind turbines (Rodrigues et al., 2014). Consequently, deployment of wind turbines at forested sites might lead to more casualties at wind turbines if bat species of high-collision risk are attracted to the open and edge habitats which were created for the deployment and operation of wind turbines. Besides, bats may also respond to the operation of wind turbines. Indeed, past studied confirmed that wind turbines repel certain bat species in open landscapes (Barr'e et al., 2018; Leroux et al., 2022) and in forests (Ellerbrok et al., 2022; Reusch et al. 2023; Gaultier et al., 2023)

Reference 2024 : Forest bat activity declines with increasing wind speed in proximity of operating wind turbines Julia S. Ellerbrok, Nina Farwig, Franziska Peter, Christian C. Voigt. Global Ecology and Conservation 49 (2024) e02782

The increasing use of onshore wind energy is leading to an increased deployment of wind turbines in structurally rich habitats such as forests. Forest-affiliated bats, in turn, are at risk of colliding with the rotor blades. Due to the legal protection of bats in Europe, it is imperative to restrict the operation of wind turbines to periods of low bat activity to avoid collisions. However, bats have also been observed to avoid wind turbines over several hundred meters distance, indicating a displacement that cannot solely be explained by modifications to the habitat. This avoidance suggests a displacement of bats by indirect factors related to wind turbine operation, e.g., wake turbulences and noise emissions. Therefore, we investigated whether the activity of forest-affiliated bats is influenced by operation mode (on/off) under variable wind conditions along transects from 80 to 450 m distance to wind turbines. We divided recordings by foraging guild, i. e., either narrow-space (Myotis, Plecotus), edge-space (Pipistrellus, Barbastella), or open-space

foraging bats (Nyctalus, Eptesicus, Vespertilio), and analyzed the effects of wind turbine operation and wind speed on the recorded bat guild activity with mixed effects models. The acoustic activity of narrow-space foraging bats decreased by 77% with increasing wind speed when wind turbines were operating, while bat activity remained unaffected by wind speed when turbines were not operating. This was neither observed for open-space foraging bats nor for edge-space foraging bats, and neither wind turbine operation nor wind speed (ranging between 0 – 4 m/s at 10 m height above ground) were found to affect bat activity when considered alone. Wind turbine noise emissions are known to increase with rotor speed and consequently, wind speed, thus presenting a likely explanation for the interactive negative effect of turbine operation and wind speed specifically on noise-sensitive narrow-space foraging bats. To understand potential ecological long-term consequences for bat populations in forest areas with wind turbines and to design effective conservation measures, future research should focus on disentangling the effects of different disturbances related to turbine operation.

Reference 2021 : Insect fatalities at wind turbines as biodiversity sinks. Christian C. Voigt. 2021. Perspectives And Notes. Conservation Science and Practice. Wiley. DOI: 10.1111/csp2.366

Evidence is accumulating that insects are frequently killed by operating wind turbines, yet it is poorly understood if these fatalities cause population declines and changes in assemblage structures on various spatial scales. Current observations suggest that mostly hill-topping, swarming, and migrating insects interact with wind turbines. Recently, the annual loss of insect biomass at wind turbines was estimated for Germany to amount 1,200t for the plant growth period, which equates to about 1.2 trillion killed insects per year, assuming 1 mg insect body mass. Accordingly, a single turbine located in the temperate zone might kill about 40 million insects per year. Furthermore, Scheimpflug Lidar measurements at operating wind turbines confirm a high insect activity in the risk zone of turbines. These numbers and observations are alarming, yet they require further consolidation, particularly across all continents and climate zones where wind energy industry is expanding. We need to understand (a) how attraction of insects to wind turbines affect fatality rates and interactions of insect predators with wind turbines. (b) We have to connect insect fatalities at wind turbines with source populations and evaluate if these fatalities add to the decline of insect populations and potentially the extinction of species. (c) We need to assess how fatalities at wind turbines change insect mediated ecosystem services. An ever-growing global wind energy industry with high densities of wind turbines may have long-lasting effects on insects and associated trophic links if negative impacts on insects are not considered during the erection and operation of wind turbines.

Reference 2023 : How far are birds, bats, and terrestrial mammals displaced from onshore wind power development? – A systematic review Anne Tolvanen , Henri Routavaara , Mika Jokikokko, Parvez Rana . Biological Conservation Volume 288, December 2023, 110382

Wind power is a rapidly growing source of energy worldwide. It is crucial for climate change mitigation, but it also accelerates the degradation of biodiversity through habitat loss and the displacement of wildlife. To understand the extent of displacement and reasons for observations where no displacement is reported, we conducted a systematic review of birds, bats, and terrestrial mammals.

Eighty-four peer-reviewed studies of onshore wind power yielded 160 distinct displacement distances, termed cases. ***For birds, bats, and mammals, 63 %, 72 %, and 67 % of cases respectively reported displacement.***

Cranes (3 3 cases), owls (2 2), and semi-domestic reindeer (6 6) showed consistent displacement on average up to 5 km. Gallinaceus birds showed displacement on average up to 5 km, but in 7 18 cases reported to show "no displacement".

Bats were displaced on average up to 1 km in 21 29 cases.

Waterfowl (6 7 cases), raptors (24 30), passerines (16 32) and waders (8 19) were displaced on average up to 500 m.

Observations of no displacement were suggested to result from methodological deficiencies, species-specific characteristics, and habitat conditions favourable for certain species after wind power development.

Wind power development can influence wildlife through many mechanisms. Habitat change and fragmentation may decrease habitat suitability and resource availability near turbines (e.g., Campedelli et al., 2014). Disturbance caused by rotor movement, noise, vibration, flickering lights, and increased human presence may lead to behavioural changes such as avoidance and changes in flight paths (Drewitt and Langston, 2006; Marques et al., 2019; Schuster et al., 2015). Avoidance can occur at different scales, at the level of the entire wind farm (macroscale), within the wind farm (meso-scale), or in the immediate vicinity of wind turbines (micro-scale, Marques et al., 2021; May, 2015). Displacement indicates principally macro- (May, 2015) and meso-scale (Marques et al., 2021) avoidance. As a result

of displacement, a reduced density of wildlife near wind turbines may be observed. Knowledge of displacement can be used to estimate distance thresholds, beyond which wind power development is not expected to have remarkable biodiversity impacts. This improves the opportunities to mitigate the detrimental effects of wind power on wildlife. There is abundant literature and review articles on the impacts of wind power development on the distribution, abundance, survival, behaviour, and displacement of birds (e.g., Coppes et al., 2020b; Marques et al., 2014, 2021), bats (Cryan and Barclay, 2009; Guest et al., 2022) and on wildlife in general (Schuster et al., 2015; Scholl ¨ and Nopp-Mayr, 2021). Benitez-Lopez ´ et al. (2010) investigated displacement distances from infrastructure using meta-analysis and meta-regression. Using data from 49 studies, of which three studied the wind power, they showed that the main response of mammals and birds to infrastructure was avoidance or a reduced population density. In their analysis, BenitezLopez ´ et al. (2010) omitted the few studies not showing the negative effects of infrastructure. Their models however showed that a large number of studies reporting neutral or positive responses to infrastructure would be needed to reverse their results.

Marques et al. (2021) included 71 studies in their review and found that approximately 40 % of studied bird taxa showed displacement from onshore and offshore wind power development. They suggested improvements for study design, for example, by encouraging observations to be made before the construction of a wind power development. Scholl ¨ and Nopp-Mayr (2021) reviewed 27 studies of birds, bats, and mammals in woodland ecosystems. They concluded that displacement distances (or distance thresholds) varied temporally and spatially, even within species. They also called for the improvement of study design and suggested that BACI (before-after-control-impact) studies should be mandatory for approval and decisions related to wind power development.

Number of cases, i.e., taxa or functional groups, for which displacement distances were presented in the published studies. Classified as displacement/no displacement

Taxa/functional group	*Displacement*	*No displacement*	*Sum*
Birds			
Cranes	*3*	*0*	*3*
Gallinaceous birds	*11*	*7*	*18*
Owls	*2*	*0*	*2*
Passerines	*16*	*16*	*32*
Raptors	***24***	***6***	***30***
Waders	***8***	***11***	***19***
Waterfowl	*6*	*1*	*7*
Several	*3*	*2*	*5*
Sum	***73***	***43***	***116***
Bats	***21***	***8***	***29***
Terrestrial mammals			
Canids	*1*	*1*	*2*
Cervids	*8*	*1*	*9*
Small mammals	*1*	*3*	*4*
Sum	***10***	***5***	***15***
Total	***104***	***56***	***160***

All three cases on cranes were classified as displaced by wind power development. Two studies focused on migrating whooping cranes (Grus americana, Ellis et al., 2022; Pearse et al., 2021). They showed 20 times more activity outside the 5000 m distance from wind turbines compared to the area inside (Pearse et al., 2021). The same displacement distance was observed when the birds looked for a stopover site to forage in the same area in the United States Great Plains (Ellis et al., 2022). GPS marked overwintering sandhill crane (Grus canadensis) showed potential indication of avoidance behaviour <10km distance, although this was suggested to be the result of habitat selection rather than displacement.

We classified eleven out of 18 cases of gallinaceous birds in the displacement category, the median distance being up to 5000 m. Birds were found to reduce lekking near wind power development (LeBeau et al., 2017a; Winder et al., 2015; Zwart et al., 2015), the longest distance being >5000 m for the decreased lek persistence of greater prairie-chicken males (Tympanuchus cupido pinnatus, Winder et al., 2015). Greater prairie-chicken males near turbines spent less time in non-breeding behaviours than those farther away, possibly to compensate for the effects of noise

disturbance (Smith et al., 2016). On the other hand, greater prairie-chicken females could nest even within a small wind power development area, but as they selected nest sites >700 m from wind power roads (Harrison et al., 2017), we classified the case as displacement.

Noise was also assumed to disturb capercaillie (Tetrao urogallus) and reduce the success rate and time invested in breeding up to over 800 m (Taubmann et al., 2021). The species showed population declines because of reduced habitat suitability near wind power development (Gonzalez ' et al., 2016), and there was no indication that habituation occurred eight years after construction (Coppes et al., 2020a). Chick survival in Columbian sharp-tailed grouse (Tympanuchus phasianellus columbianus) decreased by 50 % when there were ≥10 wind turbines within 2100 m of the nest (Proett et al., 2022). A potential reason for this was suggested to be increased predation and noise disturbance, which hindered the passing of alarm sounds to chicks by brood females (Proett et al., 2022). Summer habitat selection of greater osage-grouse (Centrocercus urophasianus) decreased with the increase of surface disturbance ≤1200 m from wind power development, although there was no direct effect on the nest site selection or the survival of females (LeBeau et al., 2017b). Seven gallinaceous bird cases were classified as no displacement, two focusing on the breeding or habitat selection of greater prairie-chicken (McNew et al., 2014; Raynor et al., 2019). The lack of responses in these studies was suggested to be connected with the habitat, i.e. the avoidance of non-grassland areas instead of the displacement from wind power development. The lack of displacement in red grouse (Lagopus lagopus scoticus) was assumed to result from methodology, i.e. a shortterm (three-year) study on a single site after wind power development was operational (Douglas et al., 2011).

Even positive associations with wind turbines were found for common pheasant (Phasianus colchicus, Łopucki et al., 2017) and red grouse (Lagopus lagopus scoticus, Douglas et al., 2011). The suggested reasons for this association were linked to species and habitat through a reduced number of predatory birds and a general affinity for tracks as a source of grit, which is important for digestion (Douglas et al., 2011; Łopucki et al., 2017). Also the short duration of study on a single site was suggested to be a reason for no displacement in Douglas et al. (2011).

Only two cases addressed owls. Both showed that the birds abandoned their territories and nests up to 5000 m from wind power development (Husby and Pearson, 2022; Lopez-Peinado ' et al., 2020). The owls were suggested to be sensitive to noise and disturbance, and open areas created by wind power development were assumed to be poor hunting habitats.

Passerines showed both displacement and no displacement in 16 cases. The median displacement distance was 500 m and was observed as avoidance behaviour and reduced bird densities (Fern' andez-Bellon et al., 2019; Pearce-Higgins et al., 2009; Shaffer and Buhl, 2016; Stevens et al., 2013), a reduced number of breeding birds (Leddy et al., 1999; Pearce-Higgins et al., 2009), and reduced nest density (Song et al., 2021). The displacement extended up to 4500 m in a study of the endangered Dupont's lark (Chersophilus duponti) in Spain, where even local extinctions were suggested to occur in the presence of wind farms (Gomez-Catasús ' et al., 2018). Nighttime lights and the rotation of turbines were suggested to disturb birds and have adverse effects on communication (Gomez-Catasús ' et al., 2018, 2022; Leddy et al., 1999). It was also observed that habitat change and reduced forest cover resulted in a large reduction of safe habitats for forest-dwelling passerines (Fernandez-Bellon ' et al., 2019; Shaffer and Buhl, 2016). In Garcia et al 2015, decreasing population trends were observed among 12 of 15 breeding passerine species during construction, but the species were observed to return to their old nesting sites when construction was completed. We nevertheless classified Garcia et al. (2015) in the "displacement" category, since displacement was observed during the construction period. Also no displacement was shown in 16 cases of passerines. In Hale et al. (2014), breeding grassland passerines were not observed to react to turbines, partially due to the difficulty of isolating the effect of turbine distance from other factors, such as barbed wire fences, covarying with distance. However, their conclusion was criticized by Johnson (2016), who claimed that the conclusion was based on inappropriate statistical analysis of data and that two of the three studied species might in fact show displacement. In Shaffer and Buhl (2016), the vesper sparrow (Pooecetes gramineus) was the only passerine species that did not respond to wind turbines, suggested reason being related to the species and habitat conditions, i.e. its life-history characteristic as the first species to occupy disturbed areas.

For the nest-site selection of the grasshopper sparrow (Ammodramus savannarum), vegetation (i.e. habitat conditions) was assumed to play a more important role than distance from turbines, and snake predation causing failure to nesting was greater close to wooded edges than near wind turbines (Hatchett et al., 2013). In Stevens et al. (2013), three out of four passerine species showed no displacement from wind turbines, and the difference between species was assumed to be in their species-specific predator evasion strategies.

Social species such as Sprague's pipit (Anthus spragueii), savannah sparrows (Passerculus sandwichensis), and meadowlarks (Sturnella sp.) were known to use open areas, and a high number of individuals was suggested to help in

the detection of predators. In contrast, Le Conte's sparrow (Ammodramus leconteii) was known to hide in thick vegetation and was observed to show displacement (Stevens et al., 2013).

In Devereux et al. (2008), corvids and Eurasian skylark (Alauda arvensis) did not show displacement and were indeed more likely to occur close to turbines than farther away. Potential reasons were suggested to be the small sampling size (methodological reason), but also higher food availability (habitat conditions) near turbines.

We found displacement in 24 cases of raptors . The median distance was 500 m, ranging from 100 m for Montagu's harrier (Circus pygargus, Schaub et al., 2020) and the golden eagle (Aquila chrysaetos, Fielding et al., 2021, 2022) to 4000 m for the white-tailed eagle (Haliaeetus albicilla, Balotari-Chiebao et al., 2016a). Displacement was represented as changes in abundance (Campedelli et al., 2014; Garwin et al., 2011) and flight behaviour near turbines (Cabrera-Cruz and Villegas-Patraca, 2016; Hull and Muir, 2013; Johnston et al., 2014; Santos et al., 2021, 2022), which were assumed to increase the birds' energy usage (Cabrera-Cruz and Villegas-Patraca, 2016). Functional habitat loss (Campedelli et al., 2014; Marques et al., 2019), and reduced breeding success were also observed (Dahl et al., 2012; Balotari-Chiebao et al., 2016a).

Time could influence the results: Raptor abundances declined immediately after installation (Farfan ' et al., 2009) but showed some recovery, although not to the preconstruction level, 6.5 years later (Farf' an et al., 2017). Displacement was not found in six raptor cases, in which distances up to 1000 and 5000 m (median 1000 m) were studied. Due to the lack of displacement, young white-tailed eagles were observed flying into the wind turbine areas, exposing them to the risk of collision (Dahl et al., 2013; Krone and Treu, 2018). The flying behaviour was observed to vary between individual eagles and in relation to food availability (Krone and Treu, 2018).

Individuals of three Buteo hawk species did not show displacement from wind turbines regarding the selection of their nesting territories, but as rotor speed increased, avoidance flights increased, thereby mitigating collisions (Watson et al., 2018). As the avoidance flights occurred in the immediate vicinity of turbine blades, we did not classify them as displacement. Montagu's harrier (Circus pygargus, was expected to choose its nesting site according to the potential of vegetation covering the nests rather than the distance to disturbing features such as wind turbines (Hernandez-Pliego ' et al., 2015). In Campedelli et al. (2014), the sparrowhawk (Accipiter nisus) was the only species of seven raptors showing no significant difference in observations between pre- and post-construction. The result was not discussed. Hawks, eagles, and falcons did not display avoidance behavior around wind turbines, suggesting that their displacement might be species- and site-specific (Smith et al., 2017).

Waders were the only bird group in which we found no displacement more often than displacement (11 vs. 8 cases, respectively). Displacement effects were manifested as decreased bird density and breeding bird abundance, the median distance being 500 m from wind turbines (Pearce-Higgins et al., 2009; Sansom et al., 2016; Shaffer and Buhl, 2016). Bai et al. (2021) showed that shoreline bird groups (all four cases classified as waders in this study) avoided crossing closely spaced (200 m) turbines. However, their abundance showed no significant change in the study area compared with the control.

Eleven cases of waders showed no displacement, median studied distance across the cases being 1000 m. The longest studied distance reached beyond 5000 m for the little egret (Egretta garzetta) in China, where bird abundance was not influenced (Xu et al., 2021). The abundance of little egrets depended on the habitat conditions, i.e. on the land use type suitable for feeding rather than the distance to the wind farm (Xu et al., 2021). Similarly, no evidence was found for golden plovers (Pluvialis apricaria) avoiding wind turbines in the UK (Douglas et al., 2011) or the USA (Pluvialis dominica, Homoya et al., 2017). These results contradicted those of Pearce-Higgins et al. (2009) and were assumed to be partially due to a single study location and the lack of an assessment before the construction of turbines (Douglas et al., 2011). Also weather conditions between the two survey years were expected to at least partly explain the observed population increase of the golden plover (Douglas et al., 2011). An interesting observation was made for killdeer (Charadrius vociferous), which not only exhibited high tolerance to turbines but also increased in density near them, as turbines were assumed to provide gravel substrates for nesting (Shaffer and Buhl, 2016). Four wetland species were not observed to avoid wind turbines, but the result was thought to arise largely from the small sample size and short duration (three years) of the study, which did not cover potential lag effects on the species (Niemuth et al., 2013).

Six cases of waterfowl showed displacement, the median distance being 500 m from wind turbines. The greatest distance was 1300 m (classified as "up to 5000 m") for the Chinese spot-billed duck (Anas zonorhyncha) and mallard (Anas platyrhynchos, Zhao et al., 2020). Displacement was often shown as changes in the selection of resting and feeding areas (Fijn et al., 2012; Harrison et al., 2018; Larsen and Madsen, 2000; Zhao et al., 2020). To avoid the wind turbines, the birds had to fly farther, which was assumed to require more energy (Madsen and Boertmann, 2008). The associated infrastructure and fragmentation of habitats caused more displacement than the turbines themselves

(Larsen and Madsen, 2000). The distance from small wind turbines decreased in 8–10 years for pink-footed geese (Anser brachyrhynchus, Madsen and Boertmann, 2008), and Bewick's swans (Cygnus columbianus bewickii), which were found to feed closer to the wind turbines according to food availability (Fijn et al., 2012). The oldest study of waterfowl, by Meek et al. (1993), indicated that the only species to respond negatively was the red-throated diver (Gavia stellata). The reason for its decline was however uncertain in the study. The only case for waterfowl showing no displacement was also presented in Meek et al. (1993) as an aggregated result for ducks. It was notable that most studies of waterfowl were conducted using wind turbines with tower heights of <50m.

Three studies of several bird groups showed displacement, and two no displacement, with the studied distances up to 100, 500 m, or 1000 m. Displacement was expressed as reduced abundance and flight rates during a 6.5-year post-construction period (Farfan ' et al., 2017), a reduction in avian activity during construction (Pande et al., 2013), and changes in aerial space and flight course (Therkildsen et al., 2021). Minderman et al. (2012) did not observe displacement in terms of bird activity related to small turbines (<50m m tower height) and assumed that turbine presence did not affect habitat use, or because displacement occurred at a different spatial scale than what was studied. There was only one study focusing on tall (even above 200 m) wind turbines. It showed that small forest birds (45 species) were sensitive to forest structure, season, and rotor diameter, but not to the proximity of wind turbines (Rehling et al., 2023). We therefore classified the study as showing no displacement. Nevertheless, the study showed that the height and number of turbines, along with rotor length, reduced bird abundance and richness (Rehling et al., 2023).

The vulnerability of bird populations to wind power development can be high especially among long-lived species (Fielding et al., 2021). For example, owls and raptors have slow maturation and reproduction rates (Farf' an et al., 2009; Garwin et al., 2011). If displacement influences their abundance during the breeding season (Lopez-Peinado ' et al., 2020), increases the abandonment of nests (Husby and Pearson, 2022), or decreases the success of breeding (Balotari-Chiebao et al., 2016a,b), and these effects occur with increased collisions (e.g., Husby and Pearson, 2022), population effects are inevitable. Habituation to wind turbines has rarely been observed in raptors, suggesting that they do not adjust easily to the presence of a wind farm, and population changes may therefore be permanent (Campedelli et al., 2014 and the references therein).

Bats showed displacement in 21 cases out of 29, the median displacement distance being 1000 m, which was also the maximum distance surveyed (Fig. 3). Apart from the studies by Minderman et al. (2012, 2017) on small wind turbines (<50m tower height) other studies were conducted on turbines taller than 50 m, extending even to over 200 m (Ellerbrok et al., 2022). None of the bat studies included observations before wind power development.

Bat responses were strongly confounded by their foraging environment (forest, edge, open) and the echolocation range of the species (short, mid, long). Especially forest species (which are also short-term ecolocators, e.g., Myotis sp., Barbastella barbastellus) showed displacement, which was expressed as reduced abundance and activity around turbines (Apoznanski ' et al., 2018; Barr'e et al., 2018; Ellerbrok et al., 2022; Leroux et al., 2022; Gaultier et al., 2023). Loss in habitat quality due to greater amount of open areas (Gaultier et al., 2023), noise (Ellerbrok et al., 2022) and red aviation lights were suggested as reasons for displacement (Barr'e et al., 2018). Displacement was observed in their optimal foraging habitats such as hedgerows (Barr'e et al., 2018) and forests (Gaultier et al., 2023), while the response could be the opposite (i.e., attraction) in less optimal open habitats (Leroux et al., 2022). Reduced activity near turbines resulted in a loss of foraging habitat, which in a tropical biodiversity hotspot was considered to threaten bat conservation (Millon et al., 2018). An interesting observation was made in Reusch et al. (2022), where 70 % of common noctule bats (Nyctalus noctula) showed avoidance behavior toward wind turbines, but when attraction was found, it occurred toward large turbines more than small turbines.

Displacement was not observed in eight cases, the studied distances being up to 1000 m. Edge-space foragers (and mid-range echolocators) Pipistrellus pipistrellus (Ellerbrok et al., 2022) and P. kuhlii nathusii (Barr'e et al., 2018; Leroux et al., 2022) showed no response to wind turbines in forest landscapes. The lack of responses in Pipistrellus pipistrellus in Ellerbrok et al. (2022) contrasted with the observation by Barr'e et al. (2018) and Minderman et al. (2017), who observed displacement in an open landscape. It was suggested that forest clearing for wind turbines would create ideal foraging habitats for edge-space foragers (Ellerbrok et al., 2022). Regarding the lack of response in P. kuhlii nathusii, a potential explanation was the contrasting behavior (avoidance vs. attractiveness) of the species within this bat group due to their different migratory status (Barr'e et al., 2018; Leroux et al., 2022). Open space foragers were observed to be attracted to wind turbines in open areas (Leroux et al., 2022) or during certain seasons (Ellerbrok et al., 2022). However, the suggested reasons for this attraction were inconsistent (Ellerbrok et al., 2022).

Bats display a mixture of displacement and attraction, of which displacement occurs at longer distances and attraction around turbines (Millon et al., 2015; Reusch et al., 2022). The maximum observed displacement distance

was 1000 m, but this might be an underestimate, since longer distances were not studied (Barr'e et al., 2018). Displacement seems to vary, depending on the preferred foraging habitat (forests or hedgerows vs. open habitats), echolocation range, and migratory pattern, but in general, the mechanisms leading to displacement remain largely unknown (Barr'e et al., 2018). Many studies report negative population effects, and even extinctions have been anticipated if wind power development continues to increase (Friedenberg and Frick, 2021). Despite initial population declines and changes in species diversity due to habitat change and displacement, some bat populations can recover, as shown in a study of 22 tropical bat species in Mexico (Briones-Salas et al., 2017).

Terrestrial mammals

There were only two studies of canids, showing displacement for the red fox (Vulpes vulpes) up to 700 m in Poland (Łopucki et al., 2017) but not significantly for the coyote (Canix lastrans), studied to almost 10,000 m in Nebraska, USA (Smith et al., 2017). Displacement for the fox was assumed to be an indirect effect of wind power development and result from lower prey availability, especially of the hare, near wind turbines (Łopucki et al., 2017) (Fig. 3). Bird carcasses killed by wind turbines were proposed to attract the foxes, but there were no observations of bird remains to support this (Łopucki et al., 2017). Coyote was assumed to have habituated to the wind turbines by the time of the study, which was started eight years after the wind turbines became fully operational (Smith et al., 2017).

Of the nine studies of cervids, six were undertaken of the semidomestic reindeer (Rangifer tarandus), all showing displacement. Three studies were carried out in the same area but on different occasions in Sweden (Skarin and Alam, 2017; Skarin et al., 2015, 2018). Displacement from 100 m to the access road (Colman et al., 2013) up to 15,000 m from the wind farm (Skarin and Alam, 2017) was observed. According to Colman et al. (2013), the distribution of the reindeer was more related to habitat quality than wind power development. Displacement nevertheless occurred especially during the construction phase (Colman et al., 2013; Skarin et al., 2015), although it was observed also during operation (Skarin and Alam, 2017). Calving time was most sensitive for the reindeer (Skarin et al., 2018; Tsegaye et al., 2017). The noise generated by wind turbines was assumed to disturb the interaction between calves and mothers and negatively affect the reindeer's ability to hear predators (Skarin et al., 2018). As a consequence, displacement during operation occurred farther away than during construction (Skarin et al., 2018). Tsegaye et al. (2017) did not observe a change in the spatial use of areas near wind power development outside calving time. A high seasonal and annual variation in displacement was also observed by Eftestol et al. (2023), and the reasons were assumed to be linked not only to natural movement patterns but also to herding activities, indicating human interference with the displacement.

Concerning wild cervids, the European roe deer (Capreolus capreolus) avoided wind farm interiors and proximity to turbines up to 600–700 m, potentially due to the difficulty of hearing or sensing their predators (Łopucki et al., 2017). The pronghorn (Antilocapra americana) showed behavioral changes during migration by avoiding turbines and moving more quickly near them, which was assumed to influence their foraging success or the availability of specific routes in the long run (Milligan et al., 2023). The Rocky Mountain elk (Cervus elaphus) was not adversely affected by wind power development, as evidenced by its home range, studied up to a distance of over 5000 m (Walter et al., 2006). The suggested reason was despite disturbance and habitat loss, riparian habitats that were critical seasonal habitats for the elk, were not altered by construction (Walter et al., 2006).

Of the four studies of small mammals, only European hare (Lepus europaeus) showed displacement up to 700 m (Łopucki et al., 2017), whereas three studies focusing on small rodents, shrews, hedgehogs, and hamsters did not show displacement (de Lucas et al., 2005; Łopucki and Mroz, ' 2016; Łopucki and Perzanowski, 2018). Large temporal variation of populations and difference in temporal trajectories between places (de Lucas et al., 2005), and behavioural and physiological characteristics (Łopucki and Mroz, ' 2016; Łopucki and Perzanowski, 2018) which were not monitored, were suggested to be reasons for the lack of responses. Also, the hamster was known to live near various types of human infrastructure, including settlements (Łopucki and Perzanowski, 2018).

In our review two thirds of 160 cases show displacement, and there is large variation in the displacement distances within and among taxa. Concerning especially cranes, owls, semi-domestic reindeer and gallinaceous birds the effects of wind power development can extend for several kilometers, suggesting a significant loss of functional habitat for these species. For flying species such as raptors and bats, displacement and collisions create a double-edged sword that causes population decline regardless of whether displacement occurs. "

Reference 2015 : Examples of onshore baseline surveys for bats (adapted from the UNEP/EUROBATS guidelines, Rodrigues *et al.* 2015)

• Identification of important maternity, hibernation and swarming sites based on signs of bats and/or presence and abundance of recorded bats.

• Bat detector surveys on the ground — use of automated detectors to the define bat activity index (number of bat contacts per hour) and habitat use, potentially supplemented with manual surveys (walked transects, vantage-point surveys) and other observational techniques (thermal/infra-red cameras).
• Activity surveys at height — use of automated detectors to define the bat activity index (number of bat contacts per hour).
• Potential need for above-canopy activity surveys and advanced techniques such as trapping and radio-telemetry in woodlands.
• Collection of environmental data (temperature, precipitation, wind speeds).

Main types of impacts on bats (drawn from the UNEP/EUROBATS guidelines)

• Collision and barotrauma — the fatal interaction between bats in flight and wind turbine structures.
• Habitat loss and degradation — the removal of, fragmentation or damage to supporting habitats.
• Disturbance and displacement at roost sites — activities in and around roost sites such as habitat removal or the presence of maintenance vehicles and personnel can result in changes in temperature, humidity, light, noise and vibration within the roost, with a consequent reduction in use or reproductive capacity.
• Loss of flight corridors and roost sites — the physical or functional loss of flight corridors and roosting sites.

Table 5-4 Types of impacts on bats during the project's life cycle for onshore wind energy developments

Types of impacts	Project phase				
	Pre-construction	Construction	Operation	Decommissioning	Repowering
Habitat loss and degradation	X	X	X	X	X
Disturbance and displacement at roost sites	X	X	X	X	X
Habitat fragmentation		X	X	X	
Collision			X	X	
Barrier effect			X	X	
Barotrauma			X	X	
Loss or shifting of flight corridors and roost sites		X	X	X	
Increased availability of invertebrate prey, and thus increased collision risk, due to night illumination			X	X	
Indirect effects		X	X	X	X

Once the wind turbines are in operation, mortality due to collision or barotrauma are considered to be the most significant effects, but the risk differs between species.
Disturbance and displacement could occur at any stage of a project's life cycle, with barrier effects occurring during operation and repowering. These likely significant effects could result in changes in behaviour including attraction (Behr *et al.* 2018; Foo *et al.* 2017), spatial shift of flight corridors, and the exclusion of bats from foraging habitats they would otherwise use (Barré *et al.* 2018). Attraction could result in higher collision risk (Rydell *et al.* 2010a; Voigt *et al.* 2018). However, Millon *et al.* (2018) considered displacement itself to be an important impact to consider, and Barré *et al.* (2018) have recently quantified this effect across a number of wind farms. The assessment of disturbance, displacement and barrier effects should be considered on a case-by-case basis, taking into account the size of the plan or project, the bat species known to be present, their habitat use, and the importance of the supporting habitat to the favourable conservation status of the population, particularly in the light of existing threats and the site's conservation objectives.

Factors for the design of baseline data collection methods and the assessment of significance, in relation to bats
Biological
• Collision risk, to a large extent defined by foraging characteristics, echolocation type and the flight behaviour of species (Denzinger and Schnitzler, 2013; Roemer *et al.*, 2017).

• Annual life cycle stage, i.e. active, hibernating, breeding, migrating, swarming.
• The presence of hibernation and maternity roosts.
• Population vulnerability, based on collision risk and the status of species affected (an example can be found in Scottish Natural Heritage *et al.*, 2019).

Environmental

• The presence of habitats within 200m of a plan or project likely to be used by bats during their life cycle, e.g. forests (especially mature broad-leaved forests), trees, hedgerow networks, wetlands, waterbodies, watercourses and mountain passes
• Confined areas where bats forage or roost, and/or the potential for narrow bat migration or commuting routes.
• Large river corridors that may serve as migration routes.
• Habitat types at a landscape scale, e.g. the presence of broadleaved woodland within 1.5 km of wind energy developments in Great Britain appeared to reduce risk to all species combined (and soprano pipistrelles analysed separately), but the total area of coniferous woodland was only associated with an increased risk to noctules (Mathews *et al.*, 2016). The responses are therefore species- and habitat-dependent. Depending on the species in question and their habitat associations, the presence/absence of a suitable habitat could be used as a way of 'ruling in' areas potentially suitable for wind energy developments rather than for identifying areas likely to be problematic (Mathews *et al.*, 2016).
• Wind speed and direction, temperature and relative humidity are known to be significantly correlated with both bat activity and mortality (Amorim *et al.* 2012; Mathews *et al.* 2016; and others cited in Rodrigues, 2015). These environmental variables may be among those used to determine the level of risk a proposed site is likely to have on bats.

Plan or project design

• Turbine number and rotor swept area.
• Turbine size, which can influence the distance over which displacement occurs [Barré *et al.* (2018) and Minderman *et al.*, (2012; 2017)].

Collision risk for European (incl. Mediterranean) species from wind turbines in open habitats(derived from Rodrigues, 2015)

High risk	Medium risk	Low risk
***Nyctalus* spp.**	*Eptesicus* spp.	*Myotis* spp.
***Pipistrellus* spp.**	*Barbastella* spp.	*Plecotus* spp.
Vespertilio murinus	*Myotis dasycneme*[2]	*Rhinolophus* spp.
Hypsugo savii		
Miniopterus schreibersii[1]		
Tadarida teniotis		

[1] *Miniopterus schreibersii* is the only Annex II species in the high-risk category

The annual life cycle of bat species must also be taken into account as the magnitude and significance of an effect can vary depending on the time of year (Table 5-6). The timing of annual life cycle stages varies between species and populations of the same species in different Member States. It is therefore prudent to refer to national guidance in relation to bats and wind energy developments, where this is available, or to the UNEP/EUROBATS guidelines (Rodrigues *et al.* 2015) if there is no national guidance. A comprehensive list of national guidance documents is provided in Appendix E.

The degree of risk associated with impacts on bats in relation to their annual life cycle(drawn in part from Rodrigues et al. 2015)

Likely significant effect	Breeding season	Hibernation season	Spring/autumn
Construction			
Habitat loss and degradation	Low to high, depending on proximity to roosts	High, depending on proximity to roosts	Low (particularly for migrating bats travelling long distances)
Loss of roost sites	Potentially high or very high	Potentially high or very high	Potentially high (e.g. loss of mating roosts)
Turbine operation			
Collision/fatalities	Low to high, depending on the species	Low	High to very high
Loss or shifting of flight corridors	Medium	Low	Low. Migration likely to occur on a broad front, but cumulative effects need to be considered

Key challenges in assessing the significance of effects on bats

All effects

- Limited evidence regarding the effects of small wind turbines, e.g. those with a hub height less than 18 m above ground level.
- Limited evidence regarding the behaviour of bats around turbines (Natural England, 201485 and Mathews *et al.* 2016). Some evidence of attraction has been reported (Behr et. al., 2015), particularly in the presence of red light (Voigt *et al.* 2018).
- In a British wind park, bat activity showed extremely high variability, both within and between years (Mathews *et al.*, 2016).

Collision

- There is no way to predict bat fatalities prior to construction with current approaches focused on site-specific surveys rather than multi-site studies, which makes it difficult to identify risk factors (Mathews *et al.*, 2016). Arnett *et al.* (2016) identified improving the predictability of bat fatalities as a key area for future research.
- It remains unclear whether pre-construction acoustic data are able to adequately predict post-construction fatality (Arnett *et al.*, 2013), and whether current environmental impact assessments fail to reduce the risk of bat casualties on wind farms (Lintott *et al.* 2016).
- It is possible that there are additional high-risk periods in the annual life cycle of bats, but that they remain undetected because of a focus on late summer/autumn, a period coinciding with both autumn migration and the beginning of the presumed mating period in many of the studied species (Rydell *et al.*, 2010; Rodrigues *et al.*, 2015).
- Search protocols might not identify all casualties, though techniques are improving, particularly with the use of dogs86. Injuries that allow bats to travel out of the typical search area before dying ('cryptic deaths') may mean bat mortality estimates are generally underestimated(Barclay *et al.*, 2017). Fatalities from turbines with greater nacelle/rotor heights may also fall outside the search area and be missed (Weber *et al.* 2018).
- There is some evidence of sex- and age-specific vulnerability to collision (Lehnert *et al.* 2014) but this has not been found in all studies (Barclay *et al.*, 2017, Mathews *et al.* 2016). The predicted effects on local populations depend heavily on the age and sex structure of casualties, so this is an important data gap.
- There are limited mortality estimates for wind energy developments located along migratory flyways (Rydell *et al.*, 2001a)
- The effects of mortality on populations is extremely poorly understood (Weber *et al.* 2018, amongst others)

Disturbance and displacement

- There is limited empirical data on the significance of disturbance and displacement, except in relation to the disturbance of roost sites.
- The extent to which wind farms may displace foraging bats is uncertain but may be important for a broad range of species, and may result in effects on species not considered to be at high risk of mortality (Barré *et al.* 2018).

Barrier effect

- The cumulative barrier effect on long-distance migrants of avoiding multiple obstacles along the course of their migration route remains unstudied.

Habitat loss and degradation

- The extent of functionally linked land that lies beyond the borders of a Natura 2000 site and is necessary to maintain or restore the favourable conservation status of a species is unknown and varies between species (e.g. Apoznański *et al.* 2018). As noted, however, the majority of species vulnerable to collision risk are not Annex II species.

Loss of flight corridors and roost sites

• Empirical data on the significance of the loss of flight corridors is limited.

• Wind turbines may influence populations outside their national borders through effects on migrating bats (Voigt *et al.*, 2012; Lehnert *et al.*, 2014).

• Connectivity between breeding and wintering areas may be weakened as the increasing cumulative density of wind energy developments disrupts national and transboundary migratory routes (Berkhout *et al.*,2013).

Key recommendations for assessing the significance of effects on bats

• Define clear significance criteria that are aligned with the conservation objectives for the bats concerned, are context specific (case-by-case) and are scientifically underpinned.

• Ensure availability of data, notably in relation to bat populations, their activities, their roost sites, etc. to inform plan-level assessments or detailed project-specific surveys and assessment.

• Invest in research in order to cover the knowledge gaps, as listed in Box 5-8.

• Benefit from the increased availability of post-development monitoring reports to improve the evidence base.

Table 5-7 Possible mitigation measures for bats (A: avoidance; R: reduction)

	Collision and barotrauma	Habitat loss and degradation	Disturbance and displacement at roost sites	Loss of flight corridors (barrier effects) and roost sites
Micrositing: Turbine arrangement and location	A/R	A/R	A/R	A/R
Infrastructure design: Turbine number and technical specifications	R		R	R
Scheduling: Avoiding, reducing or phasing construction activities during ecologically sensitive periods			A/R	
Curtailment and cut-in speeds: Turbine operation timing	R			R
Deterrents: Acoustic and visual measures	A/R			R

Reference 2014 : Consolidating the State of Knowledge: A Synoptical Review of Wind Energy's Wildlife Effects. Eva Schuster · Lea Bulling · Johann Köppel.Received: 10 August 2014 / Accepted: 10 April 2015 / Published online: 26 April 2015 © Springer Science+Business Media New York 2015

Table 1 Predominant hypotheses on wind energy-induced effects on bats based on Köppel et al. (2014 amended)

Hypothesis	Plausible/supported	Implausible/not-supported
Increased mortality due to high flight activity		
Increase in temperature enhances bat activity/fatality (up to 21 °C)	Arnett et al. (2006[δ], 2007)[δ], Baerwald and Barclay (2011)*; Behr et al. (2011)[δ], Brinkmann et al. (2011)[δ], Grodsky et al. (2012)*, Hein et al. (2011b)[δ], Kerns et al. (2005)[δ]: Meyersdale, and Redell et al. (2006)[δ]	Arnett et al. (2006)[δ] (>44 m); Horn et al. (2008)*: but in combination with wind speed; Kerns et al. (2005)[δ]: Mountaineer
Decrease in wind speed leads to a higher bat activity/fatality	Arnett et al. (2006[δ], 2008[fi]), Baerwald et al. (2009)*, Baerwald and Barclay (2011)*, Behr et al. (2007*, 2011[δ]), Brinkmann et al. (2011)[δ], Hein et al. (2011b)[δ], Horn et al. (2008)*, Kerns et al. (2005)[δ], and Redell et al. (2006)[δ]	Arnett et al. (2007)[δ]: highest at moderate wind (8 m/s) and high temperature; Grodsky et al. (2012)*, Hein et al. (2011b)[δ]: low-frequency bats
High bat fatality/activity in times of high air pressure	Kerns et al. (2005)[δ] (before and after storm fronts)	Baerwald and Barclay (2011)* (hoary bat), Cryan and Brown (2007)*, and Horn et al. (2008)*
High bat activity/fatality in times with very low humidity	Behr et al. (2011)[δ], Brinkmann et al. (2011)[δ], and Kerns et al. (2005)[δ]	
High bat activity/fatality during moonlit nights	Baerwald and Barclay (2011)*, and Cryan et al. (2014)*	Cryan and Brown (2007)* (low moon illumination together with low wind speeds, and relatively high degrees of cloud cover)
Increased bat activity/fatality during sunset and few hours after sunset	Arnett et al. (2006)[δ]: also sunrise; Behr et al. (2007)*, Brinkmann et al. (2011)[δ], Hein et al. (2011b)[δ]: high-frequency bats and hoary bat; and Horn et al. (2008)*	
Increased bat fatality during late summer/ autumn	Amorim et al. (2012)*, Arnett et al. (2006[δ], 2008)[fi], Behr et al. (2007)* (July–Oct), Brinkmann et al. (2006)[δ], Brinkmann et al. (2011)[δ]: July/August; Cryan and Brown (2007)*, Doty and Martin (2012)*: southern hemisphere; Grodsky et al. (2012)*, Hein et al. (2011b)[δ], Jain (2005)[δ], Johnson et al. (2003*, 2004)*, Redell et al. (2006)[δ], and Rydell et al. (2010b)[fi]	
Increased mortality due to flight behavior		
Migratory species particularly at risk	Arnett et al. (2008)[fi], Baerwald et al. (2009)*, Cryan and Brown (2007)*, Cryan and Barclay (2009)[fi], Grodsky et al. (2012)*, Johnson et al. (2003*, 2004*), and Kunz et al. (2007)[fi]	Ahlén (2003)[δ], Brinkmann et al. (2006)[δ], Behr et al. (2007)*, Hull and Cawthen (2013)*, Rydell et al. (2010a)[fi], and Voigt et al. (2012)*
Use of echolocation during flight, reaction time insufficient	Grodsky et al. (2011)*, Kunz et al. (2007)[fi], Long et al. (2009)[fi], and Rydell et al. (2010a)[fi]	
Increased risk for sub-adults (e.g., lower flight ability)	Fiedler et al. (2007)[δ] (sub-adults and juveniles)	Arnett et al. (2008)[fi], Grodsky et al. (2012)*, Hull and Cawthen (2013)*, Johnson et al. (2004)*, Kerns et al. (2005)[δ], and Rydell et al. (2010a)[fi]

Bats approach turbines while mating, feeding, or swarming	Arnett et al. (2008[fi], 2011b[δ]), Behr et al. (2007)*, Cryan and Brown (2007)*, Cryan (2008)[fi], Cryan et al. (2014)*, Doty and Martin (2012)*: insectivorous bats; Grodsky et al. (2011)*, Horn et al. (2008)*, Hull and Cawthen (2013)*, Redell et al. (2006)[δ], and Rydell et al. (2010a)[fi]	Baerwald and Barclay (2011)* (mating)
Open-air foragers with narrow wings more exposed to collision	Ahlén (2003)[δ], Doty and Martin (2012)*, Hull and Cawthen (2013)*, and Rydell et al. (2010a[fi], 2010b[fi])	
Increased mortality due to attraction		
Investigating turbines as possible tree-roosts increases collisions risk	Ahlén (2003)[δ], Cryan and Brown (2007)*, Cryan (2008)[fi], Cryan and Barclay (2009)[fi], Cryan et al. (2014)*, Hull and Cawthen (2013)*, and Kunz et al. (2007)[fi]	
Attraction due to increased prey availability	Ahlén (2003)[δ], Ahlén et al. (2009)*, Arnett et al (2011b)[δ], Grodsky et al. (2012)*, Horn et al. (2008)*, Kunz et al. (2007)[fi], and Rydell et al. (2010b)[fi]	Hull and Cawthen (2013)*: collision victims had empty stomachs
Bats are attracted to the turbine structure itself	Ahlén et al. (2009)*, Cryan et al. (2014)*, and Horn et al. (2008)*	
Bats are attracted to turbine lighting	Johnson et al. (2004)*: higher activity but no difference in mortality rate	Arnett et al. (2008)[fi], Baerwald and Barclay (2011)*, Horn et al. (2008)*, Johnson et al. (2003)*, and Kerns et al. (2005)[δ]
Increased mortality risk caused by indirect interaction with operating turbines		
Rapid change in air pressure by moving blades can lead to internal injuries and accounts for the main cause of fatality (barotrauma)	Baerwald et al. (2008)*	Grodsky et al. (2011)*, Houck (2012)[δ], Piorkowski and O'Connell (2010)*, and Rollins et al. (2012)*
Bats caught in vortices increases probability of collision	Horn et al. (2008)*	
Bats caught in vortices can be contorted, which may result in injury	Grodsky et al. (2011)*	

Table 2 Predominant hypotheses on wind energy-induced effects on breeding and resting birds

Hypothesis	Plausible/supported	Implausible/not-supported
Construction effects		
Displacement of birds during construction	Drewitt and Langston (2006)[6], Pearce-Higgins et al. (2012)*, and Steinborn et al. (2011)[δ]	Pearce-Higgins et al. (2012)*, and Steinborn et al. (2011)[δ]
Facility-caused effects		
Increased turbine height increases effects (displacement, collision risk)	Hötker (2006)[δ] (displacement of resting birds)	Barclay et al. (2007)*, Everaert (2014)*, Hötker (2006)[δ] (breeding birds); Pearce-Higgins et al. (2012)*, and Stewart et al. (2007)[6]
Spatial turbine layout limits effects on birds if arranged in lines or small clusters	Larsen and Madsen (2000)*	
Operation effects		
Resting species show avoidance behavior near turbines	Devereux et al. (2008)* (common pheasant), Fijn et al. (2012)*, Hötker et al. (2005)[δ], Steinborn et al. (2011)[δ], and Stevens et al. (2013)*	Devereux et al. (2008)* and Stevens et al. (2013)*
Breeding densities increase with increasing distance to turbines	Leddy et al. (1999)*, Pearce-Higgins et al. (2009)*, Winder et al. (2014)*, and Zeiler and Gruenschachner-Berger (2009)*	Douglas et al. (2011)*, de Lucas et al. (2005)*, Steinborn et al. (2011)[δ], and Steinborn and Reichenbach (2012)*
Wind farms cause no effects on breeding success	Reichenbach and Steinborn (2006)[δ]	
Decrease in comfort behavior of some species near turbines	Steinborn et al. (2011)[δ]	
Birds adapt to wind farms and show signs of habituation	Madsen and Boertmann (2008)*	Hötker et al. (2005)[δ] and Rydell et al. (2012)[6]
Enhanced effects due to species characteristics		
Resting birds are more sensitive to wind turbines than breeding birds (avoidance)	Hötker et al. (2005)[δ], Reichenbach and Steinborn (2006)[δ], and Steinborn et al. (2011)[δ]	
Collision risk is species-specific	Drewitt and Langston (2006)[6], Everaert (2014)*, Grünkorn et al. (2009)*, Gue et al. (2013)*, and Morinha et al. (2014)*	
Minor risk of collision for species that spend most of the time on the ground (in particular *Galliformes*)/outside the rotor swept zone	Brennan et al. (2009)[∀], Gue et al. (2013)*, LeBeau et al. (2014)*, Pruett et al. (2009b)*, Sandercock et al. (2013)[δ], and Winder et al. (2013)*	Falkdalen Lindahl et al. (2013)[∀]
Species show no avoidance behavior during flight	Pearce-Higgins et al. (2009)* and Steinborn et al. (2011)[δ]	Fijn et al. (2012)* and Everaert (2014)*
Displacement is species-specific	Devereux et al. (2008)*, Pearce-Higgins et al. (2009)*, and Stevens et al. (2013)*	
Inter-annual dynamics in reaction to wind turbines	Fijn et al. (2012)* and Morinha et al. (2014)*	
Decrease in predation risk due to impacts of wind turbines on predators (e.g., collision)	Winder et al. (2013)*	Sandercock et al. (2013)[δ]
Species that commute between two habitats (e. g., resting and foraging) are at higher collision and displacement risk	Drewitt and Langston (2006)[6], Hötker et al. (2005)[δ], Langgemach and Dürr (2013)[δ], and Pearce-Higgins et al. (2008)*	
Enhanced effects due to spatial/site characteristics		
Land use can have higher impacts on breeding bird abundances than wind turbines	Steinborn et al. (2011)[δ] and Steinborn and Reichenbach (2012)*	
The less disturbed a natural habitat, the higher the effects on birds by wind farms	Larsen and Madsen (2000)*, Pearce-Higgins et al. (2009)*, and Steinborn et al. (2011)[δ]	

Table 3 Predominant hypotheses on wind energy-induced effects on raptors

Hypothesis	Plausible/supported	Implausible/not-supported
Increased collision risk due to raptor abundance		
High raptor abundance increases collision risk	Barrios and Rodríguez (2004)*, Carrete et al. (2012)*, Smallwood et al. (2009)*, and Martínez-Abraín et al. (2012)*	Garvin et al. (2011)*, de Lucas et al. (2008)*, and Whitfield and Madders (2006)[δ]
High abundance on flight paths following areas with major wind currents (depending on topography and weather)	Barrios and Rodríguez (2004)*, Katzner et al. (2012)*, de Lucas et al. (2012b)*, and Hoover (2002)[δ]	
High abundance on flight paths following linear landscape features (e.g., ridges, cliffs, canyons)	Katzner et al. (2012)* and Smallwood et al. (2007)*: borrowing owl	
Increased collision risk due to flight behavior and activity		
Increased flight activity with decrease in turbine—aerie distance/ breeding site increases collision risk	Bevanger et al. (2010)[δ], Eichhorn et al. (2012)*, and Smallwood et al. (2007)*: borrowing owl	Carrete et al. (2012)*
Repeated fly-bys increase collision risk	Katzner et al. (2012)* and Ledec et al. (2011)[δ]	
Search/foraging flight within rotor swept zone increases collision risk	Dahl et al. (2013)*, Ledec et al. (2011)[δ], Mammen et al. (2011)[Ψ], Martínez-Abraín et al. (2012)*, and Smallwood and Thelander (2004[δ], 2008*)	
Local populations at greater risk than migrants due to flight behavior (e.g., foraging, fly-bys)	Barrios and Rodríguez (2004)* and Katzner et al. (2012)*	Smallwood et al. (2007)*: borrowing owl
Seasonal behavior influences flight activity	Barrios and Rodríguez (2004)*, Camiña (2011)[Ψ], May et al. (2011)[δ], and Smallwood et al. (2009)*	
Species-specific high-risk flight behavior (e.g., circular flight, foraging strategy) increases collision risk	Garvin et al. (2011)*, Hull and Muir (2013)*, de Lucas et al. (2008)*, and Smallwood et al. (2009)*	
Increased collision risk due to site and season characteristics		
Low flight altitude near summits and steep slopes increases collision risk	Barrios and Rodríguez (2004)*, de Lucas et al. (2012b)*, Camiña (2011)[Ψ], Hoover (2002)[δ], Katzner et al. (2012)*, Muños Gallego et al. (2011)[Ψ], and Orloff and Flannery (1992)[δ]	
Low flight altitude with low air temperature increases collision risk	Barrios and Rodríguez (2004)*, Camiña (2011)[Ψ], and Katzner et al. (2012)*	
Raptors drawn to wind farm due to low vegetation cover/open landscapes (favorable hunting ground) increases collision risk	Bellebaum et al. (2013)*, Dürr (2009)[δ], Mammen et al. (2011)[Ψ], and Smallwood et al. (2007)*: borrowing owls	
Avoidance		
Raptors show no avoidance behavior and exposes them to greater risk of collision	Bevanger et al. (2010)[δ], Dahl et al. (2013)*, Mammen et al. (2011)[Ψ], and Smallwood and Thelander (2004)[δ]	Garvin et al. (2011)*; Hull and Muir (2013)*; de Lucas et al. (2004)*
Low maneuverability due to flight type and morphology increases collision risk	Baisner et al. (2010)*, Barrios and Rodríguez (2004)*, Dahl et al. (2013)*, Katzner et al. (2012)*, and Smallwood and Thelander (2004)[δ]	

Low rotation speed and/or sparse distribution of turbines decreases avoidance response	Hull and Muir (2013)*: hub speed and Smallwood et al. (2007)*: borrowing owl	Orloff and Flannery (1992)[δ]
Attraction due to increase in food availability/change in food distribution increases collision risk	Dürr (2009)[δ], Camiña (2011)[ψ], and Smallwood et al. (2007)*: borrowing owl	Hoover (2002)[δ]
Inattentiveness during foraging increases risk of collision	Orloff and Flannery (1992)[δ] and Smallwood et al. (2009)*	
Inattentiveness due to interaction behavior increases risk of collision	Dahl et al. (2013)*, May et al. (2010[δ], 2011[δ]), Smallwood et al. (2009)*	
Higher risk of collision for adults than sub-adults	Bellebaum et al. (2013)*, Bevanger et al. (2010)[δ], Camiña (2011)[ψ]: Northern Spain; in Dahl et al. (2013), and May et al. (2010[δ], 2011)[δ]: due to higher involvement in social behavior	Dahl et al. (2013)*: due to higher abundance within wind farm; de Lucas et al. (2012a)*, Powlesland (2009)[δ]
Indirect effects from wind energy development		
Decrease in breeding attempts/ success due to turbine-induced adult collision risk	Bellebaum et al. (2013)*, Bevanger et al (2010)[δ]: territorial shift, Dahl et al. (2012)*, and Martínez-Abraín et al. (2012)*	
Displacement during operation	Garvin et al. (2011)* and de Lucas et al. (2004)* (except *Falco tinnunculus*)	Dahl et al. (2013)*, Hull and Muir (2013)*, and Madders and Whitfield (2006)[δ]

Table 4 Predominant hypotheses on wind energy-induced effects on migratory birds offshore

Hypotheses		Plausible/supported	Implausible/not-supported
Increase of potential collision risk			
Times of high bird abundance	Migration peaks in spring and autumn	Hein et al. (2011a)*, Hill et al. (2014)[δ], Hüppop et al. (2004*, 2006*), and van de Laar (2007)[δ]: gas platform	
	Majority: nocturnal migrants (esp. songbirds, ducks)	Aumüller et al. (2011)*, Christensen et al. (2004)[δ], Hill et al. (2014)[δ], and Hüppop et al. (2004*, 2012*)	Plonczkier and Simms (2012)*: pink-footed geese
	Few mass migration events per year	Aumüller et al. (2011)*, Hüppop et al. (2004*, 2006*, 2012*), and Nilsson et al. (2006)*: blue tit	
Weather patterns in departure area trigger migration activity	Tailwinds	Aumüller et al. (2011)*, Hüppop et al. (2004*, 2006*), Nilsson et al. (2006)*, Pettersson and Fågelvind (2011)[δ], and Plonczkier and Simms (2012)*	Nilsson et al. (2006)*: regular migrants less influenced then partial
	Low cloud cover	Nilsson et al. (2006)*: blue tit, and Plonczkier and Simms (2012)*	
	Low precipitation	Hüppop et al. (2004)*, Nilsson et al. (2006)*: blue tit, and Pettersson (2005)[δ]	
	Atmospheric pressure/change	Hein et al. (2011a)* and Shamoun-Baranes et al. (2006)*	
	Temperature	Hüppop and Winkel (2006)*: pied flycatcher	
Areas of high abundance	Migration corridors	Aschwanden et al. (2011)[δ] (onshore study); Pettersson and Fågelvind (2011)[δ], and Reichenbach and Grünkorn (2011)[δ]	
	Near coastlines	Burger et al. (2012)*, Hüppop et al. (2004*, 2006*), Kahlert et al. (2011)[δ], and Stienen et al. (2007)*	
Reverse migration	Repeated fly-bys	Hüppop et al. (2006)*	
Low maneuverability	Species-specific flight ability resulting from morphology	Furness et al. (2013)*, Garthe and Hüppop (2004)*, and Plonczkier and Simms (2012)*	
	Experience of bird	Hüppop et al. (2006)*	
Low flight altitude	Species-specific flight altitude	Furness et al. (2013)*, Hüppop et al. (2004*, 2006*), and Pettersson and Fågelvind (2011)[δ]	
	Time of the day and year	Hüppop et al. (2004)*: afternoon, 2. half of night and spring, and Pettersson and Fågelvind (2011)[δ]: during day and spring	
	Migration distance and flight experience	Hüppop et al. (2006)*	
Decrease in flight altitude	Low visibility	Aumüller et al. (2011)*, Hüppop et al. (2006)*, and Plonczkier and Simms (2012)*	Pettersson and Fågelvind (2011)[δ]: fly above fog
	Rapid change in weather conditions (precipitation, headwind, strong winds)	Aumüller et al. (2011)*, Hüppop et al. (2004*, 2006*), Pettersson and Fågelvind (2011)[δ], and Reichenbach and Grünkorn (2011)[δ]	
Attraction to artificial light sources	Adverse weather condition with low visibility	Aumüller et al. (2011)*, Blew et al. (2013b)[ψ], Hill et al. (2014)[δ], Hüppop et al. (2006)*, and van de Laar (2007)[δ]: gas platform	Kahlert et al. (2011)[δ] (periods of low visibility very infrequent)
	Permanent/intense light	Blew et al. (2013a)[ψ], Hüppop et al. (2006)*, and van de Laar (2007)[δ]: gas platform	

Decrease of potential collision risk			
Avoidance behavior	Species-specific	Furness et al. (2013)*, Mateos et al. (2011)[Ψ], Petersen et al. (2006)[δ], and Plonczkier and Simms (2012)*	
	Weather dependent	Aumüller et al. (2011)*, Coppack et al. (2011)[Ψ], Hüppop et al. (2006)*, and Reichenbach and Grünkorn (2011)[Ψ]	Pettersson (2005)[δ]
	Horizontal/vertical/between turbines	Desholm and Kahlert (2005)*, Kahlert et al. (2011)[δ], and Plonczkier and Simms (2012)*	
	Macro-/micro-avoidance	Christensen et al. (2004)[δ], Desholm and Kahlert (2005)*, Furness et al. (2013)*, Hill et al. (2014)[δ], Petersen et al. (2006)[δ], and Pettersson and Fägelvind (2011)[δ]	
	Increased micro-avoidance at operating wind turbines	Hill et al. (2014)[δ]	
Habituation	Over the years	Plonczkier and Simms (2012)*	

Table 5 Predominant hypotheses on wind energy-induced effects on marine mammals

Hypothesis	Plausible/supported	Implausible/not-supported
Habitat change		
Increase in prey availability due to exclusion of fishery	Scheidat et al. (2011)*, SMRU (2009)[Ω], and Simmonds and Dolman (2008)[Ψ]	
Increase in habitat quality due to artificial reef-effect	Gill (2005)[ß], Russell et al. (2014)*, Scheidat et al. (2011)*, SMRU (2009)[Ω], and Simmonds and Dolman (2008)[Ψ]	
Entanglement/entrapment in cables/structures	Simmonds and Brown (2010)[ß]	
Collision with floating or submerged structures	Gill (2005)[ß] and Simmonds and Brown (2010)[ß]	Russell et al. (2014)*
Disorientation due to change of magnetic fields	Gill (2005)[ß], SMRU (2009)[Ω], Simmonds and Dolman (2008)[Ψ]	Lucke et al. (2008)[δ]
Increased vessel activity causing stress/disturbance and risk of strikes	Gordon (2012)[Ψ], Nedwell and Howell (2004)[Ω], SMRU (2009)[Ω], and Simmonds and Dolman (2008)[Ψ]	Refuge function: Lindeboom (2012)[Ψ], and Scheidat et al. (2011)*
Contamination due to leaks, spills, and biocides	SMRU (2009)[Ω], Simmonds and Brown (2010)[ß], and Simms and Ross (2000)[ß]	
Pre-construction		
Increased vessel activity causing stress/disturbance and risk of strikes	Gordon (2012)[Ψ], Nedwell and Howell (2004)[Ω], and Simmonds and Dolman (2008)[Ψ]	
Noise emission from wind farm-related geophysical surveys	Gordon (2012)[Ψ], Nedwell and Howell (2004)[Ω], SMRU (2009)[Ω]	
During construction		
Displacement due to noise emission during piling	Brandt et al. (2009[δ], 2011*), Carstensen et al. (2006)*, Dähne et al. (2013)*, Haelters et al. (2012)[δ], Kastelein et al. (2013b)*, Nedwell and Howell (2004)[Ω], Nedwell et al. (2007)[δ], Nehls and Betke (2011)[δ], Tougaard et al. (2006a[δ], b[δ], 2009a*), and Wahl et al. (2013)[Ψ]	
Behavioral disturbance due to underwater noise (e.g., feeding, nursing, resting, migration)	Dähne et al. (2014b)[Ψ], Gordon (2012)[Ψ], Kastelein (2013a)[Ψ], SMRU (2009)[δ], and Tougaard et al. (2009a*, 2012[Ψ])	
Temporal hearing impairment	Gordon (2012)[Ψ], Kastelein (2013a)[Ψ], Lucke et al. (2009)*, and Nedwell et al. (2007)[δ]	
Hearing loss/injury/death close to piling site	Gordon (2012)[Ψ]; Kastelein (2013a)[Ψ]; Lucke et al. (2009)*; Nedwell and Howell (2004)[Ω]; Nedwell et al. (2007)[δ]	

Increased risk due to simultaneous, long-lasting piling activity or contemporary piling intervals	Dähne et al. (2013)*, Lucke et al. (2009)*, Madsen et al. (2006)[δ], Nedwell et al. (2007)[δ], Nehls and Betke (2011)[δ], and Thompson et al. (2010)*	
Mother-calf-separation/ disturbance	Dähne et al. (2014b)[∀], and Kastelein (2013a)[∀]	
Increased vessel activity causing stress/disturbance and risk of strikes	Carstensen et al. (2006)*, Gordon (2012)[∀], Nedwell and Howell (2004)[ϖ], SMRU (2009)[ϖ], Simmonds and Dolman (2008)[∀], and Simmonds and Brown (2010)[ñ]	
Tendency to return after piling	Brandt et al. (2009)[δ], Haelters and Vanermen (2013)[∀], Nehls and Betke (2011)[δ], Scheidat et al. (2011)*, Tougaard et al. (2006b)[δ]: Horns Rev, and Wahl et al. (2013)[∀]	Tougaard et al. (2006a)[δ]: 2 years
Disperse of sediment causing re-suspension of potentially polluted sediment and turbidity	Carstensen et al. (2006)*, Gill (2005)[ñ], and Simmonds and Dolman (2008)[∀]	
During operation		
Masking causing disruption of usual behavior	Koschinski et al. (2003)*: harbor seals; Lucke (2008)[δ]: at very short distance	Gordon (2012)[∀], Haelters and Vanermen (2013)[∀], Koshinski et al. (2003)*: harbor porpoises, Lucke (2008)[δ], Nehls and Betke (2011)[δ], and Tougaard et al. (2009b)*
Avoidance of wind farm area/ change of behavior due to noise emission and vibration	Simmonds and Dolman (2008)[∀]and Tougaard et al. (2009b)*: porpoises at very short distance/seals likely	Dähne et al. (2014a)[δ], McConnell et al. (2012)[δ], Nedwell et al. (2007)[δ], and Scheidat et al. (2011)*
During decommissioning		
Habitat loss due to removal of structure	Gill (2005)[ñ], and Gordon (2012)[∀]	
Injury or behavioral response due to noise emission (e.g., explosion, cutting)	Gordon et al. (2007)[δ], Lucke et al. (2009)*, Prior and McMath (2008)[∀], SMRU (2009)[δ], and Simmonds and Dolman (2008)[∀]	
Increased vessel activity causing stress/disturbance and risk of strikes	Nedwell and Howell (2004)[ϖ], and Simmonds and Brown (2010)[ñ]	
Disperse of sediment causing re-suspension of potentially polluted sediment and turbidity	Carstensen et al. (2006)*, Gill (2005)[ñ], and Simmonds and Dolman (2008)[∀]	

Note The possible impacts to Bats from Windfarms are extensive & under the Precautionary Principle have to be refused.

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Wind turbines can lead to micrometeorological alterations of immediate areas. They extract kinetic energy and momentum from the atmosphere , reduce wind speed in the downwind region and cause downwind turbulence (wakes) which alter the surface-atmosphere exchange of energy, momentum, mass, and moisture , and stimulate vertical mixing .

Micrometeorological changes due to WF deployment directly affect the soil carbon cycle and indirectly impact the biotic environment that regulates the soil carbon cycle. Implications for biogeochemical ecosystem processes are highly uncertain.

The impacts of WFs on biodiversity and wildlife species comprise habitat loss, habitat degradation, habitat fragmentation, vegetation disturbance, a potential suppression of ecosystem functions, and alterations of species behaviour.

WFs can affect vegetation structure and vitality negatively and induce an inhibiting effect if near surface Air Temperature (Ta) changes reduce soil moisture and enhance water stress resulting causing inhibited photosynthesis, primary production, and vegetation growth.

Aves (birds) and Chiroptera (bats) are the most evidenced taxa regarding onshore WE impact. It is hypothesized that insects are attracted by Wind Turbines because they accumulate in the lee of tall structures and swarm above prominent high points in landscapes, rest on the surface of towers, or are attracted by light-colored turbines, warm surface temperature induced by blade rotation, heat emission, or the herbaceous vegetation cover around wind turbine bases.
Birds and bats suffer from lethal and sublethal injuries in Wind Farms due to collision with Wind Turbine components and associated infrastructure, electrocution at transmission lines (giant birds), or barotrauma (bats) caused by a sudden pressure drop near the turbine edges. Wind Turbines affect many bird and bat species at all land-cover types.
At the global scale, birds that most likely collide with Wind Turbines are of the orders Accipitriformes, Ciconiiformes, Falconiformes, many species within Charadriiformes, Podicipediformes, Strigiformes, Cuculiformes, or Bucerotiformes. Small passerines are the most common bird fatalities caused by collision with Wind Turbines in Latin America, the USA, and Canada, followed by upland game birds and diurnal raptors. In North America, less than one permille of the continent-wide population for each species is estimated to be killed annually by collisions with Wind Turbines.
In most studies, bat fatalities outnumber birds. They are estimated to be tens per turbine per year. Molossidae suffer the most fatalities in Latin America. Together with Hipposideridae, Molossidae have the highest death rates globally. Bats in the genus Lasiurus are among the most collision-susceptible bats in the USA. Nearly one-quarter of all bat species in the USA and Canada are affected by Wind Turbine-related bat mortalities.
The species with the highest collision numbers in Europe are the common pipistrelle (*Pipistrellus pipistrellus*), Nathusius's pipistrelle (*P. nathusii*), and the common noctule (*Nyctalus noctule*), which account together with five other species for 98 % of all bat fatalities at Wind Turbines in northwestern Europe. The largest bat family, Vespertilionidae, includes the five bat species most vulnerable to collision. Some areas are susceptible to bird and bat fatalities.
Hotspots of bird vulnerability are often within critical migratory corridors and along coastlines or regions where raptors use thermals to gain altitude to move between locations and forage.
The most significant number of collisions for bats is observed and predicted in North America at Wind Farms along forested ridgetops in the eastern USA and agricultural regions of southwestern Alberta, Canada, and Europe.
Cumulative direct mortality estimates of birds and bats from Wind Farms mainly focus on the USA and exhibit high uncertainty and a wide value range. Collision risk depends on multiple factors such as season, Wind Turbine and Wind Farm properties, species characteristics, and behavior, number of birds and bats found in the area, climatic conditions, topography, food availability, and habitat quality in general.
Many studies indicate that the seasonal effects of collision mortality are likely due to varying bird and bat behaviour, particularly in habitat use and flight activity. For many migratory passerine and raptor species, spring, fall, and early winter migration, pre-migration, and postmigration periods are characterized by peak mortality at Wind Turbines. In the temperate Northern Hemisphere, fatalities of migratory bats are concentrated during late summer and autumn migration, with a smaller peak in early spring.
Bat species particularly vulnerable to collision, though of different genera, have some morphological and ecological similarities. Migratory, tree-roosting, high-flying, edge or open space aerial foraging, insectivorous bats seem to be at particular collision risk. Still, both migratory and resident bat species are prone to collisions with Wind Turbines throughout Europe. Collisions of bats with Wind Turbines do not appear as chance events. Evidence has been found that bats conduct activities near Wind Turbines and use them. There are different hypotheses as to why bats could be attracted to wind turbines, including bats seeking shelter (roosts), social opportunities (conspecifics; mating), or food (insect prey) at wind turbines. Bats could also be attracted by swishing sounds, heat, acoustic, or visual attractors. Furthermore, bats may misperceive the smooth surfaces of Wind Turbine towers to be water, misperceive Wind Turbines as trees, or suffer from echolocation failure and electromagnetic disorientation.
Bats have the highest collision risk during nights with low wind speed, relatively high air temperature, and no precipitation due to higher activity
Noise pollution generally contributes to disturbance, habitat degradation, and wildlife displacement and masks auditory life-history traits essential for survival and reproduction. It affects habitat use, territorial behaviour, and breeding success of animals. Consequences are, for instance, reduced bird densities, avoidance behaviour of bats and birds, alterations of wildlife migration routes, or other behavioural impacts. Operation noise can be a deterrent or an attractive effect. For wildlife, the loudness of noise is relatively less critical than the consistency of noise. In general, the impacts of Wind Turbine noise on wildlife are highly species specific, and some species even occur in zones with the highest noise exposure.

Reference 2025 : Wind turbines displace bats from drinking sites. Carolin Scholz, Hannah Klein, Christian C. Voigt. Biological Conservation 302 (2025) 110968. https://doi.org/10.1016/j.biocon.2025.110968. 3 January 2025. 0006-3207/© 2025 The Authors. Published by Elsevier Ltd.

Bats depend on water for drinking and foraging, but the increasing number of wind turbines may pose a problem for bats, as operating wind turbines are known to displace bats over long distances. We asked whether turbines displace bats from critical habitats, namely small ponds where bats drink and forage. We recorded the acoustic activity and foraging activity of three functional guilds of bats, i.e. open space, edge space and narrow space foraging bats, using automated detectors at 59 ponds located at varying distances (~50 to 5000 m) from wind turbines. We observed that edge space foraging bats were most abundant at focal ponds compared to narrow and open space foraging bats. The overall acoustic activity of open and narrow space foraging bats decreased with decreasing distance to wind turbines, whereas the activity of edge space foraging bats was unaffected by wind turbines. The feeding activity of bats at focal ponds decreased for open space foraging bats in proximity to wind turbines. For narrow space foraging bats, we observed a trend towards reduced feeding activity at ponds close to wind turbines, whereas we did not observe any effect of wind turbines on the feeding activity of edge space foraging bats. The siting of wind turbines close to drinking sites may degrade the resource landscape for bats, which could lead to population declines. Avoiding the proximity of turbines to important bat habitats is essential to protect biodiversity on farmland.
We investigated whether wind turbines displace bats from drinking sites during the critical lactation and weaning period of females in early summer. Our study was conducted in northeastern Germany, an area characterised by intensive agriculture, increasing drought (Zink et al., 2016, Boeing et al., 2021), a high density of wind turbines (FA Wind, 2023, Voigt et al., 2015), and high rates of bat mortality at wind turbines (Kruszynski et al., 2022; Voigt et al., 2022). At the same time, many small ponds are scattered across the landscape, providing drinking and foraging sites for local bats. We found that both general activity and hunting activity of narrow and open space foraging bats decreased with decreasing distance from wind turbines, even in highly attractive habitats such as drinking sites; however, we acknowledge a trend in hunting activity of narrow space foraging bats. Overall, our observations are consistent with the idea that bats avoid ponds in close proximity to wind turbines.
We conclude from our results that the operation of wind turbines on farmland can contribute to a reduction in local bat diversity, not necessarily due to casualties at wind turbines, but rather due to displacement from wind turbines. This decline in the abundance of narrow and open space foraging bats near wind turbines is associated with a loss of their ecological function on farmland (Scholz and Voigt, 2022). **Bats are known to provide ecosystem services by consuming insect pests** (Kunz et al., 2011; Boyles et al., 2011; Williams-Guill´en et al., 2016; Maslo et al., 2022; Russo et al., 2018). Therefore, displacement of bats over large areas around wind turbines may contribute to **reduced crop production** and the need for **increased pesticide application** to compensate. Displacement effects on wildlife caused by wind turbine operations may contribute to cryptic cascading trophic effects that have not been previously recognised (Thaker et al., 2018; Scholz and Voigt, 2022). Our results highlight the urgent need to consider the loss of critical habitats for vulnerable bats and other wildlife when planning wind turbines (Barr´e et al., 2018).

Reference 2025 : Wind turbines displace bats from drinking sites. Carolin Schotz , Hannah Klein , Christian C. Voigt. Biological Conservation 302 (2025) 110968. https://doi.org/10.1016/j.biocon.2025.110968

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Reference 2023 : Insects are Attracted to White Wind Turbine Bases: Evidence from Turbine Mimics: Lusha M Tronstad, Madison Crawford, Delina Dority, Michael E. Dillon.. September 2023. Western North American Naturalist 83(2):232-242 DOI: 10.3398/064.083.0208.
Wind power is one of the fastest growing forms of renewable energy, but the interactions between wind turbines and insects are largely unknown beyond the observation that the accumulation of dead insects on turbine blades drastically

reduces the power produced. Insects may be attracted to wind energy facilities because of topography, the heat that turbines produce, the lighting, or the visual cue of the turbine itself. Turbines can present a striking visual contrast relative to the surrounding landscape, particularly when they are painted bright white and reflect ultraviolet wavelengths. To test the hypothesis that wind turbine color attracts insects, we sampled insects near experimental wind turbine mimics of 9 colors. The mimics were located on a hill with characteristics similar to sites of nearby wind energy facilities. Passive traps painted the same colors and placed next to their corresponding turbine mimic provided an estimate of insect attraction to turbines of different colors. Insect abundance was highest next to the white, violet, and blue turbine mimics, and lowest adjacent to the green, orange, yellow, light gray, and dark gray turbine mimics. Our results suggest that white, the predominant color of wind turbines globally, is one of the most attractive colors to insects. We encourage others to investigate whether painting turbine bases a less attractive color (e.g., gray or green) may drastically reduce the attraction of insects to wind energy facilities.

Reference 2025 : Flight height patterns of a critically endangered insectivorous bat, impacted by wind turbine collision. May 2025. Amanda Bush, Lindy Lumsden, Thomas A. A. Prowse. DOI: 10.1101/2025.05.23.655017

Harnessing wind energy, using wind turbines, is a prominent form of renewable energy production. There are, however, biodiversity impacts, including collisions by birds and bats with rotating blades. High levels of mortalities can cause localised and species-level population declines, which is especially significant for threatened species. The height at which species fly is a key collision risk factor. In this study we investigated the flight height patterns of a critically endangered bat to inform mitigations to reduce impacts. Methods We captured and GPS tagged 244 Southern Bent-wing Bats (Miniopterus orianae bassanii) (14 to 19 g) in south-eastern Australia, in spring and late summer/early autumn. We retrieved 93 units, yielding 4,289 bat observations from an 18 to 21 day period in each season. The vertical measurement error of the GPS units at different heights and sampling intervals was investigated with drone test flights. A Bayesian state-space modelling approach was then developed to estimate flight height distributions while accounting for measurement error.

Our results suggest that the majority of bat activity occurs between ground level and 30 m altitude, at least in early spring and late summer/early autumn. However, the bats were recorded taking short flights above 60 m and at times even flew above 80 m (maximum model estimate was 92.7 m with a maximum 95% CI of 144.1 m) and demonstrated that they are capable of quick and frequent altitudinal changes from ground level to almost 40 m. Flight heights were on average higher when associated with trees in summer. Mean flight heights appear to be higher when associated with tree habitats in summer.

This study shows that the flight height distribution of small bats can be investigated using store-on-board GPS devices and illustrates a statistical approach that incorporates vertical measurement error. It provides the first insights into the flight heights of this small bat species, which can help inform a more complete flight height profile across different seasons and conditions with future improvements in GPS technology. Results suggest that, although the Southern Bent-wing Bat primarily flies at lower heights, it exceeds 30 m altitude at times, increasing the risk of mortalities due to wind turbine collision. Accurately determining the proportion of time that threatened species such as the Southern Bent-wing Bats spend within high-risk flight zones will provide the evidence base for implementing effective mitigation measures to reduce population-level impacts.

Reference 2019 : Balancing nature and economic interests in the European Union: On the concept of mitigation under the Habitats Directive. Lorenzo Squintani. c 2019 The Author. Review of European, Comparative & International Environmental Law Published by John Wiley & Sons Ltd. wileyonlinelibrary.com/journal/reel. DOI: 10.1111/reel.12292

"THE FOUR CRITERIA TO ESTABLISH A MITIGATION MEASURE"

3.1 | Mitigation measures in context

Article 6 of the Habitats Directive gives teeth to the Directive by establishing proactive, preventive and procedural requirements for the conservation of Natura 2000 sites. This provision refers to three kinds of measures: conservation, preventive and compensatory measures. It does not refer to mitigation measures. Before discussing what the latter measures are, it is important to briefly explain what the former three measures are, in order to distinguish between them.

Conservation measures are covered by Article 6(1) of the Directive. These measures focus on positive and proactive interventions to maintain and improve the status of conservation of a Natura 2000 site. Any measure leading to deterioration therefore falls outside the realm of this concept.

Preventive measures are envisaged under Article 6(2) of the Directive and aim at avoiding deterioration, similarly to conservation measures. Yet these kind of measures do not need to take the form of positive action, as in the context of Article 6(1). Non-action is also a form of preventive measure, if it prevents damage from occurring. What matters under this provision is avoiding disturbance that is likely to affect the objectives of the Directive significantly, particularly its conservation objectives in relation to Natura 2000 sites.

Compensation measures are mentioned in Article 6(4) of the Directive, which establishes an exception to the obligation contained in Article 6(3). Together, Articles 6(3) and 6(4) describe a two-step – or, in case the derogation clause is used, a three-step – procedure for granting development consent to plans or projects likely to have a significant effect on a Natura 2000 site, based on a 'first come, first serve' approach. The concepts of 'plan' (such as land-use plans, sectoral plans, etc.) and 'projects' (such as construction works or other interventions in the natural environment) have to be interpreted broadly, and **include also developments outside a Natura 2000 site**, which are likely to have a significant effect on it (the so-called 'external effect'). **In light of the precautionary principle, the assessment of the effects of plans of projects inside or outside Natura 2000 sites – either individually or in combination with other plans or projects (so-called cumulative impacts) – is based on the likelihood of effects, not on their certainty**. If the screening phase indicates **the presence of a potentially significant negative effect, an appropriate assessment needs to be performed, in light of the site's ecological functions and conservation objectives. A negative outcome should lead to the refusal of authorization.**

Yet, Article 6(4) of the Directive specifies that if, in spite of a negative assessment of the implications for the site and in the absence of alternative solutions, a plan or project must nevertheless be carried out for imperative reasons of overriding public interest, a Member State must take all compensatory measures necessary to ensure that the overall coherence of a Natura 2000 site is guaranteed. All the constitutive elements of this derogation clause have to be interpreted restrictively, for balancing environmental protection and economic development. In particular, the concept of compensation measures entails, typically, the designation of like-for-like replacement habitat. In the view of the European Commission, what matters is that the function performed by the affected site is successfully recreated elsewhere.

Adequate implementation and enforcement of Article 6 of the Directive strengthens nature conservation. Yet the complex relationship between Articles 6(3) and 6(4) has led to uncertainty as to what 'adequately implemented and enforced' means, and where 'gold-plating' starts. In particular, in certain Member States questions have arisen on the extent to which measures adopted to avoid damage can be taken into account in concluding that no significant adverse effect will occur.

It is here that the concept of mitigation measures enters into the legal discussion under Article 6 of the Directive, creating much uncertainty, and potential abuses.

Thanks to the judgments in the Waddenzee, Sweetman, Briels and Orleans cases, it can confidently be established that **mitigation measures are allowed under the Habitats Directive only if four cumulative requirements are met:**

(i) the measure aims at preventing the damage caused by a specific plan/project (functional linkage criterion);
(ii) the measure must ensure that this damage (specificity criterion);
(iii) will be prevented (prevention criterion); and
(iv) that there is no doubt about this preventive effect (no-doubts criterion).

In Sweetman, the Court clarified that the specificity criterion refers to each individual conservation objective, justifying the designation of that site in the list of Sites of Community Importance (SCIs) in accordance with the Directive. Similarly, from Briels it is clear that, under the prevention criterion, measures provided to replace a damaged area with another cannot be taken into account in the assessment of the implications of a project provided for in Article 6(3). In the judgment under review, the Court confirmed both criteria by stating: the case-law relating to Article 6 of the Habitats Directive requires a distinction to be drawn between protective measures forming part of the plan or project at issue and intended to avoid or reduce any direct adverse effects caused by it, in order to ensure that that plan or project does not adversely affect the integrity of the sites concerned, which are covered by Article 6(3),

and measures which, in accordance with Article 6(4), are aimed at compensating for the negative effects of the plan or project on that site and cannot be taken into account in the assessment of the implications of that plan or project on that site …

Moreover, according to the Court's case-law, it is only when it is sufficiently certain that a measure will make an effective contribution to avoiding harm to the integrity of the site concerned, by guaranteeing beyond all reasonable doubt that the plan or project at issue will not adversely affect the integrity of that site, that such a measure may be taken into consideration in the 'appropriate assessment' within the meaning of Article 6(3) of the Habitats Directive

The use of the adverb 'likely' in Article 6(3) of the Directive was clearly linked to the precautionary principle by the Court of Justice already in the Waddenzee case. Since then, the requirement that there should be no scientific doubt about the ability to prevent the specific damage of a specific project has gained clarity. The Court of Justice made clear that there are two ways of complying with this criterion.

First, a proposed measure can qualify as a mitigation measure under Article 6(3) of the Directive if, at the moment of the authorization of the plan or project, 'the procedures needed to accomplish the alleged mitigation measures have already been carried out'. Clearly, the implementation of a mitigation measure makes it easier to analyse whether the significant negative effects of a plan or project have been avoided or not.

The concept of 'project' must be interpreted broadly. The PAS (Dutch Programma Aanpak Stikstof 2015–2021, PAS) judgment clarifies that this concept is probably even broader than originally thought. Indeed, not only the Court of Justice defines this concept without linking it to that used in the EIA Directive, that is, by covering activities not covered by the EIA Directive. Most importantly, the Court defines it by linking its meaning to the effects of the activities on the protected site. Indeed, the Court states that it is important to examine whether such activities are likely to have a significant effect on a protected site. This is an effects-based test, which is capable of covering any kind of activity, even the spreading of fertilizers.

In the context of the establishment of mitigation measures, following Briels, it remained unclear whether mitigation measures have to be 'functionally' linked to a project development, that is, whether the proposed measures are part of the scrutinized project or of a mitigation scheme or restoration programme that does not take into account the specific project under scrutiny. Following Orleans, the present judgment confirms that a proposed mitigation measure must aim at avoiding the damage caused by the plan or project under scrutiny specifically. Management plans and generic restoration measures taken under Articles 6(1) and 6(2) of the Habitats Directive can be taken into account under the concept of mitigation measures when scrutinizing a specific project only if they specifically address the negative effects of that project.

What matters is that there is no reasonable scientific doubt as to the absence of adverse effects of each plan or project on the integrity of the site concerned. Therefore, there is no de-linking effect, meaning that the conservation goals of the Directive can be used to review the appropriateness of the assessment of a specific plan, differently than in other fields of EU environmental law, such as under the Nitrates Directive

The approach to the no-doubts criterion is a very stringent one. It stems from the Orleans case, in which the Court of Justice ruled that only those measures which are completed at the moment of the appropriate assessment can be taken into account as mitigation measures. Orleans concerned the development of a large part of the port of Antwerp (Belgium), affecting a Natura 2000 site. The Court found that the Belgian Regional Development Implementation Plan allowing the project only did so after the sustainable establishment of habitats and habitats of species in core ecological areas. Second, the Court ruled that a decision would have to declare that habitats in the nature reserves had in fact been sustainably created, and the application for a planning permit relating to implementing the intended use of the area concerned would also have had to include that decision. Accordingly, the negative effects would have taken place only after that certainty regarding the effectiveness of the positive effects had been proven.

Yet, the Court ruled that such certainty would have been acquired only after the plan had been adopted, and thus that the proposed measures could not qualify as mitigation measures under Article 6(3) of the Directive.

The second way in which a measure could qualify as a mitigation measure under Article 6(3) of the Directive is when there is no scientific doubt about the effectiveness of the proposed measure.

This means that, even when a measure has not been carried out yet, it is still possible to speak of a mitigation measure. What matters is that there is scientific certainty about the effectiveness of such a measure, thus avoiding the significant damage that would otherwise occur. This criterion is clearly less demanding than the previous one. Still, the question is when scientific certainty exists about the effectiveness of a measure. This criterion could therefore be more difficult to fulfil in practice than it seems. It is still unclear what burden of proof the Court would consider to be sufficient under this approach. In the present judgment, the Court left this matter to the national court to decide, in an exercise of judicial subsidiarity. Yet, it cannot be discounted that the Court of Justice will formulate some guidance in future case law if called upon to clarify this issue

Reference 2024 : Environmental Impact of Wind Farms. Bošnjakovi´c, M.; Hrka´c, F.; Stoi´c, M.; Hradovi, I. Environments 2024, 11, 257. https://doi.org/ 10.3390/environments11110257

Toxicity

The toxicity of substances to humans can be expressed in different ways and is often expressed in CTUh (Comparative toxic unit for human). Onshore wind farms have an average of around 3.9 CTUh/TWh.

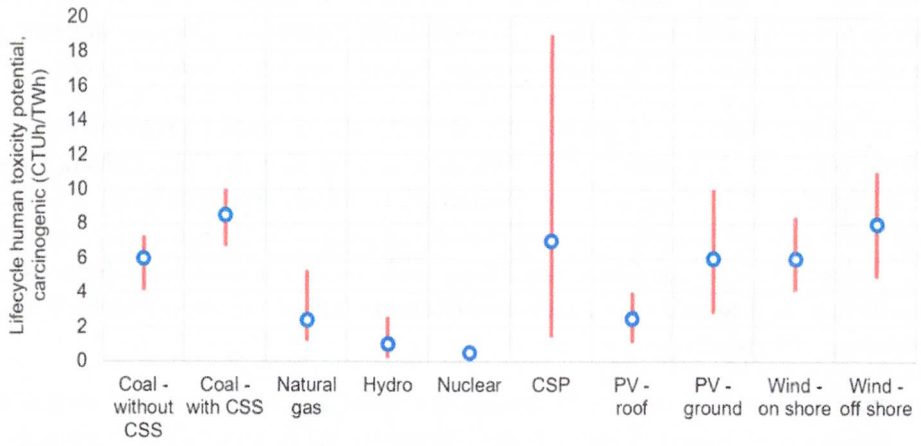


Figure 4. Lifecycle human toxicity potential, carcinogenic. The red line represents the range and the circle represents the median.

Danger of Ice Flying off the Blades

Ice build-up on the rotor blades of wind turbines can pose a serious threat to people and objects in the immediate vicinity. It is, therefore, important to assess the dangers associated with ice shards falling and flying from the rotor blades. Icing can also lead to the failure of wind turbines because the structural integrity is impaired. The hazard posed by ice depends on the severity of the icing, the type of icing, the wind, the rotor speed and other environmental conditions. **A piece of ice with a weight of 0.2 kg and a density of 500 kg/m3 falling from a height of 30 to 50 m is considered fatal if the impact has a kinetic energy of more than 40 J.**

Danger of Blade Parts Flying Off

A "blade failure" can have a number of causes and can result in either whole blades or parts of blades being thrown from the turbine. **A total of 537 separate incidents have been recorded. It has been documented that parts of the blades have travelled up to 1.6 km.** In Germany, parts of the blade penetrated the roofs and walls of nearby buildings. For this reason, a law was passed in Germany (Bavaria) in 2016 requiring a minimum of two kilometers to be kept between dwellings or workplaces and wind turbines, and Ireland is considering a similar measure.

Impact on Radio Waves and Air Traffic

Offshore wind turbines can interfere with radar systems on board ships and on land as well as radars used to monitor air traffic. Wind farms located near weather radars can cause false echoes that can be misinterpreted as weather phenomena such as precipitation or thunderstorms. The reason for the interference lies in the structure of the turbines, the height of the turbines and the displacement of the rotors, which can reflect radar signals. In addition, telecommunication and data transmission signals can be weakened when wind turbines are in the line of sight (LOS) for radio communications. In general, two types of effects of wind farms on radar systems can occur:
Formation of radar shadows behind wind turbines, which can result in lower targets being poorly recognised or not recognised at all. The relatively high frequencies used by the radar are attenuated when the signal passes through the wind farm, i.e., they shorten the range of the radar.
Reflection of the radar beams from the wind turbines can lead to false radar targets (false echoes).

Radar systems work by recognising weak reflections that are often in motion. In addition, the rotor blades of wind turbines produce false reflections in the direction of the receivers, causing the radar to misinterpret the signals. While the wind farm industry is growing rapidly, they are causing serious interference problems in critical civil and military radio systems, degrading radar detection range and increasing the complexity of air surveillance and navigation missions.

Habitat Destruction

Based on 84 studies of onshore wind farms in 22 countries, (Tolvanen et al). presented data on the average distance of habitat displacement from the edge of wind farms. The predominant height of wind towers in the studies was 50–99 m.

For birds, bats and mammals, habitat displacement accounted for 63%, 72% and 67% of cases, respectively. Cranes, owls and semi-wild reindeer showed consistent habitat displacements of up to 5 km on average. Gallinaceus birds showed movements of up to 5 km on average, but "no movement" was reported in 40 cases. Bats were displaced by an average of up to 1 km in most cases. Waders, birds of prey, sparrows and black-winged stilts moved their habitats by up to 500 m on average.

Furthermore, human-caused forest landscape fragmentation may lead to a rise in the number of predators (Pasanen-Mortensen and Elmhagen, 2015). For instance, infrastructure like buildings and maintenance roads could attract fox activity (Hradsky et al. 2017), so the risk of predation may be higher near wind farms. Grouse are known to be sensitive to human disturbance (Coppes et al 2017). Many grouse species are site-loyal and therefore highly vulnerable if their habitat overlaps with areas that are suitable for wind turbine installation, particularly in the absence of another suitable habitat (Braunisch et al. 2015).

Collision with a Wind Farm

For some bat species, the installation of wind turbines creates new habitats because there are more insects to feed on in the vicinity of the wind turbines. **Direct causes of bat death at wind turbines are well recognised and include barotrauma (Rollins et al. 2012) and collisions with rotating blades (Horn et al. 2008) or a combination of both.** The potential threats of wind farms to birds are well documented in the literature, for example. Research suggests that mortality rates (although they may be relatively high in certain areas) are highly variable and depend on a number of factors such as the bird species, the size and the location of the wind farm and others. (Barclay et al. 2007) reported a mortality rate of 0.00–9.33 birds per year per turbine and a mortality rate of 0.00–42.7 for bats.

The selective shutdown of wind farms along the bird migration route using radar is very effective in reducing collision rates (Tomé et al 2017).

Noise Onshore Wind Farm

Noise pollution has a negative impact on wildlife as it disrupts mechanisms that are crucial for their survival. According to studies, noise can result in the following:

Result in physiological trouble, such as genuine hearing loss or persistently elevated stress hormone levels.

Be viewed as a direct danger, which would lead to an increase in predatory behaviour at the expense of foraging or the departure of the afflicted region, which would result in the loss of habitat.

Distract attention during foraging and reduce foraging efficiency.

Interfere with animal communication by reducing the distance from which the signal can be perceived and lowering the quantity of information that can be taken out of the signal, such as the sound of a predator or approaching potential prey.

Influence the reproductive process. Taubmann et al. reported that noise disturbs grouse up to a distance of 865m. Increasing turbine noise, turbine visibility, and turbine shadow during the breeding season reduced the likelihood of selecting a breeding site.

The roles that these processes play in determining the effects of noise pollution on different species are not mutually exclusive. Different species respond differently to noise as they have different sensitivities to noise. In general, noise pollution alters animal communities. The effects of noise can contribute to the reduction in biodiversity and also threaten the sustainability of local ecosystems.

The Effects of Vibrations from Wind Turbines on the Ecological System

The impact of vibrations is one of the aspects to be considered when analysing the impact of wind turbines on the environment. Vibrations are mechanical oscillations that can be caused by the operation of the wind farm and its

components. In this chapter, the effects of vibrations on the environment are analysed, taking into account the possible consequences for living beings, structures and the surrounding space.
The source of vibrations in wind farms is the rotating parts of the turbines, such as rotor blades and generators. The rotation of these parts generates periodic vibrations that are transmitted to the ground via the foundations of the wind farm. These vibrations can have a negative impact on the animals in the surrounding area, especially on their sensitive acoustic perception. A study by Estefania Velilla and colleagues from 2021 shows how vibrations from wind farms affect the abundance of earthworms in the soil. The relative intensity of vibrations in the soil was measured and the results showed a decrease in the number of earthworms near the wind turbines, which is considered a negative impact on soil organisms. A decrease in earthworms was found in a radius of about 200 m around the wind turbines, where the noise level decreased by an average of 23 ± 7dB. Earthworms are considered important engineers of the ecosystem, and interference with their abundance, survival and reproduction can indirectly affect important processes such as water filtration, nutrient cycling and carbon sequestration. In addition, the vibrational noise generated by the wind turbine can mask the vibrational signs of approaching moles, making earthworms in noisy areas more vulnerable to predation (Dominoni et al. 2020).

Wind farms generate noise that can have harmful effects on humans and animals, especially in the vicinity of the wind farm. Problems noted in humans include insomnia, headaches and the like. For animals, there is a wide range of potential impacts: from possible hearing damage to interference in foraging, predator marking, habitat abandonment and more. The moving rotor blades of the wind farm can pose a risk of collision and death for birds and bats.
Reference Number 113 : How far are birds, bats, and terrestrial mammals displaced from onshore wind power development? – A systematic review Anne Tolvanen a, Henri Routavaara, Mika Jokikokko, Parvez Rana. Biological Conservation 288 (2023) 110382
Wind power is a rapidly growing source of energy worldwide. It is crucial for climate change mitigation, *but it also accelerates the degradation of biodiversity through habitat loss and the displacement of wildlife. To understand the extent of displacement and reasons for observations where no displacement is reported, we conducted a* systematic review *of birds, bats, and terrestrial mammals. Eighty-four peer-reviewed studies of onshore wind power yielded 160 distinct displacement distances, termed cases.*
For birds, bats, and mammals, 63 %, 72 %, and 67 % of cases respectively reported displacement.
Cranes (3/3 cases), owls *(2/2), and semi-domestic reindeer (6/6) showed consistent displacement on average up to 5 km.*
Gallinaceus birds showed displacement on average up to 5 km, but in 7/18 cases reported to show "no displacement".
Bats were displaced on average up to 1 km in 21/29 cases.
Waterfowl (6/7 cases),
raptors (24/30),
passerines (16/32)
and waders *(8/19) were displaced on average up to 500 m.*
Observations of no displacement were suggested to result from methodological deficiencies, species-specific characteristics, and habitat conditions favourable for certain species after wind power development.
This review provides information on distance thresholds that can be employed in the design of future wind energy *projects. However, most studies assessed the effects of turbine towers of <100 m high, while considerably larger turbines are being built today.*

Reference 2023 : Responses of GPS-Tagged Territorial Golden Eagles Aquila chrysaetos to Wind Turbines in Scotland. Alan H. Fielding, David Anderson, Stuart Benn, John Taylor, Ruth Tingay, Ewan D. Weston and D. Philip Whitfield. Diversity 2023, 15, 917. https://doi.org/10.3390/d15080917
https://www.mdpi.com/journal/diversity
Birds' interactions with wind turbines are a concern, and research has often focused on large raptors. This focus is largely on large raptors' demonstrable or purported vulnerability to collision with turbine blades.
Large raptors also possess life history traits sensitive to additive mortality from anthropogenic sources, notably in older individuals. Alarms have been raised
on collision mortality potentially affecting population viability in several species.
Another potentially adverse effect is avoidance, including avoidance of turbine arrays (wind farms) or individual turbines (macro- or meso-/micro-avoidance, respectively: through disturbance and displacement or wariness. This can produce functional habitat loss.

Despite an erstwhile predominance of recorded or assumed collision mortality, several studies have nonetheless concluded avoidance as the main response of large raptors to wind turbines, highlighting the consequential functional (indirect) habitat loss.
Functional habitat loss can incur serious impacts on large raptor populations. It may potentially affect territory occupancy and reproductive output in part because individuals occur at low densities with extensive habitat requirements. The significance of any habitat loss to territorial birds will depend not just on the amount of lost habitat but also on whether there is scope for compensatory territorial boundary reconfiguration which will, in turn, depend on the adjacent landscape suitability and the proximity of neighbouring pairs. The use of key resources by migratory individuals may also be affected detrimentally.
Simplistically, avoidance is antagonistic to collision. A bird that does not enter a wind farm or avoids flying close to turbine blades cannot collide with a turbine blade and be killed. The two processes are not necessarily mutually exclusive in risk, however. The observed balance in risk between avoidance (towards functional habitat loss) and collision (towards fatality) appears complex, involving several factors. Understanding these risk factors to predict the most likely adverse impact is critical in environmental impact assessments of future wind farm proposals.
The golden eagle Aquila chrysaetos is well-studied in wind farm research. In North America, the consensus is that both non-territorial and territorial birds are mostly vulnerable to collision and consequent fatalities. Avoidance may be more likely in migrating eagles through the use of different sources of wind energy uplift to some resident birds. First-year (juvenile) eagles at Altamont in California, USA were less likely collision victims.
In Europe, the spatial coincidence between wind farm development and golden eagle distribution has been described repeatedly [53–55]. To our knowledge, however, there are no reports of golden eagle collision fatality rates from European wind farms comparable to those from North America. Scottish studies empirically concluded avoidance as the substantive response of golden eagles to wind turbines.
The risk of collision via proximity to turbines for non-territorial birds during natal dispersal in Scotland was increased if turbines were placed in a more preferred habitat, and at higher wind speeds, but not according to the age of turbines and their specifications or birds' age. Given the number of turbines, the duration of their operation, and their coincidence with the distribution of numerous eagles, however, reported collision fatalities were very low. In confirmation, a subsequent update (NatureScot unpublished data) lists only five collisions over a 10-year period. This observation shows the balance between avoidance and collision is not either/or. It is independently consistent, nevertheless, with the predominant reactions of GPS-tagged dispersing Scottish golden eagles to the presence of turbines, to avoid flying near them. This evidence from movement behaviour included records of spatial use before and after turbine presence.
Most Scottish studies have involved non-territorial eagles. Territorial eagles may not show the same degree of avoidance as non-territorial dispersing birds because they are more spatially constrained to a territory. Non-territorial birds have a greater capacity to compensate for functional habitat loss by being able to utilise more areas free of turbines. An inherent cost of wariness in avoiding turbines, which occupy intrinsically preferred habitats, should be greater for territorial birds. Moreover, despite no evidence suggesting habituation in non-territorial eagles, repeated exposure to the same turbines may favour habituation in territorial birds (see also. This, again, could lessen avoidance responses so that collision may be more likely. Territorial birds also engage in flight displays, pair interactions, and territory defence behaviours that may distract from their ability to detect and respond to spinning turbine blades. We could expect, therefore, that territorial birds differ in their reaction to turbines and are less wary.
A key and generic international takeaway from the present and earlier studies of Scottish golden eagles' responses to turbines is that, if proposed turbines are in a highly
preferred habitat, then regardless of the base response to turbines (on the avoidance— collision continuum), such locations should be problematic in wind farm planning. This is because, if consented, they will either disproportionately increase the risk of greater functional habitat loss or increase the risk of collision fatalities. The two outcomes differ in their effects, but each has detrimental impacts.

Reference 2022 : Wind Turbine Noise Behaviourally and Physiologically Changes Male Frogs, Jun-Kyu Park and Yuno Do . Biology 2022, 11, 516. https://doi.org/10.3390/biology11040516
https://www.mdpi.com/journal/biology
Wind turbines can induce behavioural and physiological responses in animals by emitting various types of noises. In this study, we investigated the behavioural, physiological, and immunological responses of male Japanese tree frogs (Dryophytes japonicus) when exposed to wind turbine noise.

To determine the effects during the breeding season, frogs were collected from areas with and without wind turbines. Additionally, we exposed the frogs to recorded wind turbine noise at a site without a wind generator for 1 h to 24 h to analyze the short-term effects.
Three types of calling patterns (dominant frequency, note duration, and call rate) were analyzed to investigate behavioural responses. Physiological responses were assessed using two steroid hormones assays, namely testosterone and corticosterone detection in the saliva. The immunity of each individual was assessed using a bacterial killing assay. The wind turbine group in the field had a higher call rate and corticosterone levels and lower immunity than the group in the field without turbines present, and all three of these variables were correlated with each other. Conversely, in the noise exposure experiment, a higher call rate was only observed post-exposure compared to pre-exposure. Thus, turbine noise seems to induce decreased immunity in Japanese tree frogs as an increase in energy investment that triggers a behavioural response rather than acting as a sole physiological response that leads to a direct increase in corticosterone. This decreased immunity due to energy tradeoff or physiological response can change the disease epidemiology of the population and create new adaptive patterns in these habitats.
In addition to humans, these noises can potentially affect other animals that hear or interact with sounds. Graylag geese raised near wind turbines were physiologically affected by the noise itself, so they had higher cortisol levels in blood and lower weight gain than geese raised away from turbines. Turbine noise also affects the vocal communication of the greater prairie chicken (Tympanuchus cupido pinnatus) by changing the soundscape of its surroundings.
Additionally, turbine noise actually induces increases in cortisol through the hypothalamic–pituitary–adrenal (HPA) axis response of the European badger (Meles meles), which the researchers suggest could alter the risk of infection or disease in the population by changing the immune system.
Frogs that live in various types of freshwater habitats assemble at specific locations during the breeding season and use acoustic signals to find mates. Therefore, wind turbine noise during the breeding season may negatively affect the mating of frogs. If the sound pressure level of the noise during this period is large or the frequency of noise overlaps with that of the calling in a frog species, a masking effect that dilutes the acoustic signal can occur at breeding sites. Although select studies have reported on the masking effect of noise on various biological responses in frogs, these studies have focused primarily on noise emitted by traffic and airplanes. These noises can show strong pulses in a short time, with irregular intervals, whereas the noise generated by wind turbines can be persistent and of relatively low intensity. Additionally, it is necessary to understand whether wind turbine noise acts as a single stressor or affects species through other complicated processes.
Male frogs can enhance advertisement calling to avoid these masking effects, a response that could be physiologically associated with corticosterone, a glucocorticoid hormone that aids in glucose mobilization. Additionally, noise can directly affect the endocrine system of frogs. A change in the endocrine response due to stress leads to increased corticosterone by stimulation of the HPA axis. Whether these two effects act alone or in combination, a momentary increase in corticosterone allows the animal to respond appropriately to a threatening situation by assisting in the immediate coping mechanism caused by metabolic changes and the allocation of required energy.
However, the chronic increase in corticosterone due to prolonged energy tradeoffs caused by stress can lead to reduced immunity by a maladaptive response, such as imbalances in energy allocation.

The importance of the watercourses within the area of the Wind Farm Site have been fully assessed. The Wind Farm Site is drained by three river subbasins: Cloonalaghan_010, Gortmore Stream (Mayo)_010, and Knockboha_010. The watercourses on the proposed Wind Farm Site itself are all small – medium 3rd, 2nd, and 1st order streams. These streams are in the upper reaches of the Gortmore Stream (Mayo)_010 and Cloonalaghan_010 sub catchments. These watercourses are of limited aquatic ecological value. However, downstream at the receptor sites where the rivers increase in size fish diversity and habitat quality improves. Many of these watercourses have been identified as being salmonid nursery and spawning areas.

Potential effects that could arise during the Construction, Operation and Decommissioning phases of the Proposed Development are assessed for designated sites and biodiversity interests within the Site and surrounding areas. Where significant adverse effects are identified, mitigation measures in accordance with best practice and guidance shall be implemented to eliminate or reduce the effect.

The strict mitigation measures which will be enforced to maintain water quality in local drains and watercourses during all phases of the Proposed Development will ensure that there will be no significant residual effects on water quality or aquatic habitats or species, including otter and salmonid fish species. The implementation of these measures

will also ensure that there will be no likely significant effects on identified designated sites with hydrological connectivity with the Proposed Development site.

While the Proposed Development will result in the loss of approximately 0.68 ha of relatively intact blanket bog, an adverse effect rated as of Significance in a Local context, the loss of bog will be off-set by the implementation of the Biodiversity Enhancement and Management Plan which will preserve and enhance an area of 3.9 ha of blanket bog for the lifetime of the Proposed Development.

With mitigation measures implemented in full to minimise disturbance to high bog adjoining the work area at the wind turbine AT13 location, the significance of a disturbance effect can be reduced from a Moderate effect of medium-term duration to a Slight effect of medium-term duration.

The effect of the permanent and temporary loss of hedgerows will be offset by the implementation of an extensive hedgerow and woodland planting scheme.

With mitigation measures as presented implemented in full, it is considered that the significance of the predicted effect on terrestrial mammal species and amphibian and reptile species as a result of the Proposed Development will be Not Significant.

Following extensive surveys within and surrounding the site for the Wind Farm, it is considered that the landscape in which the proposed Wind Farm is situated is of moderate risk for soprano pipistrelle, Leisler's bat and common pipistrelle. With the implementation of the mitigation outlined above the potential risk of fatality from collision and/or barotrauma events to foraging and/or commuting high risk species such as pipistrelle and Leisler's have been significantly reduced, and it is concluded that the Proposed Development will not have any long-term adverse effects on the local bat populations. Impacts on other bat species have also been assessed. While these species are not at high risk from collision they can be affected by loss of connectivity features and loss of roosting sites. However, the Proposed Development will include extensive hedgerow and woodland planting and these planted areas will be connected to existing habitats, which will be beneficial for local bat populations.

8 ORNITHOLOGY

Chapter 7: Ornithology of the EIAR evaluates the effects of the Proposed Development arising from the construction/decommissioning and operational phases on bird populations within and surrounding the Redline boundary. The assessment is based on desk studies and detailed **Site surveys carried out between April 2021 and June 2023.** The surveys comprised the following:

- Flight activity (Vantage Point) surveys
- Lackan Bay coastal survey
- Breeding & winter bird transect surveys
- Breeding merlin survey
- Breeding woodcock survey
- Breeding wader survey
- Winter hen harrier roost survey

While the site is in close proximity to the Killala Bay/Moy Estuary SPA, none of the Special Conservation Interests of the SPA utilise the area of the Wind Farm.

The species recorded of the highest conservation importance was hen harrier, which utilises the area for both foraging and roosting in winter (absent as a breeding species). The presence of merlin, albeit on a very local basis, is also of note. Both of these species are listed on Annex I of the Birds Directive.

Snipe, a Red-list species, breeds (3 recorded pairs) within the Wind Farm area and is also widespread in winter. Kestrel, also Red-listed, hunts within the Wind Farm Site area through the year and is likely to breed locally. Woodcock (Red-list) is a scarce winter visitor to the area. Two red-listed passerine species, meadow pipit (resident) and redwing (winter), are widespread throughout the study area.

A range of Amber-listed species breed within the Wind Farm Site, including skylark, swallow, willow warbler, starling, house sparrow and linnet.

The Green-listed sparrowhawk and buzzard are both widespread species within the study area.

For hen harrier (winter), kestrel (all year) and snipe (breeding), the study area is rated as of County Importance (following NRA 2009 Guidance). For all other species as described above, the study area is rated as of Local Importance (higher value).

Potential effects that could arise during the Construction, Operation and Decommissioning phases of the Proposed Development are assessed for designated sites and bird populations within the Site and surrounding areas. Where significant effects are identified, mitigation measures in accordance with best practice and guidance will be implemented to eliminate or reduce the effect.

With mitigation measures, including a Biodiversity Enhancement Management Plan (BEMP) and the hedge and woodland planting programme, implemented in full, it is considered that the significance of the predicted adverse effects on birds as a result of the Project will range from Imperceptible to, at most, Slight.

In particular, the localised loss of peatland habitat at AT13 location will be offset by the BEMP and over time the effect on birds will be reduced to a level of Slight Significance.

Similarly, the effect on birds by the loss of hedgerows and trees will be offset by a rigorous planting programme and over a medium-term period (up to 15 years) it is considered that the effect will be reduced to the level of Not Significant.

In the absence of mitigation, the construction phase of the Wind Farm may result in disturbance to breeding birds within a distance of up to 500 m of the work area – this is rated as an Adverse Significant Effect of Short-term duration for sparrowhawk, buzzard, kestrel and snipe. With mitigation in place, comprising the use of work restrictive zones around identified nests areas (as determined by survey at the time), the disturbance effect will be avoided completely or, at most, reduced to level of Not Significant.

All construction works associated with the Proposed Development have potential to result in direct effects on breeding birds. However, as surface clearance works will be carried out largely outside of the breeding season (in compliance with the Wildlife Acts), this impact will be avoided. Should removal of any vegetation be required during the breeding season, this would be subject to survey for presence of breeding birds by an experienced ornithologist and appropriate mitigation implemented to avoid or minimise adverse effects.

During the operational phase of the Proposed Development, predicted collision rates for target species have been shown to range from Not Significant (hen harrier, buzzard, sparrowhawk & peregrine) to a Slight Adverse Effect (kestrel, lesser black-backed gull). For kestrel (Red-listed) in particular, mitigation will be implemented to discourage birds from hunting close to turbines and the significance of the effect can be reduced.

During the operational phase of the Proposed Development, birds may show some avoidance of suitable habitat as a result of the presence of turbines. This is rated as a Slight Adverse effect for hen harrier and buzzard. However, will time and a degree of habituation, this effect is likely to be reduced.

The baseline surveys did not identify any regular migration routes or local movements of wetland bird species or birds of prey through the Wind Farm Site. The Proposed Development is not expected to have any residual effect on migrating species or local wetland bird populations.

With appropriate mitigation in place to prevent effects on the quality of habitats within the Killala Bay/Moy Estuary SPA, significant residual adverse effects on the Special Conservation Interests, as well as Wetlands, are not predicted (assessed in detail in the AA Screening Report and NIS).

The Proposed Development includes rigorous ornithological monitoring (in line with best practice guidance) at pre-construction, construction, and operational phases.

7.1.1 Description of the Wind Farm Site

A detailed ecological description of the Proposed Development Site is presented in **Chapter 6: Biodiversity**. Briefly, the site is located approximately 5.2 km northwest of the village of Killala and approximately 2.4 km east of Ballycastle village in north Mayo (see **Chapter 1: Figure 1.2**). The Wind Farm Site covers a total area of approximately 108.06 ha.

The Wind Farm Site, and especially the northern sector, is situated within a landscape which previously had been dominated by blanket bog and heath. Much of this has now been cut or converted to pasture grassland, with fields often small in size and bounded by hedgerows. Commercial coniferous forestry is a feature of the area.

7.1.4 Statement of Authority

The chapter has been prepared by Dr. Brian Madden of BioSphere Environmental Services. The baseline ornithology surveys between 2021 and 2023 were carried out by Brian Madden, Conor Ryan, Mick Hogan, Hannah Keogh, David Miley and Joe Adamson.

7.2 METHODS

7.2.1 Study Area

Due to the ornithological importance of Lackan Bay (part of Killala Bay/Moy Estuary SPA), particular attention was focused on the strip of land between the bay and the Wind Farm to determine the potential for flightlines towards the Wind Farm.

Table 7.1: Target species identified for the Tirawley Wind Farm Study Area.

Target Species	Conservation Status	Target Species for Site Y/N
Barn Owl (*Tyto alba*)	BoCCI Red-listed	Y
Buzzard (*Buteo buteo*)	BoCCI Green-listed	Y
Curlew (*Numenius arquata*)	BoCCI Red-listed/SCI	Y
Golden Plover (*Pluvialis apricaria*)	Annex I EU Birds Directive/ BoCCI Red-listed/SCI	Y
Hen Harrier (*Circus cyaneus*)	Annex I EU Birds Directive/ BoCCI Amber-listed/SCI	Y
Kestrel (*Falco tinnunculus*)	BoCCI Red-listed	Y
Kingfisher (*Alcedo atthis*)	Annex I EU Birds Directive/ BoCCI Amber-listed	Y
Lapwing (*Vanellus vanellus*)	BoCCI Red-listed/SCI	Y
Long-eared Owl (*Asio otus*)	BoCCI Green-listed	Y
Merlin (*Falco columbarius*)	Annex I EU Birds Directive/ BoCCI Amber-listed	Y
Peregrine Falcon (*Falco peregrinus*)	Annex I EU Birds Directive / BoCCI Green-listed	Y
Red Grouse (*Lagopus lagopus*)	BoCCI Red-listed	Y
Snipe (*Gallinago gallinago*)	BoCCI Red-listed/SCI	Y
Sparrowhawk (Accipiter nisus)	BoCCI Green-listed	Y
Whooper Swan (Cygnus cygnus)	Annex I EU Birds Directive/ BoCCI Amber-listed/SCI	Y
Woodcock (Scolopax rusticola)	BoCCI Red-listed	Y

Table 7.2: I-WeBS data for Lackan Bay (subsite 0D488), winters 2018/19 to 2022/23. Figures given are peaks for each winter.

Species	Peak	2018/19	2019/20	2020/21	2021/22	2022/23
Whooper swan	25	25	20	-	-	-
Brent goose	65	40	53	55	42	65
Shelduck	9	-	-	-	9	-
Wigeon	19	-	8	-	19	16
Teal	1	-	1	-	-	-
Mallard	6	6	-	-	-	2
Cormorant	88	6	18	19	18	88
Little egret	2	--	-	2	-	-
Grey heron	3	3	-	3	1	-
Oystercatcher	197	197	101	76	69	29
Ringed plover	83	63	-	40	21	83
Golden plover	147	-	-	-	29	147
Grey plover	10	-	-	6	-	10

Lapwing	3	3	-	-	-	-
Knot	12	-	6	-	12	-
Sanderling	53	21	-	30	47	53
Dunlin	103	16	14	9	48	103
Black-tailed godwit	3	-	-	-	3	-
Bar-tailed godwit	20	8	11	6	20	20
Curlew	77	77	52	23	26	40
Redshank	11	4	1	2	10	11
Greenshank	3	3	-	-	1	1
Turnstone	16	-	-	11	16	-
Black-headed gull	85	6	14	19	7	85
Common gull	483	483	160	328	83	92
Lesser black-backed gull	4	-	2	-	4	-
Herring gull	31	31	2	15	27	27
Great black-backed gull	446	446	9	9	14	34

Table 7.3: Conservation status of species recorded within the area of the proposed Tirawley Wind Farm.

Species	Annex I	Red list	Amber list	Green list
Hen harrier	Y		Y	
Sparrowhawk				Y
Buzzard				Y
Kestrel		Y		
Merlin	Y		Y	
Peregrine	Y			Y
Snipe		Y		
Woodcock		Y		
Lesser black-backed gull			Y	
Goldcrest			Y	
Skylark			Y	
House martin			Y	
Swallow			Y	
Willow warbler			Y	
Starling			Y	
Redwing		Y		
Wheatear			Y	
House sparrow			Y	
Meadow pipit		Y		
Linnet			Y	

7.4.3.1 Collision

Collision risk posed to bird species is one of the main environmental concerns associated with wind energy developments (**Drewitt & Langston 2006, Band *et al.* 2007, Drewitt & Langston 2008**). However, bird species differ widely in their susceptibility to collision mortality. Essentially, birds are at risk of collision only when their flight path overlaps with the rotor blade sweep area of a turbine. It follows that birds whose flight heights coincide with the height of the turbine rotor sweep are most at risk.

The assessment of potential impacts considers and assesses the Vesta V117 - 4.3 MW IEC IIA parameters (16 no. turbines). The turbine parameters can be seen in **Table 7.4**.

Table 7.4: Turbine Parameters: Vesta V117 model

Turbine Parameter	Assessment Envelope
Turbine Blade Tip Height	135 m
Rotor Diameter	117 m
Hub Height	76.5 m

Turbine Hardstand (Main Crane Hardstand Area) L x W	65 x 25 m

Collision Risk Modelling (CRM) is a method to estimate the number of birds likely to collide with turbines at the Wind Farm Site. This method uses vantage point data to calculate the risk of collision. In this case, the vantage point data collected over the 24 month period April 2021 to March 2023 (two breeding seasons and two winter seasons) at the Wind Farm Site were used.

Table 7.5: Summary of estimated mean number of collisions (with avoidance rates) predicted for key ornithological receptors over the lifetime of the Proposed Development.

Species	Mean no. of predicted collisions over lifetime of the Project (nominal 35 years)	Mean number of predicted collisions per year	One bird collision every 'x' years
Kestrel	10.5 birds	0.3	3.33 years
Buzzard	10.5 birds	0.3	3.33 years
Lesser blackbacked gull	7.0 birds	0.2	5 years
Sparrowhawk	0.0 birds	0.0	-
Hen harrier	0.0 birds	0.0	-
Peregrine	0.0 birds	0.0	-

7.4.3.2 Displacement effect due to turbines

Displacement of birds from otherwise suitable habitat as a result of the presence of wind turbines has been reported as a potential impact of wind turbines (Drewitt & Langston 2006, de Lucas *et al.* 2007, Pearce-Higgins *et al.* 2009). The displacement occurs as a result of behavioural responses that prevent or decrease the use of an area for activities such as nesting or foraging. However, the results of studies on potential displacement have varied widely and in an overall review of the literature Madders & Whitfield (2006) concluded that displacement effects of wind turbines on raptors are negligible for the most part.

7.4.3.3 Barrier effect due to turbines

The potential effect of lines of wind turbines creating a barrier effect to passing birds is mostly relevant to locations where migratory species pass regularly. Rees (2012) cites eight published studies of flight behaviour which reported changes in flightlines for swans or geese initially seen heading towards turbines, at distances ranging from a few hundred metres to 5 km (the larger distances were by birds on migration); 50-100% of individuals/ groups avoided entering the area between turbines, but in some cases the sample sizes were small.

As the Wind Farm Site has not been identified through the baseline surveys or desk review as being along a migration route for birds, such as wetland species (swans, geese etc.) or birds of prey, there is not likely to be a barrier effect. Also, the turbines are dispersed over a relatively large area and could not be considered to be arranged in 'lines' with potential for creating a barrier effect.

7.5 CUMULATIVE EFFECTS

Chapter 2, Section 2.3.3 of the EIAR identified a total of 14 no. operational, consented and proposed wind farms within a 20 km radius of the site of the Proposed Wind Farm Development (see **Table 6.13** in **Chapter 6** and **Figure 2.3** in **Vol III**). In addition, there are 2 no. single domestic turbines at distances of 1.1 km (north of AT15) and 4.1 km southeast of the Proposed Development. The nearest operational wind farms are the Killala Community Wind Farm Phase 1 (6.0 km) and Killala Community Wind Farm Phase 2 (5.8 km). The Glenora (awaiting a planning decision) and Keerglen (awaiting a planning decision) projects are located at distances of 6.9 and 6.5 km respectively of the Tirawley Site. All the other wind farm projects are at distances greater than 10 km from the Tirawley Site, with the majority located within afforested and bog habitats to the southwest.

Some of the other wind farm sites, such as Glenora, Oweninny Phases 1-3, and Sheskin South, have (in the absence of mitigation) the potential for impacts on bird species of high conservation importance, including red grouse and breeding and/or wintering golden plover. It is noted that these species do not occur within the study site of the Tirawley project.

While there is a hen harrier winter roost within the Oweninny Phase 3 study area, this roost is at a distance of over 15 km from the roost recorded within the Tirawley study area and interchange between the locations would not normally be expected. For both projects, adverse effects on the hen harriers are not anticipated.

Breeding snipe, which occurs within the Tirawley study area, were also recorded within the Oweninny Phases 1-3, Glenora and Sheskin South study areas. With appropriate mitigation, especially the avoidance of disturbance to birds during the construction phases, significant effects on this red-listed species can be avoided.

Species such as kestrel and sparrowhawk are fairly widespread at most of the wind farm sites with local breeding populations. Mitigation has been proposed as necessary to avoid disturbance to breeding birds.

While the Tirawley Wind Farm will add a further 16 turbines to the total of 222 turbines in the 20 km review zone (should all turbines be eventually built), with the location of the majority of turbines at distances of more than 10 km and separated by extensive areas of bog, forestry and agricultural land, and with appropriate mitigation implemented where required, it is considered that the Tirawley Proposed Development will not contribute to a significant effect on bird populations when considered in-combination with other wind energy projects.

An inventory of other permitted or proposed projects (awaiting decisions) bigger than a one-off house within a 10 km distance of the Proposed Development Site has been compiled (see **Chapter 2, Table 2.2**). Most of the projects are agricultural related developments or the continued use and operation of quarries. A series of the projects granted or under review are associated with the industrial facility at Killala, which is a distance of approximately 7 km from the site for the proposed Tirawley Wind Farm. All of these projects have been, or are, subject to rigorous evaluation of effects on the environment and especially potential for effects on bird species of conservation importance. For these reasons, the Proposed Development will not contribute to any significant cumulative effect on birds when considered in combination with other developments within the study area.

VEON: Collision Risk Model - Collision Risk Model Calculations For target species at the proposed Tirawley Wind Farm - Compiled by: Veon Ltd (Veon Ecology)
David M. McGillycuddy B.Sc. (Hons) in Wildlife Biology, ACIEEM, AEnvCW.
Prepared for: BioSphere Environmental Services.

Table 1.1: Wind turbine specification and parameters for the proposed wind farm development.

Wind Farm Components/Turbine Parameters	
Technical Information and Wind Farm Component	Data used/Scenario Modelled
Turbine model	Vestas V117
Number of turbines	16
Number of blades per turbine rotor	3
Rotor blade maximum chord (m) (i.e., depth of blade)	4
Rotor Radius (m)	58.5
Rotor Diameter (m)	117
Circumference of blade tip (m) (Pi x Rotor Diameter)	367.6
Swept area (m2) (Pi x Rotor Radius2)	10751
Turbine blade tip height (m)	135
Hub height (m)	76.5
Swept height (m)	18 - 135
Maximum height to blade tip (m)	135
Minimum height to blade tip (m)	18
Speed (Dynamic Operation Range) (m/s)	6.7 - 17.5
Turbine operation time*	85%
Average blade pitch (degrees)**	15^0
Mean rotational speed (rpm)***	12.1
Average Rotational period (s) (60/12.1)	4.959

Turbine rotational speed varies with wind conditions, and a mean operational speed is used in the model. Ideally, this is based on wind data collected over time; where such data are not available, a representative speed anticipated by the

wind farm developer is used. In line with guidance (NatureScot, 2024), a mean rotation speed of 12.1 rpm is applied in this assessment.

Due to the low frequency of recorded flights, the collision risk for Merlin can be assumed to be effectively zero. At <0.01 collisions within the nominal 35-year operational phase of the Proposed Development is predicted for Sparrowhawk, Hen Harrier and Peregrine. The collision risk for Kestrel is estimated at 0.3 birds per year (or 10.5 birds over the nominal 35-year operational phase), similarly the collision risk for Buzzard is estimated at 0.3 birds per year (or 10.5 birds over the nominal 35-year operational phase), and the collision risk for Lesser Black-backed Gull is estimated at 0.2 birds per year (or 7.0 birds over the nominal 35-year operational phase).

Six species fulfilled the criteria for undertaking CRM:

- Kestrel (*Falco tinnunculus*)
- Buzzard (*Buteo buteo*)
- Lesser Black-backed Gull (*Larus fuscus*)
- Sparrowhawk (*Accipiter nisus*)
- Hen Harrier (*Circus cyaneus*)
- Peregrine (*Falco peregrinus*)

Other species of conservation concern were recorded during the vantage point surveys but were excluded from consideration in the collision risk analysis for the following reasons:

Merlin (*Falco columbarius*) was observed flying within the collision risk height band during the surveys. However, only two flights (two individuals) meeting the criteria were recorded across all survey years. Due to the low frequency of recorded flights, the collision risk for Merlin can be assumed to be effectively zero. As a result, they are excluded from further consideration in the analysis.

Table 1.2: Avian biometric data and avoidance rates.

Avian Biometric Data & Avoidance Rates

Species Name	Length (m)	Wingspan (m)	Mean flight speed (m/s)	Avoidance rates (%)
Kestrel	0.34	0.76	10.1	95
Buzzard	0.54	1.2	13.3	98
Lesser Black-backed Gull	0.58	1.43	11.9	98
Sparrowhawk	0.33	0.67	10	98
Hen Harrier	0.48	1.1	9.1	99
Peregrine Falcon	0.42	1.02	12.1	98

The recommended avoidance rate for each species is in accordance with NatureScot guidance (2025) and SNH (2010; SNH, 2018), with a default value of 98% applied where species-specific avoidance rates are not available.

Table 1: Recommended avoidance rates for use with the onshore NatureScot Collision Risk Model for key bird species commonly identified in wind farm environmental statements for which supporting evidence is available. The recommended default avoidance rate for species not listed is 98%.

Table 1		
Species	**Recommended avoidance rate**	**Rationale/supporting evidence**
Red-throated diver	99.5%	Furness (2015)
Black-throated diver	99.5%	Breeding birds show similar behaviour to red-throated diver; Furness (2015)
Swans (all species)	99.5%	Increased from previous rate of 98% based on evidence presented in Whitfield & Urquhart (2015), but slightly more precautionary than report recommendation given this was based on a short run of data from one study
Geese (all species)	99.8%	SNH (2013)
Red kite	99%	Urquhart & Whitfield (2016)
Hen harrier	99%	Whitfield & Madders (2006a)

Golden eagle	99%	Whitfield (2009)
White-tailed eagle	95%	Sufficient evidence from flight behaviour and collision monitoring studies in Norway for vulnerability to collisions; see May et al. (2011)
Kestrel	95%	Sufficient evidence from flight behaviour (including hovering) and collision monitoring studies for vulnerability to collisions; see Whitfield & Madders (2006b)
Great skua	99.5%	Furness (2015)
Arctic skua	99.5%	Similar behaviour of breeding birds to great skua: Furness (2015)
Large gulls (herring gull, lesser black-backed gull, great black-backed gull)	99.5%	Furness (2019)
Small gulls (common gull, black-headed gull)	99.2%	Furness (2019)

Nature Scotland 2024

Guidance on using an updated collision risk model to assess bird collision risk at onshore wind farms

Published: 2024

1. Introduction

An environmental statement for an onshore wind farm should include a quantitative estimate of collision risk for all bird species present on the site for which the level of risk has the potential to be important. This should include a view on the significance of that collision risk to the respective bird populations.

The aim of this guidance is to promote a standardised approach to collision risk assessment for onshore wind farms, to increase the transparency of calculations and to promote greater confidence in the results. It will enable estimates from different wind farms to be more easily compared and combined to facilitate cumulative assessment. It may also enable collision risk assessment to be used as a tool in selecting the best areas for onshore wind farm development.

The guidance describes the information needed, and how to use that information to arrive at an estimate of collision risk. It is accompanied by a spreadsheet which enables the necessary calculations to be performed in a standardised way.

The approach builds on previous models developed by Band *et al.* (2007) and Band (2000). The approach does not change the single transit probability calculation but adds the other stages of the model, which would previously have been undertaken by consultants and others wishing to conduct collision risk modelling, to standardise these calculations. The approach is intended to provide collision risk estimates that are comparable across different wind farms.

This guidance provides an explanation of the model input parameters, how the information should be presented and how the outputs of the model should be expressed. It is associated with a **spreadsheet** for performing the calculations. **A fuller report is available explaining the derivation of the model (Band, 2024)**.

2. Information needed

The model requires information on:

- The number of birds flying through or around the site, and their flight height (derived from bird survey).
- Any predicted or likely changes of behaviour of birds, e.g. in avoiding or being attracted to the wind farm.
- The number, size and rotation speed of turbine blades.
- Physical details on bird size and flight speed.

Figure 1 illustrates graphically the process involved. The guidance does not cover:

- bird survey methods - for which there are various advisory sources, notably our guidance **Survey methods for use in assessing the impacts of onshore windfarms on bird communities**; or
- bird behaviour – which can be obtained from other guidance, such as our guidance **Use of avoidance rates in the NatureScot wind farm collision risk model.**

The key outputs from the collision model – the collision risk - is expressed as the likely number of birds per month or per year which will collide with the wind farm. It should include the range of uncertainty surrounding that estimate. Presentation of the output should be accompanied by a clear statement of the assumptions on avoidance made in arriving at the estimate as these are often critical to the magnitude of the collision estimate.

The model provides only an assessment of collision risk. Where collision risk is estimated to be not negligible, a developer will need to consider the significance of the predicted mortality. This will include the sensitivity of the bird population, the degree of protection afforded by legislation and any protected sites in the vicinity which may be designated for that species by legislation and any protected sites in the vicinity which may be designated for that species.

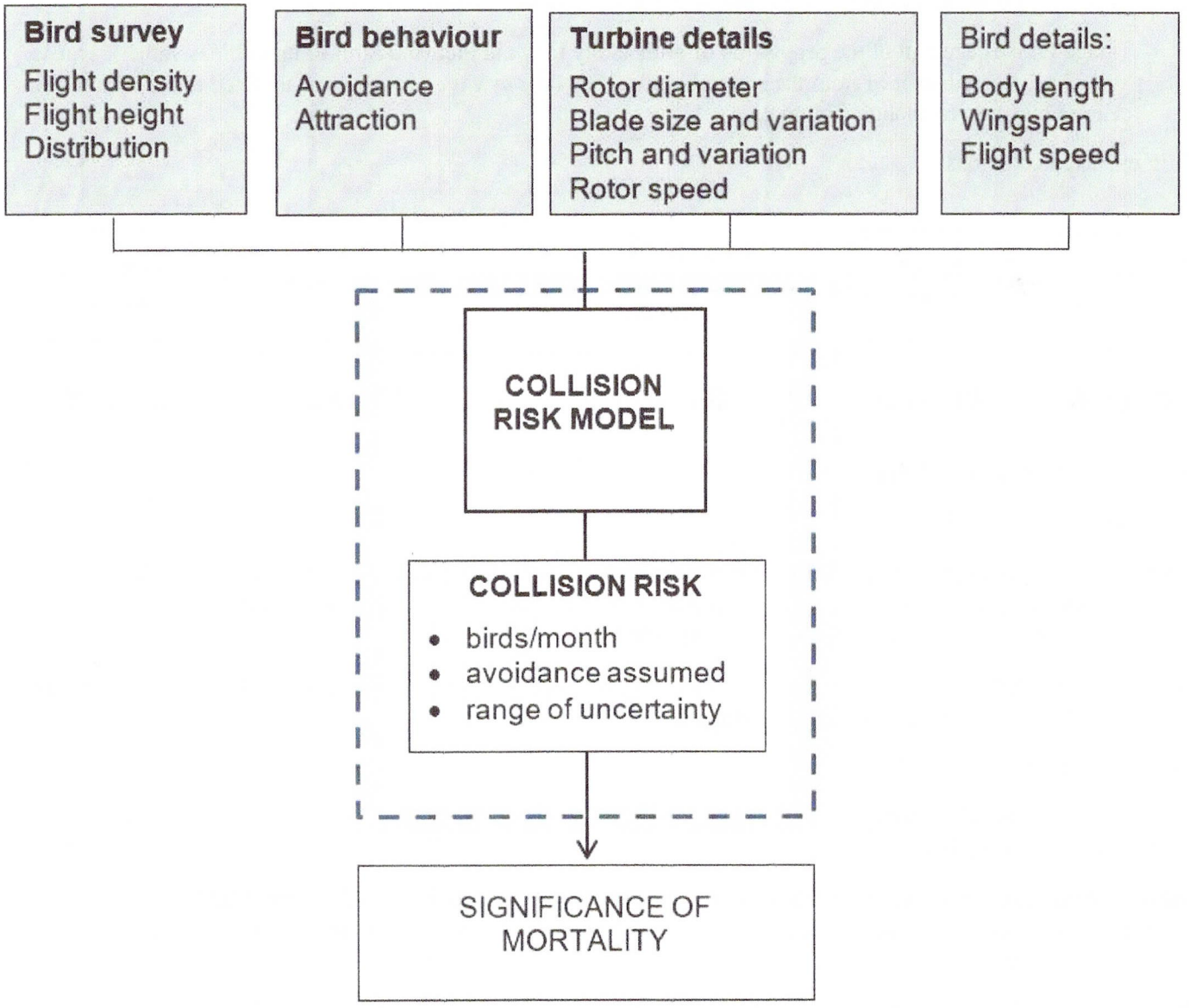


Figure 1. Collision risk model process. Grey boxes require a standard presentation of information.

Click for a full description

Figure 1 is a flow chart describing model inputs and outputs. Input data is on bird behaviour, i.e. avoidance or attraction to the site, bird survey, i.e. flight density, height and distribution, turbine details, i.e. rotor diameter, blade

size and variation, blade pitch and variation and rotor speed, and details of the bird species, i.e. their body length, wingspan and flight speed. Data is analysed in terms of the number of birds per month, avoidance behaviour and an assumed range of uncertainty, and the output results presented as the significance of the risk of mortality occurring. Input data needs to be in a standardised form to allow the calculations to be made accurately.

3. Collision risk model

The model estimates the number of collisions through a process of five stages:

- Stage A uses bird survey data to establish the density of flying birds in the vicinity of the turbines, and the proportion flying at a risk height, between the lowest and highest points of the rotors.
- Stage B provides an estimate, based on the bird density and proportion at risk height, of the potential number of bird passages through rotors in the period in question.
- Stage C calculates the probability of collision during a single bird rotor transit.
- Stage D estimates the potential collision rate for a bird species, assuming current levels of bird use of the site, allowing for the proportion of time that turbines are not operational.
- Stage E takes account of the proportion of birds likely to avoid the wind farm or its turbines, either because they have been displaced from the site or because they take evasive action or are attracted to the wind farm, e.g. in response to changing habitats.

Thus, expected collisions =

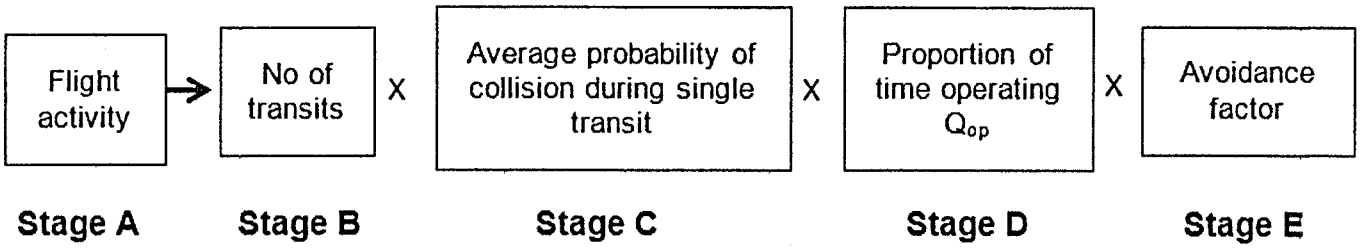


Figure 2. The collision risk model stages.

Click for a full description

Figure 2 is a flow chart presenting the five stages of the model. Data in flight activity is used to estimate the number of single transits through the rotor area, the average probability of collision during each of these transits, then multiplied by the proportion of the turbine operational time (Q_{op}) and the avoidance factor.

The guidance describes each of the five stages. It includes an additional stage, Stage F, which describes how to express the uncertainty surrounding a collision risk estimate.

4. Collision risk model spreadsheet

This guidance is carried out using a spreadsheet which enables user to work easily through stages A-E of the process. It comprises five worksheets.

Collision risk. This is the 'master' spreadsheet into which all required data is entered (except blade profile), and which presents the collision risk output. An illustration of this spreadsheet, as used for the worked example, is reproduced at Annex 1.

Data is entered in the top section of the spreadsheet. It is brigaded under three headings: 'Bird data', 'Wind farm data' and 'Turbine data'. The only data which requires input elsewhere is in the 'Blade profile' sheet where, if the data is available, the blade profile may be replaced by a more specific one for the turbine blades used.

The remainder of the sheet is organised according to Stages A-E of the process. It provides outputs from each stage:

- Stage A - the calculated flight activity (expressed as a density figure).

- Stage B - the estimated number of potential bird transits through rotors of the wind farm.
- Stage C - the probability of collision during a single bird rotor transit.
- Stage D - potential collision mortality for the bird species, assuming current use of the site and no avoiding action is taken.
- Stage E - potential collision mortality for the bird species, taking avoidance and other likely behaviour change into account.

The source data used for each input should be listed in full within the environmental statement.

Blade profile is a table giving the chord width of the blade, relative to its maximum chord width, at points along the blade length. 21 data points are required, at points r/R = 0, 0.05, 0.1, 0.15 etc. up to r/R=1 where r is the distance out from the hub and R is the blade length. The value for r/R=0 is not used in the calculation as this will be the hub.

Daylight and night hours. Given the input latitude, this sheet computes the daylight and night hours in each month within which there could potentially be bird activity.

Large array correction. This enables a correction to be made for large arrays where the collision rate is such that bird density might significantly decline as birds pass through the wind farm. These correction factors are then applied to the collision rate estimates in the 'Collision risk' sheet. In most circumstances the results will demonstrate that a large array correction is not significant and can be ignored.

Spreadsheet protection

The spreadsheet uses visual basic functions to calculate collision risk for single transits. For these to work, the spreadsheet must be macro-enabled. Some corporate systems routinely disable macros as a computer security precaution. These can be enabled in File/Options>Trust Center>Trust Center>Settings>Macros Settings and activating 'Enable all macros'.

To protect against unintentional overwriting of formulae, or the entry of input data other than in the 'Collision Risk' sheet, each of the worksheets is protected. The spreadsheet is fully usable in this state, with data entry allowed in the sections coloured orange.

5. Stage A - Flight activity

This stage estimates the number of flights which, in the absence of birds being displaced, taking other avoiding action or being attracted to the wind farm, would potentially be at risk from the turbines. It requires field data to determine levels of flight activity within the proposed wind farm.

For non-directional flights, two key parameters derived from survey observations are needed to describe the magnitude of flight activity:

(i) Areal bird density (D_A) and
(ii) Proportion of birds flying at risk height (Q_{2R})

Areal bird density (D_A) is the number of birds, in flight at any height at a given point in time, per unit area. D_A is most often recorded in bird seconds, which is particularly appropriate where bird numbers are low, and is usually expressed per square kilometre (km^2). For use in the formulae, it must be divided by 10^6 to yield D_A in SI units, i.e. birds m^{-2}. The spreadsheet does this division. Note that areal bird density is different from the 'true density' (Dv) that is expressed in terms of bird-seconds per cubic meter (m^3) of air space, and which is calculated from D_A in stage B.

Vantage point survey is usually the most appropriate way to record daytime flight behaviour, location and levels of flight activity on a proposed onshore wind farm site. Such a survey records, from a set of key vantage points, all bird flights and their duration within a defined sector of the wind farm airspace, leading to a measure of bird occupancy in that airspace.

We advise that all of the proposed wind farm site, plus at least a 200 m buffer, is covered by vantage point surveys. This ensures that data are available for the whole site and the immediate surroundings, should layout plans change during the planning application process. This also allows for the appropriate siting of turbines in areas with minimal flight activity, if possible. However, the key flight-activity data for use in the CRM are those from within the turbine envelope. This comprises an area with radius equal to the rotor length plus 500 m, extending from each turbine.

Bird occupancy is readily converted to areal bird density (bird-seconds per m2) by dividing by the area scanned from the vantage point. Where flight activity from vantage point watches is recorded in bird seconds, DA is calculated as follows:

$D_A = b / (t \times A)$ bird-seconds m^{-2}

where:

(b) is the number of flight seconds from a vantage point;
(t) is the time (in seconds) that the vantage point is watched;
(A) is the area of the vantage point view-shed (km^2).

D_A can be calculated for each vantage point and the figure averaged. Where there is significant difference in the area and/or time covered by vantage points, the average figure should be weighted. This approach should also be used where differences in data are likely to be the result of natural variability. The weighting factor used acknowledges that the quantity of data collected in a watch is proportional both to the size of the area observed and the duration of the watch. Thus:

mean density $D_A = \Sigma\, b_i \sqrt{(t_i \times A_i)} / (t_i \times A_i) / \Sigma \sqrt{(t_i \times A_i)}$

Where the conditions are such that it is likely to be a notable difference, for example because the underlying habitat is different, either the bird density should be calculated separately for each watch area and applied to calculate collision risks within that area, or a turbine-weighted average bird density should be used, i.e. weighting the bird density for each watch area by the number of turbines within that watch area. The formula for this is:

$D_{average} = \Sigma\, (N_i \times D_i) / \Sigma\, N_i$

where:

D_i is the areal bird density for watch area (i);
N_i is the number of turbines to be sited in that watch area; and
$D_{average}$ is the average areal bird density.

The worked example in Annex 2 illustrates this calculation.

Proportion of birds flying at risk height (Q_{2R}) is the proportion of birds between the lowest and highest points of a rotor, measured relative to the rotor base. Where only flights in the rotor swept height band are recorded, Q_{2R} will be 1.

Where flights are directional, calculations from vantage point watches should estimate the number of flights within each view-shed that cross a baseline perpendicular to the main flight direction. D_A can be calculated by measuring bird flux (the number of birds crossing an imaginary surface within the airspace), expressed as birds per second or birds per second per square metre (birds sec^{-1} m^{-2}) of that surface. It is measured in the field as Mean Traffic Rate (MTR), which is the number of birds flying per hour across an imaginary horizontal line of length 1km. MTR can be converted to areal density (in birds m^{-2}) using the formula:

$D_A = MTR \times (\pi/2) / (v \times h)$ birds m^{-2}

where:

MTR is expressed as number of birds per m (of baseline), per second
v is bird speed (m per sec); and
h is the height band within which bird flights are recorded (m).

The full derivation of this equation is given in the report.

For non-directional flights, where there is a significant difference between vantage points in terms of the length of the baseline within each view-shed and/or in terms of time watched, the figures from each vantage point should be averaged and weighted as necessary.

An environmental statement should clearly state the bird density used in collision calculations, expressed as birds per km^2 across the site, including birds flying at all heights. It should also state the proportion of birds estimated to be flying within the risk height band, i.e. between the lowest and highest points of the rotors.

Where survey information leads to a range of perspectives on bird density, e.g. including or excluding data for buffer areas, the Environmental Statement should make clear which survey data has been used, and why.

5.1 Daylight hours and nocturnal activity

Most bird survey is undertaken by day and it is generally assumed that sample levels of flight activity persist throughout daylight hours. Daylight hours depend both on time of year and on latitude. Forsythe *et al.* (1995) provide a ready reckoner for daylight hours which is reproduced in the 'Daylight and night hours' sheet of the CRM spreadsheet. Inputting the latitude of the site in the 'Collision risk' sheet triggers the calculations which returns the 'Collision risk' sheet the appropriate number of daylight and night hours in each month

Figures used in the collision model should take both day and night flights into account. Daytime activity should be based on field survey and, if night-time survey is not possible, expert assessment of likely levels of nocturnal activity for the species in question should be sought, including at other sites if not at this site. These rankings are translated in the spreadsheet to levels of activity F_{night}, which are respectively 0%, 25%, 50%, 75% and 100% of daytime activity.

The information on bird density, proportion at risk height, nocturnal activity, and day and night hours provides the input to Stage B.

Table 1. Input parameters for Stage A.

Symbol	Description	Units	Notes
D_A	Bird density (day)	bird seconds km^{-2}	Average number of bird seconds of flight time during the day at any height, per square kilometre, as derived from field observation. Entered for each month. If only a year average is available, enter this value for all 12 months: the monthly figures may not be meaningful, but the year average and totals will be valid.
H	Hub height	m	The height above ground of the rotor hub.
R	Rotor radius	m	The length of the rotor blades, from axis to tip.
Q_{2R}	Proportion at rotor height	%	% derived from bird survey, in the light of the projected rotor diameter and rotor hub height.
-	Nocturnal activity ranking	1 to 5	Enter a ranking on the scale 1-5, from 1 = hardly any night activity to 5 = as active at night as by day
-	Latitude of wind farm	degrees latitude	Include degrees and minutes in degrees with decimal places; this data is used to work out daylight hours in each month

Table 2. Outputs from Stage A.

Symbol	Description	Notes
-	Risk height range	Based on the hub height (H) and rotor radius (R), the range of flight heights H-R to H+R within which collisions could occur.
f_{night}	Nocturnal activity factor	The spreadsheet converts the nocturnal activity ranking 1-5 to an assumed factor of 0%, 25%, 50%, 75%, 100% daytime activity. It should be noted that this translation is not based on flight activity evidence but is an expert judgement on how the rankings should be interpreted.
t_{day}	Daylight hours	The spreadsheet uses the wind farm latitude to calculate daylight and night-time hours for each month, and the total for a year.
t_{night}	Night-time hours	The spreadsheet uses the wind farm latitude to calculate daylight and night-time hours for each month, and the total for a year.

6. Stage B - Estimating number of bird flights through rotors

The total number of bird transits expected through rotors is proportional to the number and cross-sectional area of the rotors, and to the density of birds in the airspace at risk height. The spreadsheet performs this calculation for each month, if monthly data on bird density is available.

A key output within the collision risk assessment should be a clear statement of the potential number of bird transits per month and per year through the wind farm turbines, assuming birds take no avoiding action. The collision risk is directly proportional to the potential number of bird transits.

Stage B draws on the figures for bird density (D_A), the proportion at risk height (Q_{2R}), the nocturnal activity factor f_{night} and the figures for monthly daylight and night hours as established in Stage A. To estimate the number of birds flying through rotors, additional information is required on the number of turbines, the rotor radius and flight speed of the species being observed. For flight speed, a typical mean flight speed as given in standard references will usually be adequate. However, where there is a need to explore the collision risk arising from different types of bird behaviour involving very different flight speeds, e.g. pursuit, or foraging, the collision risk calculation should separate out the risk for those birds engaged in each behaviour and provide a sum of their collisions risk, as this varies with flight speed in a non-linear way.

Table 3. Input parameters for Stage B.			
Symbol	**Description**	**Units**	**Notes**
T	Number of turbines	-	-
R	Rotor radius	m	measured from rotor axis to blade tip
v	Flight speed	m sec^{-1}	bird speed, relative to the ground

Table 4. Outputs from Stage B.		
Symbol	**Description**	**Notes**
-	Total rotor frontal area	The total cross-sectional area of all the rotors ($T \pi R^2$). If the size and number of turbines is not known, a figure may be entered directly in this sheet for the 'total rotor frontal area': which may be amenable to a better estimate than either the turbine number or size.
-	Projected number of bird transits	This is expressed for each month and totalled for a year.

7. Stage C - Probability of collision for a single rotor transit

This stage uses information on the size and speed of the turbines and physical details on the size and speed of the bird to compute the risk of collision for a bird flying through a rotating rotor.

It is assumed that birds can avoid stationary infrastructure, so no account is taken of the turbine towers or the blades when stationary. The model evaluates the probability of a bird colliding if it passes at random at any point through the rotor disk on a flight path perpendicular to the rotor plane. It also that the collision probability for oblique angles of approach is the same as for perpendicular approach; that there is no effect of turbulence in the wake of a blade; and that there is no slipstream effect, i.e. air rushing over a blade may carry a bird clear of it.

You are also asked to enter whether gliding or flapping flight is most appropriate for the species in question. Gliding flight has a marginally lower collision risk than flapping flight, notably for passage at points level with the rotor hub where the wings lie parallel with potentially colliding blades. However, the difference is rarely sufficient to warrant detailed consideration of different bird behaviours; the flight type used should be that which best typifies most flights for the species in question.

Because of the geometry of the blades in relation to the flight direction, the collision risk for upwind flight is higher than for downwind, even if the bird's flight speed relative to the ground is taken to be the same. If both upwind and downwind flights are equally likely, it is appropriate to take an average of their collision probabilities. In taking an average, the 'Collision risk' sheet uses the relative proportion of upwind and downwind flights to weight the respective collision probabilities. By default the proportion is set to 50:50 probability of upwind:downwind.

The 'Blade profile' sheet of the spreadsheet provides a collision risk calculator for a single passage through the rotor. It evaluates the probability of collision for a bird making a single passage through a rotor at each radius (r) and angle (φ), in increments from r/R=0.05 out to r/R=1, and at 10-degree intervals of φ. The collision probability is then averaged over the entire area of the rotor disc to obtain the average collision risk for a passage at any point across the rotor.

7.1 Rotor rotation speed

Wind turbines currently available are designed to operate at a range of speeds. They do not typically operate below a cut-in speed, usually between three and four m/sec, then increase in speed with wind speed up to an operating wind speed which may be around 12 m/sec. Thereafter, they maintain a constant operating speed by altering the pitch of the blades until, in extreme conditions, the turbine is shut down for safety.

Collision risk should be evaluated using the turbine rotational speed for an operating turbine. Where turbines operate with a range of rotational speeds, the calculation should be done using a mean operational turbine speed. The mean used should be a measure over time and using an analysis of wind data to enable the likely frequency distribution of turbine speeds to be determined. Allowance is made at Stage D for the proportion of time that a turbine is non-operational, either because of low wind speeds or for maintenance. The mean turbine speed should thus be a mean over operational time only, not including times when the turbine is idling or stationary. Ideally, this should be a mean over time, using an analysis of wind data to enable the likely frequency distribution of turbine speeds to be determined. This may not always be available, in which case the speed used should be based on the most likely value as anticipated by the wind farm developer.

Table 5. Input parameters for Stage C.

Turbine data			
Symbol	**Description**	**Units**	**Notes**
b	No of blades	-	-
Ω	Rotation speed	rpm (revolutions per minute)	The underlying formulae makes use of rotation speed Ω expressed in radians per second. The spreadsheet converts rpm to radians/sec. One complete revolution is 2π radians, and there are 60 seconds in a minute, so $\Omega = (\text{rpm}/60) \times 2\pi$ The rotation speed when generating of most contemporary turbines is variable within a pre-determined range. A time-averaged mean of operational rotor speeds should be used, taking account of the expected frequency of different wind speeds and the resulting rotor speeds.
R	Rotor radius	m	Measured from the axis of rotation to blade tip. This value will already have been entered in Stage B.
C	Maximum blade chord width	m	The model considers a blade to be a twisted lamina, i.e. of zero thickness. It has a chord width, which varies along the length of the blade as it tapers towards the tip. The value to be entered here is the maximum chord width i.e. the blade width at its widest point.
γ	Average blade pitch	degrees relative to rotor plane	The blade also has a pitch angle – the angle between the blade surface and the axis of the rotor. Pitch angle varies along the length of the blade, from a high angle close to the hub, to a low pitch angle towards the blade tips, i.e. the blade is twisted. Pitch angle also varies as the pitch is controlled to alter the rotation speed of the turbine. In the model, an average angle is used, representing an average pitch along the blade length. 15-30 degrees is reasonable for a typical large turbine.
-	Blade profile	m	The table in worksheet 'Blade profile' enables the full tapered profile of a blade to be described. The values are the width of the blade as a proportion of the maximum chord width, at intervals of 1/20 the blade length from r=0 to r=R. The default chord profile in the spreadsheet is typical of a modern 5MW turbine.

Bird data			
Symbol	**Description**	**Units**	**Notes**
L	Length of bird	m	These should be drawn from standard reference works, e.g. Cramp & Simmons (1983), from BTO Bird Facts or NatureScot guidance on flight speed and biometrics.

W	Wingspan of bird	m	As above.
v	Bird flight speed	m s^{-1}	This value will already have been entered in Stage B.
F	Flight type	-	Either 'flapping' or 'gliding' - the spreadsheet then applies the relevant factor F = 0 for flapping flight, or +1 for gliding flight.
-	Proportion of flights upwind	%	This should be set to 50% unless survey indicates a predominant direction relative to wind, e.g. for large-scale migration flights.

Table 6. Outputs from Stage C.		
Symbol	**Description**	**Notes**
-	Single transit risk (upwind)	The probability of collision for a bird flying through any point of the rotor at random. The values are respectively for upwind and downwind flight.
-	Single transit risk (downwind)	The probability of collision for a bird flying through any point of the rotor at random. The values are respectively for upwind and downwind flight.
-	Single transit risk (Weighted mean)	The mean of the above two values, weighted by the proportions of birds flying upwind and downwind.

8. Stage D - Multiplying to yield expected collisions per year

Stage B estimated the likely number of flights through rotors across the wind farm; Stage C calculated the risk of collision for each single bird transit through a rotor. Stage D multiplies these together to yield an estimate of total potential collision risk, including a factor to allow for the proportion of time that the wind turbines are operational. This is before considering avoidance behaviour, which is stage E.

8.1 Non-operational time

Turbines do not operate all the time. A turbine may typically be at rest or idling for a considerable proportion of time because the wind is too weak to generate power or, exceptionally, because the turbines have been closed down to avoid damage in high wind. There is also a requirement for some downtime for maintenance. This non-operational time is accounted for by the factor Q_{op} representing the proportion of time the turbine is operational. If data are available, this factor should be stated monthly to reflect the different proportions of non-operational time at different times of year, for example, reflecting differing wind conditions across the year and increased access for maintenance during the summer. Where such data are not available, the default for use in the model is 15% non-operational time.

Table 7. Input parameters for Stage D.			
Symbol	**Description**	**Units**	**Notes**
Q_{op}	Proportion of time turbines are operational	%	This includes down-time for maintenance as well as time inactive because of low-wind or storm conditions. If available, monthly data should be used as both wind conditions and accessibility for maintenance are seasonally dependent. If such data is not available, enter the year average for all 12 months.

Table 8. Output from Stage D.		
Symbol	**Description**	**Notes**
-	Collision rate before avoidance	The estimated collision rate, for each month and for the year, before any account is taken of avoidance.

9. Stage E - Applying the avoidance rate

9.1 Avoidance

The preceding stages of the model assume that birds take no avoiding action in response to wind turbines. In reality, birds mostly take action to avoid collision with wind turbines. Data being derived from collision monitoring based on regular site scans for bird corpses and observations of habitat use in the vicinity of wind farms suggests that, for many bird species, avoidance rates of 98% or higher have been observed, implying that the collision risk is less than 2% of that calculated from stages A-D alone.

All current flight activity should be included within a wind farm collision risk estimate, and the avoidance rates used for collision risk estimates should be characteristic of overall avoidance, i.e. include both behavioural displacement and behavioural avoidance. The potential direct impact of displacement on the bird population in terms of reduction in available habitat, should also be assessed elsewhere in the bird impact assessment.

Where detailed information on avoidance is not available, overall avoidance rates are best estimated by using monitoring data from existing wind farms, comparing actual mortality to that predicted if pre-construction levels of flight activity were maintained. Care should be taken to ensure that the data on which such avoidance rates are based are on a consistent basis. This should include, for example, changes in turbine model and flight risk heights between those modelled in a collision risk assessment at the time of preparing an environmental statement and those actually built.

The collision risk estimate should conclude with a table showing potential collision mortality using a range of assumed avoidance rates. The text explaining this table should point to any evidence from existing post-construction monitoring on the respective or similar bird species which might indicate what levels of avoidance are best supported by evidence. In the absence of specific avoidance information for the species in question, it is recommended that collision risks be evaluated assuming avoidance rates of 95%, 98%, 99% and 99.5%.

9.2 Attraction

Consideration should be given to whether any habitat changes associated with developing the wind farm may result in attracting bird species. Any lighting on wind turbines may also have the effect of attracting birds at night. Where such attraction occurs, it follows that collision risk may be enhanced because of increased flight activity through the wind farm. Where, as part of an overall bird impact assessment, attention is drawn to the potential for a wind farm to attract birds, the potential for additional collision risk should also be considered.

9.3 Large turbine array correction factor

The model assumes that risks are additive, i.e. that a wind farm with 50 turbines will have 50 times the risk of a single turbine. However, where a bird passes successively through two or more turbines, it is exposed to the risk for each rotor transit. While it is possible that a bird encountering its first turbine may deviate to pursue a safer course through, above or around the wind farm, this is avoidance behaviour and therefore properly taken into account at Stage E rather than here.

More strictly, for large wind farms where the overall probability of a bird colliding is appreciable, it may be appropriate to take account of the fact that a declining proportion of the birds will survive passage through early rows of turbines and will thus be exposed to collision risk in later rows. This adjustment is only likely to be of any significance for large arrays of turbines.

The 'Large array correction' sheet in the CRM spreadsheet provides a calculator for this factor. Setting 'Allow for large array correction?' in the spreadsheet to 'Yes', applies this correction factor to the output collision rates by multiplying each projected collision rate, for each of the various avoidance rates, by the appropriate correction factor. In most circumstances it will be evident that the difference made is minimal.

Table 9. Input parameters for Stage E.

Avoidance rates			
Symbol	**Description**	**Units**	**Notes**
A	Avoidance rates to be used	%	The spreadsheet provides room for four avoidance rate options to be entered (the default set is 95%/ 98%/ 99%/ 99.5%) (see paragraphs 69-77). Each of these is then used to calculate the likely collision rates allowing for avoidance. If possible, use avoidance rates which have been established from previous monitoring studies for this species, and an appropriate range to cover the uncertainties involved.

Large array correction			
Symbol	**Description**	**Units**	**Notes**

-	Allow for large array correction?	-	Optional: enter 'Yes' or 'No'. In most circumstances the correction is likely to be insignificant, so better omitted for simplicity ('No'). However, where it is significant, enter 'Yes'.
w	Width of wind farm	km	If the large array correction is to be applied, it requires a value for the overall width of the wind farm in kilometres.

Table 10. Output from Stage E.

Symbol	Description	Notes
-	Large array correction factor %	If the large array correction factor is used, its values are listed and used to make an appropriate adjustment to the collision rates after allowing for avoidance. If it is not used, the factor is set to 100%.
-	Collision rates allowing for avoidance and (if used) the large array correction factor	The estimated collision rate, for each month and for a year, after avoidance (and any large array correction, if applied) is taken into account. The table shows the collision rates for each of the four specified avoidance rates.

10. Stage F - Expressing uncertainty

In a collision risk estimate following the above method, there are many sources of variability or uncertainty in the output, e.g. survey data is sampled, often both in time and space, and usually exhibits a high degree of variability; survey data is unavailable for certain conditions, including nighttime and storm conditions; there is natural variability in bird populations, over time and space, for ecological reasons. A fuller explanation of sources of uncertainty, and a method of evaluating and presenting this, is set out in the Band (2016).

The output should convey the uncertainty in the collision risk estimate, by indicating, in addition to a 'best estimate', a range of confidence around that estimate. Though it is unlikely that these can be subject to detailed statistical analysis (with the exception of the survey data), the aim should be to reflect the range of uncertainty as it would impact on target species populations and/or growth rates. Information to include should reflect:

- uncertainty or variability in flight activity data, including imprecision on flight height estimates and lack of knowledge about night-time behaviour;
- uncertainty due to the limitations of the collision model, including the variability of bird dimensions and flight speed, the simplification in shape of a bird and turbine blades; and
- uncertainty arising from turbine options yet to be decided, in number, size and speed. These options should include a 'worst case' in terms of the option likely to present greatest bird collision risk.

References

Band, W., Madders, M. & Whitfield, D.P. 2007. Developing field and analytical methods to assess avian collision risk at windfarms. In: De Lucas, M., Janss, G. and Ferrer, M. eds. *Birds and Wind Power*. Servicios Informativos Ambientales/Quercus, Madrid, Spain.

Band, W. 2000. **Windfarms and birds – calculating a theoretical collision risk assuming no avoiding action**. Scottish Natural Heritage Guidance Note.

Band, B. 2024. **Using a collision risk model to assess bird collision risks for onshore wind farms**. *NatureScot Research Report 909.*

BTO, n.d. **Bird facts.**

Cramp, S. & Simmons, K.E.L. 1983. *Handbook of the birds of Europe, the Middle East and North Africa: The birds of the Western Palaearctic*. Oxford University Press.

Forsythe, W.C., Rykiel, E.J., Jr, Stahl, R.S., Wu, H., & Schoolfield, R.M. 1995. A model comparison for daylength as a function of latitude and day of year. *Ecological Modelling*, 80(1), 87–95.

SNH, 2018. **Avoidance rates for the onshore SMH wind farm collision risk model**. Scottish Natural Heritage Guidance Note. Version 2.

Whitfield, D.P. & Madders, M. 2006. Flight height in the hen harrier *Circus cyaneus* and its incorporation in wind turbine collision risk modelling. Natural Research Information Note 2.

Annex 1 - Worked example

This worked example follows the six stages A-F of the guidance:

Stage A - Flight activity
Stage B - Number of bird flights through rotor
Stage C - Probability of collision for a single rotor transit
Stage D - Expected collisions per year
Stage E - Allowing for avoidance and attraction
Stage F - Expressing uncertainty

It is accompanied by a **spreadsheet** comprising a set of five worksheets using the data detailed in this example. It does not, however, include any specific collision risk for migrating birds, hence the examples do not include the 'Migrant collision risk' worksheet. All input data (except for blade profile) are entered in the 'Collision Risk' sheet, and the outputs also appear in that sheet. The supporting sheets perform various supporting calculations.

This example is entirely fictitious, including the bird density and turbine specifications used. The results are not characteristic of collision risks at any particular site.

1.1 Imagined scenario

An onshore wind farm is proposed in a high moorland area of Scotland. Among the birds present on site and viewed as sensitive to collision risk are Hen harrier (*Circus cyaneus*). This document describes the collision risk assessment for hen harrier.

This wind farm is still at the design stage and the results of this preliminary collision risk assessment will be used to help determine the final design. The maximum area of the site is around 7 km^2. If that full area were used the maximum generating capacity would be around 150 MW. This collision risk assessment has been undertaken for this maximum capacity. Collision risks to birds are expected to scale broadly in proportion to wind farm capacity.

1.2 Stage A: Flight activity

1.2.1 Bird density

Vantage point watch bird survey has been undertaken over two years from vantage points covering the entire site plus a buffer area of 200 m outside the proposed wind farm boundary. The site is approximately 7 km^2, and with the buffer made a total survey area of around 9 km^2. The entire survey area was covered from three vantage point viewpoints. These three areas overlapped such that around 10% of the area fell within two vantage point areas.

All areas were watched for at least 72 hours during the breeding season (mid-March – September) and for 36 hours during the non-breeding season (October – mid-March) in each of two years. The watches were divided into three-hour sessions and the sessions spread to include a representative sample of daylight hours. Flights of hen harriers were recorded for the entire duration of each watch period, yielding total flying time in bird-seconds over the duration of the watch. Flying time was divided by the period of the watch (in seconds) and the area watched to give the average density of birds in flight per square kilometre.

Survey results are presented in Table A1-1. The number of watch periods was too few to give reliable month-by-month times in flight (nine watch periods for the non-breeding season and 18 for the breeding season), therefore the data has been aggregated into only two periods: breeding and non-breeding. There is no significant difference in habitat between the three vantage point areas. The data does suggest a slightly higher level of flight activity during the breeding season in year two than in year one; this may be an aspect of natural variability. The data for both years is aggregated and a mean and standard deviation calculated for each period (breeding and non-breeding). The standard deviation is calculated based on six measurements of bird density (three vantage point watches, each for two years) and gives an indication of the variability in this survey data:

Non-breeding period mean density 0.0133 bird seconds per km^2 standard deviation 0.0018
Breeding period mean density 0.0528 bird seconds per km^2 standard deviation 0.0074

Table A1-1. Survey results – observations in bird-seconds and bird density in bird seconds per km^2						
-	-	-	**Non-breeding season (Oct - mid March) total watch time 36 hrs= 129600 secs**	**Non-breeding season (Oct - mid March) total watch time 36 hrs= 129600 secs**	**Breeding season (mid Mar - Sep) total watch time 72 hrs =259200 secs**	**Breeding season (mid Mar - Sep) total watch time 72 hrs =259200 secs**
-	-	Area (km^2)	Time in flight (bird-secs)	Density (bird-secs/km^2)	Time in flight (bird-secs)	Density (bird-secs/km^2)
Year 1	VP1	4.1	6204	0.0117	59152	0.0557
Year 1	VP2	2.3	3472	0.0116	24382	0.0409
Year 1	VP3	3.5	7298	0.0161	43210	0.0476
Year 2	VP1	4.1	7544	0.0142	63187	0.0595
Year 2	VP2	2.3	4181	0.0140	33108	0.0555
Year 2	VP3	3.5	5627	0.0124	52673	0.0581
-	Mean bird density	-	-	0.0133	-	0.0528
-	SD	-	-	0.0018	-	0.0074

These bird densities have been used in the relevant months in the spreadsheet; for the month of March a straight average of 0.0331 bird-seconds/km^2 has been used.

1.2.2 Proportion flying at risk height

The assessment considers two turbine options (see next section) whose rotors respectively span the height range 30-130 m (2MW turbine) and 33-147 m (3.2 MW turbine).

The surveys recorded the flight heights of birds, using bands of < 20 m, 20-50 m, 50-200 m, and > 200 m. Hen harriers spend a high proportion of their flight time in low foraging flights, therefore it is important to make best use of this limited data.

It was assumed that, in each of the height ranges within which flight height was classified, flight heights were distributed uniformly. Thus, the proportion of flights within each of the relevant height ranges 20-50 m and 50 m-200 m could be calculated for each of the rotor height ranges, as in Table A1-2. Taking the 3.2 MW turbine as an example, 17 m of its rotor height span falls within the 20-50 m height range, so 17/30 of the 15.6% of birds flying within that height range would be at rotor risk height. The remaining 97 m of the rotor height is within the 50-200 m height range, so 97/150 of the 8.4% would also fall within rotor risk height.

Table A1-2. Proportion flying at rotor risk height.				
Number of hen harrier flights observed	**Proportion observed 20 – 50 m height**	**Proportion observed 50m-200 m height**	**2MW turbine: proportion between 30 m and 130 m**	**3.2 MW turbine: proportion between 33 m and 147 m**
382	15.6%	8.7%	(20/30)*15.6%+(80/150)*8.7% = 15.0%	(17/30)*15.6%+(97/150)*8.7%=14.5%
Data northern	-	-	14.0%	12.3%

harrier from USA				

Alternative quantitative data is available from USA sources on the flight height distribution of northern harrier (a subspecies very similar to hen harrier) at the Altamont wind farm, California. Using the USA data, the proportion flying within rotor risk height range would be 14.0% (2 MW Turbine) or 12.3% (3.2 MW turbine). Collision risks have been worked out using both the site survey data and the US flight height distribution data.

1.2.3 Nocturnal activity factor

Levels of nocturnal activity by hen harrier are believed to be low. A score of one on the one to five scale used in the spreadsheet (nocturnal activity = 0% of daytime activity) has therefore been attributed. Nocturnal activity of hen harrier is almost certainly much less than the 25% of daytime activity which would be implied by a score of two. *(Where possible local information should be obtained on nocturnal activity. However there has as yet been no night-time survey at this site.)*

1.2.4 Wind farm latitude

The wind farm latitude is 56° 30' north (entered in decimals as 56.5°). It is used in the model by Sheet three – 'daylight and night-time hours' to determine the total daylight hours for which these bird densities may be expected to persist.

Table A1-3. Stage A data input to spreadsheet.

Table A1-3. Stage A data input to spreadsheet. (Jan - June)						
-	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**
Bird density (bird-secs/km^2)	0.0133	0.0133	0.0331	0.0528	0.0528	0.0528

Table A1-3. Stage A data input to spreadsheet. (July-Dec)						
-	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Bird density (bird-secs/km^2)	0.0528	0.0528	0.0528	0.0133	0.0133	0.0133

-	**2 MW option**	**3.2 MW option**
Hub height	80	90
Rotor radius	50	57
(output) Risk height range	30-130m	33-147m
Proportion Q_{2R} flying at risk height (using site survey data)	15%	14.5%
Proportion Q_{2R} flying at risk height (using Altamont data)	14%	12.3%
Nocturnal activity factor	1	1
Wind farm latitude	56.5°	56.5°

1.3 Stage B: Estimating number of flights through rotors

1.3.1 Wind farm data

Decisions have not yet been taken on the size or model of turbines to be used. However it is likely that these will be among the larger currently available for onshore use, in the range 2 – 3.2 MW. On the basis of the expected maximum site capacity of around 150 MW, CRM has therefore been undertaken for two options:

- 75 of 2 MW turbines and
- 46 of 3.2 MW turbines.

As collision risk is greater for the larger number of smaller turbines, the 2 MW option represents a worst-case scenario and the 3.2 MW turbines a best-case scenario for collision risk.

The potential number of flights through rotors depends on rotor size. The rotor radii are respectively 50 m for the 2 MW turbine option, and 57 m for the 3.2 MW turbine.

1.3.2 Bird data

Typical hen harrier flight speed is taken as 8m/sec. In the absence of data on flight speeds from site survey, the flight speed assumed is that used, based on by Whitfield and Madders (2006).

Table A1-4. Stage B data input to spreadsheet.

Wind farm data		
Wind farm data	**2 MW option**	**3.2 MW option**
Number of turbines	75	46
Rotor radius	50m	57m

Bird data	
Bird data	-
Hen harrier flight speed	8 m/sec

1.3.3 Output

The output from Stage B is shown in the 'Collision risk' sheet as the potential number of bird transits through rotors, per month and per annum. The spreadsheet was used to evaluate two options for each turbine size:

1. using the proportion of birds flying at risk height as derived from site survey: 15.0% (2 MW turbine) or 14.5% (3.2 MW turbine) of birds flying at risk height, with equal probability at any height between minimum and maximum rotor height.
2. using the USA data from the Altamont wind farm on northern harrier flight heights to model the expected flight height distribution: 14.0% (2MW turbine) or 12.3% (3.2 MW turbine) of birds flying at risk height.

For both options, the survey data from the proposed wind farm site is used for the overall density of birds.

-	-	**2 MW turbines**	**3.2MW turbines**
Total rotor frontal area	-	589049 m^2	-
Projected number of rotor transits per annum	using Q_{2R} from site survey data	4568 birds/annum	3087 birds/annum
Projected number of rotor transits per annum	using Q_{2R} from Altamont data	4263 birds/annum	2619 birds/annum

Note that at this stage, non-operational time for the turbines has not yet been factored in.

1.4 Stage C: Probability of collision for single rotor transit

1.4.1 Bird data

Typical dimensions for hen harrier have been taken from BTO Bird facts: wingspan 1.1 m, length 0.48 m. As in Stage B, typical flight speed is taken as 8m/sec. It should be noted that the same flight speed is used in this CRM for flights upwind and downwind.

Typical hen harrier flight is a mix of gliding and flapping: flapping flight has been used in this collision risk modelling, which will give a slightly more precautionary estimate, ie a higher collision estimate, than for gliding flight.

The orientation of the wind turbines may be expected to have a distribution across many directions, according to the wind rose for the site. It has been assumed that hen harrier flights through rotors of the wind farm are equally split as between upwind and downwind.

1.4.2 Turbine data

The number of blades, rotor radius and maximum blade width are derived directly from manufacturers' specifications.

1.4.3 Average pitch

A pitch of 15 degrees is estimated as an average when the turbine is operating at around its mean rotational speed: this is used throughout the CRM. The variation of pitch along the length of the blades is not provided by manufacturers, nor is data available for the pitch at different wind speeds.

1.4.4 Rotation speed

The mean operational rotation speed for the turbines has been estimated using the turbine manufacturer's data (Table A1-5) on operational rotor speeds and cut-in and cut-out wind speeds, in association with the wind frequency distribution determined for the site. This is preferable to basing the collision assessment on maximum rotor speed, which would lead to an over-assessment of collision risk.

Annex 3 describes how to calculate a mean rotor speed and uses as an example the 3.2 MW turbine data and wind frequency distribution for this same worked example. Figure A3-3 of that Annex shows the turbine data for both the 2 MW and 3.2 MW turbine models, and the following table shows how the mean rotation speed of 9.87 rpm (for the 3.2 MW model) is derived from that graph. A similar table (not shown) leads to a mean rotation speed of 11.64 rpm for the 2 MW model.

1.4.5 Output

The 'Collision Risk' spreadsheet calculates the risk of collision during in a single transit. The result is expressed as a percentage risk for upwind and downwind flight respectively, and the average - 8.81% for the 2 MW turbine and 8.16% for the 3.2 MW turbine - is used in calculating collision risk.

Table A1-5. Information on rotation speeds.		
Manufacturer's data	**2 MW model**	**3.2 MW model**
Rotation speed	7.8 – 13.89 rpm	6.7 - 12.1 rpm
Cut-in wind speed	3 m/sec	3 m/sec
Cut-out wind speed	22 m/sec	22 m/sec
Rated wind speed	11 m/sec	12 m/sec
Derived mean rotation speed at this site (see Annex 3)	11.64 rpm	9.87 rpm

Table A1-6. Stage C data input to spreadsheet.	
Bird data	-
Bird length	48 cm
Wingspan	110 cm
Flight speed	8 m/sec
Flight style	Flapping
Proportion of flights upwind	50%

Turbine data		
Turbine data	**2 MW model**	**3.2 MW model**
No of blades	3	3
Rotation speed	11.64 rpm	9.87 rpm
Rotor radius	50m	57m
Maximum blade chord width	3.7m	4.2m
Average pitch	15°	15°
Blade taper profile	default taper used	default taper used

1.5 Stage D: Multiplying to yield expected collisions per year

In this stage, the output from Stage B (number of potential transits through rotors) is multiplied by the output of Stage C (collision risk for a single rotor transit) to yield the projected number of bird collisions per month or year. However, allowance must first be made for the proportion of time that rotors are not operational.

1.5.1 Proportion of time operational

Monthly proportion of time operational refers to the proportion of time when a turbine is rotating. It excludes time when the wind is below cut-in wind speed, when the rotors may be stationary or idling, time when the rotors are stopped and feathered for protection in very high wind speeds, and down-time for operations and maintenance (O&M). These proportions vary over the year, reflecting different wind conditions in different seasons, and the increased opportunities for maintenance access in summer. The data in Table A1-7 has been acquired from the developer for the two turbine options and is based on the wind frequency distribution at the site and experience of O&M requirements at similar operational sites. In the absence of such data, the default figure for operational time is 0.85 (or 85%, or 15% non-operational time).

Proportion of time operational =

Proportion of time available (i.e. excluding maintenance shutdown)	x	Proportion of time wind speed is above cut-in and below cut-out

Table A1-7. Proportion of time turbine operates.

2 MW turbine												
-	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Prop of time available	0.94	0.94	0.92	0.94	0.85	0.85	0.85	0.92	0.92	0.94	0.94	0.94
Prop of time above cut-in and below cut-out	0.93	0.95	0.95	0.90	0.80	0.81	0.81	0.84	0.93	0.97	0.93	0.92
Prop of time operational	0.87	0.89	0.87	0.84	0.68	0.68	0.68	0.77	0.85	0.91	0.87	0.86
3.2 MW turbine												
-	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Prop of time available	0.95	0.95	0.94	0.95	0.90	0.91	0.90	0.94	0.94	0.95	0.95	0.95
Prop of time above cut-in and below cut-out	0.93	0.95	0.95	0.90	0.80	0.81	0.81	0.84	0.93	0.97	0.93	0.92
Prop of time operational	0.88	0.90	0.89	0.85	0.72	0.73	0.72	0.79	0.87	0.92	0.88	0.87

Table A1-8. Stage D data input to spreadsheet.												
Proportion of time operational	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
2 MW turbine	87.4	89.3	87.4	84.6	68.0	68.9	68.9	77.3	85.6	91.2	87.4	86.5
3.2 MW turbine	88.4	90.3	89.3	85.5	72.0	73.7	72.9	79.0	87.4	92.2	88.4	87.4

1.5.2 Output

The output from Stage D, shown in row 43 of the 'Collision risk' sheet, is the expected number of collisions assuming no avoidance:

No of collisions (no-avoidance)	**2 MW turbines**	**3.2 MW turbines**
using Q_{2R} from site survey	309	194
using Q_{2R} from Altamont data	289	164

The 'Large array correction factor' sheet has calculated the correction factor which should be applied to take account of any depletion of bird density because of collisions. A figure close to 100% means little correction. For either of the turbine options, the factor is greater than 99.7% for any of the avoidance rate assumptions made below, that is, the adjustment required is less than 0.3%. Such a minor adjustment is insignificant in relation to the other uncertainties in the collision risk estimate, and can be disregarded.

1.6 Stage E: Applying the avoidance rate

1.6.1 Avoidance rates

NatureScot (2018) provides guidance on the use of avoidance rates in collision risk assessments. The evidence for hen harriers indicates that an overall avoidance rate of 99% is reasonable. Collision risks have been calculated for avoidance rates of 95%, 98%, 99%, and 99.5%. The central result is taken to be that for 99% avoidance.

1.6.2 Large array correction

If the full site is developed, the area of the wind farm would be approximately 7 km^2. For the purpose of applying a large array correction, the wind farm is taken as occupying a circular site of area 7 km^2, of which the diameter gives an average 'width' dimension of 3 km. No specific assumptions are made as to the number of turbine rows; the model assumes by default that the number of turbine rows will be the square root of the number of turbines.

Table A1-9. Stage E data input to spreadsheet.	
Input variable	**Data**
Avoidance rates	95%, 98%, 99%, 99.5%
Allow for large array correction?	Yes
Width of wind farm	3km

1.6.3 Outputs

The results of the CRM are summarised in Table A1-10. The 'central results', i.e. those judged most realistic, are those in bold. The Collision Risk sheet used to calculate the 2MW option (using Q_{2R} derived from site survey) is reproduced in Annex 2.

Table A1-10. Outputs using CRM Collision risk spreadsheet.					
-	-	**Using Q_{2R} from site survey**	**Using Q_{2R} from site survey**	**Using Q_{2R} from Altamont data**	**Using Q_{2R} from Altamont data**
-	-	75 x 2MW	46 x 3.2MW	75 x 2MW	46 x 3.2MW
Stage B	Potential annual bird transits through rotors	4568	3087	4263	2619
Stage C	Risk for single rotor transit	8.8%	8.2%	8.8%	8.2%
-	Collisions allowing for non-operational time:	-	-	-	-
Stage D	assuming no avoidance	309	194	289	164
-	95% avoidance	15.5	9.7	14.4	8.2
Stage E	98% avoidance	6.2	3.9	5.8	3.3
-	99% avoidance	3.1	1.9	2.9	1.6
-	99.5% avoidance	1.6	1.0	1.4	0.8

Annex 2 - Collision risk model spreadsheet (showing data for worked example)

Annex 2 can be downloaded as PDF document by clicking on the link below.

Annex 2: Collision risk model spreadsheet (showing data for worked examples)

Annex 3 - Calculating a mean rotor speed

This annex describes how to calculate a mean rotor speed, for use when calculating the single transit collision risk. The rotor speed required is the mean over operational time, not just a mean as between minimum and maximum operational speeds. Operational time excludes periods when the turbine is not rotating, either closed for maintenance or because of low wind or high wind conditions.

To do obtain a mean over operational time one needs:

- the expected wind speed frequency distribution for the site
- the cut-in and cut-out wind speeds for the turbine
- the rotor speed range for the turbine
- the rated wind speed for the turbine, i.e. the minimum wind speed at which full power is generated

The expected distribution of wind speeds is based on wind data collected from the site over two years. Figure A3-1 below shows the smoothed frequency wind distribution for a site. To smooth out the variability in the observed data, the observed data has been fitted by a Weibull probability distribution which is controlled by a shape factor (k) (equal to or close to 2.0) and a scale factor (λ) (proportional to overall wind speeds). A Weibull distribution function is available within Excel.

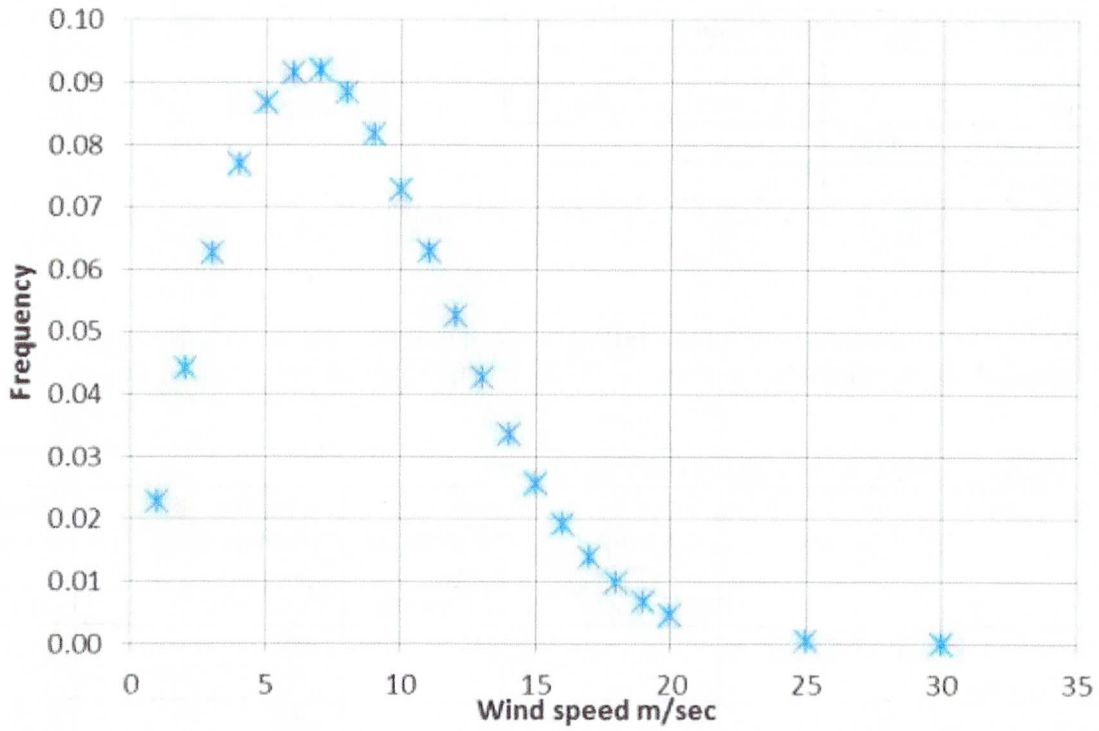


Figure A3-1. Site wind speed distribution.

Response from MLavelle: Note for a wind speed of 9m/s as at Tirawley, the frequency is 0.08

Click for a full description

Figure A3.1 is a unimodal graph presenting the expected wind speed distribution for a site. It sets wind speed in metres per second - the x-function - against frequency of occurrence - the y-function. The graph demonstrates a probable proportional increase in frequency of wind speed up to approximately 7 metres per second with an exponential decrease to 25 metres per second.

Wind turbines usually operate with a range of operating rotor speeds between cut-in at the lowest wind speed enabling operation and maximum operating speed which is achieved when wind speed first enables full power to be generated. At increasing wind speeds above this operating wind speed, rotor speed is maintained at this maximum until at a high wind speed the turbine is shut down for protection, usually around 22-25m/sec. Between minimum and maximum rotor speeds, for simplicity it is assumed that rotor speed increases linearly with wind speed. Figure A3-2 indicates schematically how rotor speed varies with wind speed.

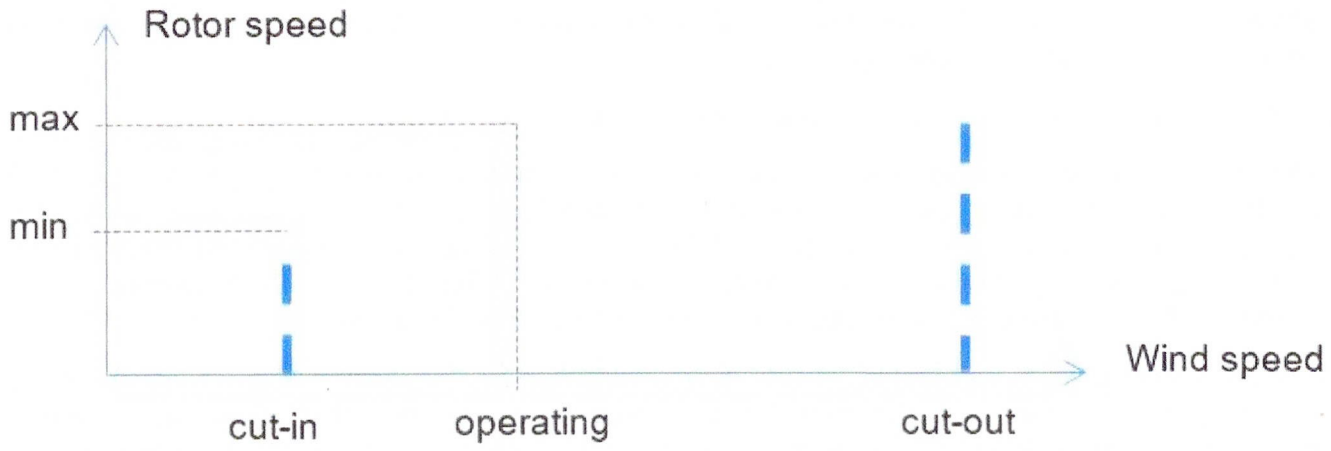


Figure A3-2. Rotor speed as a function of wind speed.

Click for a full description

Figure A3.2 is a schematic representation of rotor speed as a function of wind speeds. The horizontal function sets out three distinct stages of operation with increasing wind speed from left to right: cut-in, operating then cut-out. The vertical function represents the rotor speed in relation to these, with minimum operation coinciding with cut-in speeds and the maximum rotor speed coinciding with the operating stage. There is no coincidence between rotor speed and the cut-out wind speed.

The information available from the turbine manufacturer will usually specify an operational rotor speed range, a cut-in wind speed below which the rotor does not operate, a cut-out wind speed above which the turbine is shut down for protection and a rated wind speed which is the minimum wind speed at which the turbine will generate full power.

These two sets of data – wind speed frequency and rotor speed as a function of wind speed - must be brought together to calculate a mean rotor speed. Fig A3.3 shows both the site wind speed distribution, and the rotor speed (axis at right) as a function of wind speed for each of the two turbine options described in the worked example (Annex 1). For example, the manufacturer's data for the 3.2 MW turbine indicates operating speeds in the range 6.7–12.1 rpm, with a cut-in wind speed of 3 m s^{-1}, a cut-out wind speed of 22 m s^{-1} and rated wind speed (minimum wind speed generating full power) of 12 m s^{-1}.

If a turbine has rotor speed $\Omega(w)$ at wind speed (w), and wind speed (w) occurs with frequency f(w), then the mean rotor speed is:

$$\frac{\text{Sum of (frequency x rotor speed)}}{\text{Sum of (frequency)}}$$

where the sums are over all wind speeds between cut-in and cut-out.

i.e. $$\sum_{\text{cut-in}}^{\text{cut-out}} f(w)\,\Omega(w) \Big/ \sum_{\text{cut-in}}^{\text{cut-out}} f(w)$$

Equation A3-1

Click for a full description

Equation 3.1 calculates the mean rotor speed by dividing the sum of the frequency of the wind speed times the rotor speed by the frequency of the wind speed. This is explained in text and in mathematical format, i.e. between cut-in and cut-out speeds, sigma f(w) ohm(w) over sigma f(w).

The denominator is the proportion of time for which the wind speed is in operational range.

For the purpose of collision risk analysis it is sufficient to do this calculation by scaling off a graph like Figure A3-3, taking values for each frequency range of width one m/sec, e.g. from 7.5 m/sec to 8.5 m/sec. The accuracy of a graphical method is quite adequate within the context of the various other uncertainties in the calculation. (If desired, a more refined calculation may be done using a spreadsheet, an interpolation formula to evaluate the rotor speed at any given wind speed. A spreadsheet also facilitates comparison of a range of turbine options.)

Table 3.1 shows the results of scaling off Figure A3-3 for the 3.2 MW turbine. The second column reads wind speed frequency f(w) off the wind speed distribution, and the third column reads rotor speed Ω(w) off the rotor speed line. The final column calculates the mean rotor speed over operational time, taking the average of rotor speed weighted by frequency, as in equation (A3-1). It yields a mean rotor speed of 9.87 rpm for the 3.2 MW turbine used as an example.

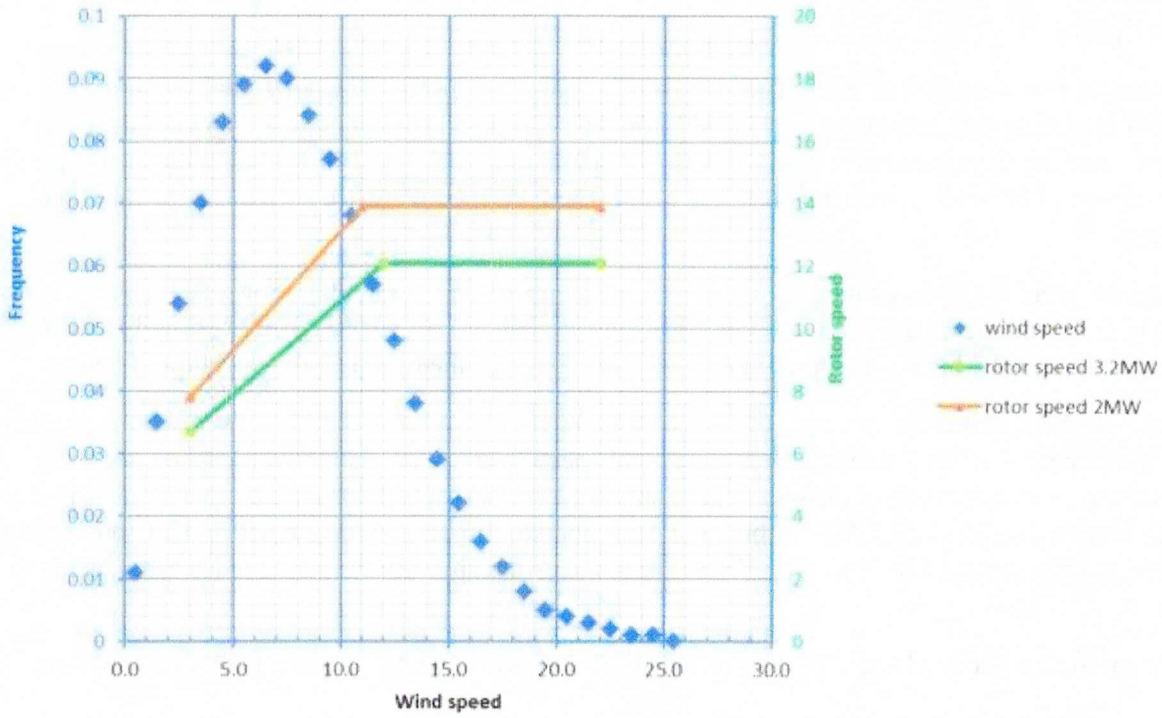


Figure A3-3. Bringing together wind frequency distribution and rotor speed data to calculate a mean rotor speed.

Click for a full description

This figure is a graphical overlay of information previously presented in Figure A3.1 (site wind speed distribution) and rotor speeds using an additional axis on the right, for two example turbines, i.e. 3.2MW and 2MW. The 3.2MW turbine is presented as a red line and the 2MW as a green line. The graph demonstrates proportionately lower rotor speeds for the 2MW turbine but both following a pattern of increasing to a point after which they plateau. Rotor speed lines above this wind speed remain horizontal.

Table A3-1. Calculation of mean rotor speed for 3.2MW turbine.

The wind speed frequency and rotor speed are read off from Figure A3-3.
Proportion of time wind speed is in operational range 3-22m/sec = 89.5
Mean rotor speed = 8.835 / 0.895 = 9.87 rpm

Table A3-1. Calculation of mean rotor speed for 3.2MW turbine.			
Wind speed w	**Wind speed frequency f(w)**	**Rotor speed Ω (w)**	**Product Ω (w) f(w)**

0-1	0.011	-	-
1-2	0.035	Below cut-in	-
2-3	0.054	-	-
3 – 4	0.070	7.0	0.490
4 – 5	0.083	7.6	0.631
5 – 6	0.089	8.2	0.730
6 – 7	0.092	8.8	0.810
7 – 8	0.090	9.4	0.846
8-9	0.084	10.0	0.840
9 – 10	0.077	10.6	0.816
10 – 11	0.068	11.2	0.762
11-12	0.057	11.8	0.673
12-13	0.048	12.1	0.581
13-14	0.038	12.1	0.460
14-15	0.029	12.1	0.351
15-16	0.022	12.1	0.266
16-17	0.016	12.1	0.194
17-18	0.012	12.1	0.145
18-19	0.008	12.1	0.097
19-20	0.005	12.1	0.061
20-21	0.004	12.1	0.048
21-22	0.003	12.1	0.036
>22	0.000	Above cut-out	-
Sum Σ f(w)	0.895	Sum $\Sigma \Omega$ (w) f(w)	8.835
Mean operational rotor speed $\Sigma \Omega$ (w) f(w) / Σ f(w)	-	-	**9.87 rpm**

Last updated: 16/04/2025

Scotland Nature - Wind farm impacts on birds - Flight Speeds and Biometrics for Collision Risk Modelling Published: 2014

Background

Collision risk models require the use of single value biometric data and estimated flight speeds for bird species at risk of colliding with turbines (or power lines). Given the potential for greatly differing values being used in these calculations, SNH has prepared this note to identify published sources for such values.

Collision risk models assume that bird shape can be simplified as a simple cross which can be measured as bird length (beak to tail) and wingspan (to the tip of the outermost primary feather).

Click for a full description

This is shown in this figure, showing a bird of prey in plan view with the measurements for bird length and wingspan identified. The data to be used are by necessity mean values for 'typical' individuals. Intraspecific variation (such as differences due to sex or race) cannot be incorporated without over-complicating such models. Biometric data sources are given in the reference section, primarily from published resources such as *Birds of the Western Palearctic*, (Snow & Perrins, 1998) or in the online resource, BTO BirdFacts.

Flight speed data

The use of a single value for flight speed poses a number of challenges. Clearly bird flight speeds will vary, sometimes considerably, and that variability will be intrinsic (bird size and shape, body condition and behaviour) and extrinsic (altitude, wind velocity, wind direction and light conditions).

Data are not always available for every species of interest. Even where they are, they may be based on measurements taken under very different conditions to those typically found at proposed renewable energy sites or transmission line routes. Birds adjust flight speeds according to the activity being undertaken. For example, foraging activity may lead to slower flight speeds in some species dependent on ambushing prey, whereas for pursuit predators, flight speed may show a rapid increase. Theoretical development of optimal flight speeds have focused on foraging, migration, and display flights (Hedenström & Alerstam, 1995).

In selecting flight speed data for use in collision risk models, we have only referred to published data sources. In addition, a key report we commissioned has also been used (Provan & Whitfield 2006). Flight speed data from this publication have been calculated directly from observations at proposed wind farm sites. The range of species for which data were available, however, was limited and with the expansion of the renewables industry, especially into marine waters, this has necessitated addition of other species. Two key sources of data are regularly used: Bruderer & Bolt (2001) and Alerstam *et al.* (2007). The latter publication incorporates some data from Bruderer & Bolt (*op. cit.*), but also provides new data for some species covered by Bruderer & Bolt (*op. cit.*). It is also important to note that collision risk will vary according to whether a bird is considered to use predominantly flapping or gliding flight as this can make a significant difference to collision risk calculations. The SNH Collision Risk Model (Band *et al.*, 2007) calculates collision risk probabilities taking this into account. An example for a particular species for a specific turbine design is given in Figure 1. Where a bird uses both types of flight, collision risk modelling can use an estimate of collision probability calculated as a weighted average of the two flight behaviours.

Where data for any particular species are not available, we recommend the use of surrogate species. Alerstam *et al.* (2007) have shown that species that are similar both taxonomically and morphologically, have similar flight speeds, largely due to similar wing loadings. For example, a flight speed for golden plover (*Pluvialis apricaria*) is not given but the similar sized and closely related species grey plover (*Pluvialis squatarola)* may be suitable. Data for corncrake (*Crex crex*) cannot not be found in the literature, but the closely related spotted crake (*Porzana porzana*) gives a figure of 13.9 ms^{-1} which is very close to an estimate for corncrake suggested by Rhys Green of 13.8 ms^{-1} (*Rhys Green pers. comm.*).

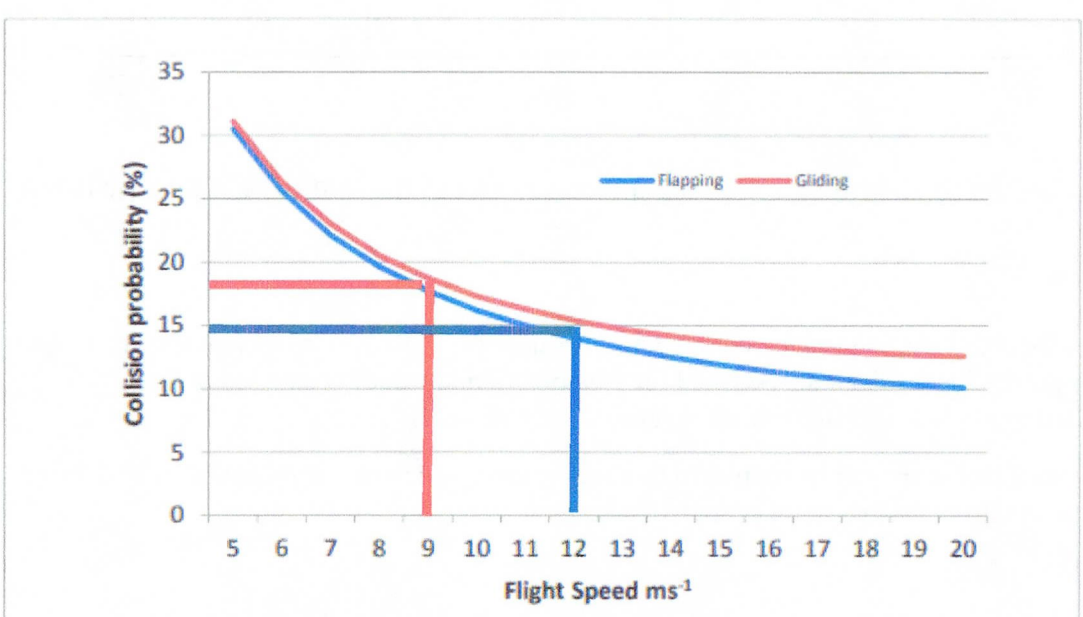


Figure 1. As flight speed increases, collision probability declines exponentially.

Click for a full description

The absolute value of collision probability is not important (it is for a 'theoretical bird') shown in flapping and gliding flight separately. Collision probability is particularly sensitive to changes in flight speed when values are low; at higher flight speeds changes in collision risk are less marked. Values for gliding and flapping flight diverge as flight speed increases: this is simply a consequence of the model and may not have any underlying physical or biological basis given the many approximations inherent in the model.

The estimated mean flight speed is recommended as the single datum for collision risk modelling. However, variation in flight speeds can be used to estimate possible lower and upper values (many are quoted in Alerstam *et al.*, 2007). In the tables, for some species only, a range is identified and data on standard deviation are not available. Where standard deviations are provided, a very rough approximation of the likely range can be calculated as plus or minus twice the standard deviation, which assumes that flight speeds are distributed normally. While this is unlikely, the approximation is suitable for estimating upper and lower bounds for collision probabilities. A slower (or faster) flight speed may be used where there is good empirical evidence from vantage point watches that a particular type of flight behaviour (e.g. foraging flight) predominates over other flight behaviours.

Environmental statements should routinely reference the source of biometric and flight speed data used in collision risk modelling calculations.

References

Alerstam T., Rosén M., Bäckman J., Ericson P.G.P., Hellgren O. 2007. Flight speeds among bird species: allometric and phylogenetic effects. PLoS Biol, 5, 1656-1662. DOI:10.1371/journal.pbio.0050197

Band, W., Madders, M., & Whitfield, D.P. 2007. Developing field and analytical methods to assess avian collision risk at wind farms. In: de Lucas, M., Janss, G.F.E. & Ferrer, M. (eds.) *Birds and Wind Farms: Risk Assessment and Mitigation*, pp. 259- 275. Quercus, Madrid.

BTO Bird Facts [web based information - http://www.bto.org/about-birds/birdfacts - downloaded 13/01/2014]

Bruderer, B. & Bolt, A. 2001. Flight characteristics of birds: I. Radar measurements of speeds. *Ibis*, 143, 178-204.

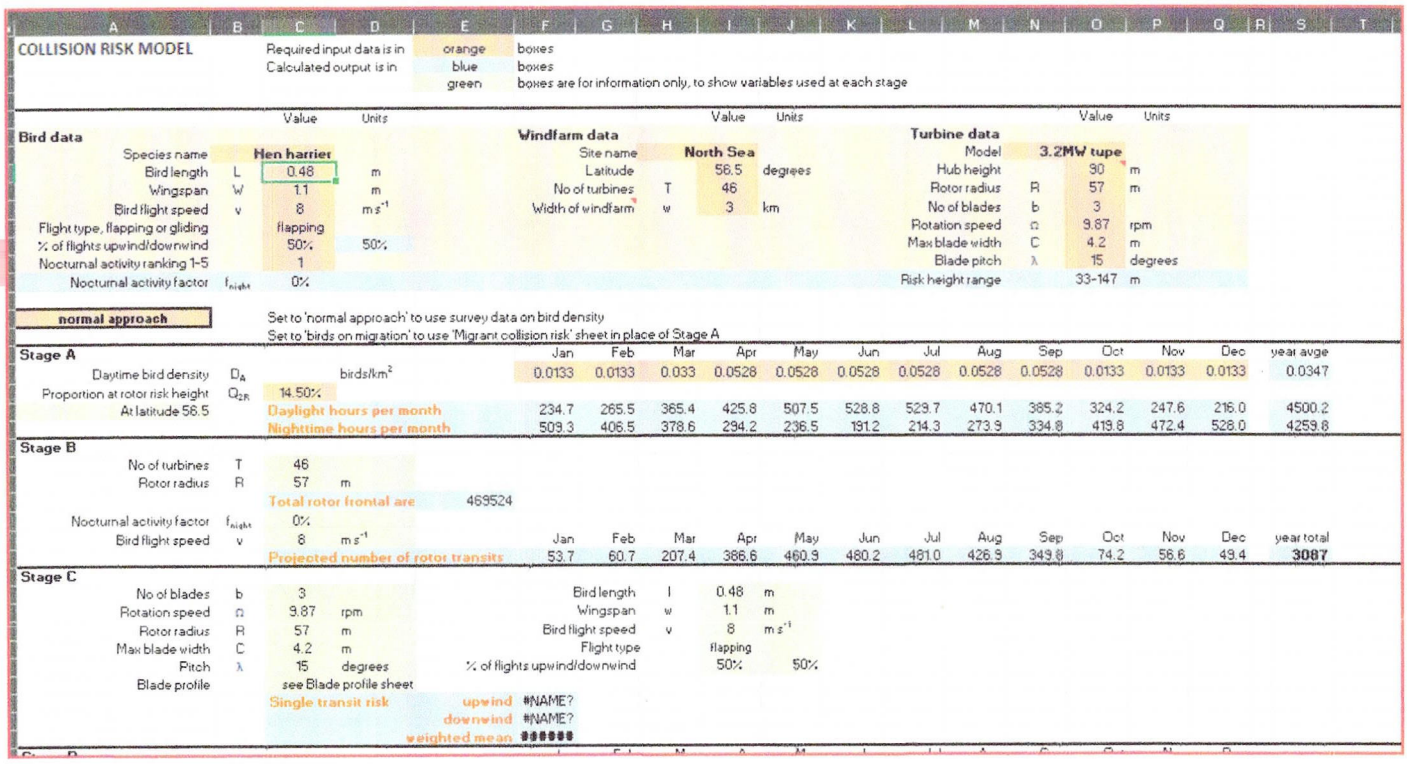
Hedenström, A. & Alerstam, T. 1995. Optimal flight speeds of birds. *Phil. Trans. R. Soc. London B*, 348, 471-487.

Provan, S. & Whitfield, D.P. 2006. *Avian Flight Speeds and Biometrics for Use in Collision Risk Modelling*. Unpublished Report to Scottish Natural Heritage.

Snow, D. & Perrins, C. M. 1998. *The Birds of the Western Palearctic*. Concise Edition. Oxford University Press, Oxford.

Date 28th October 2014

The following is the example from Nature Scotland [The 3rd Table was a 12month Table, but too long to include here]



COLLISION RISK MODEL

Required input data is in orange boxes
Calculated output is in blue boxes
green boxes are for information only, to show variables used at each stage

Bird data		Value	Units
Species name		Hen harrier	
Bird length	L	0.48	m
Wingspan	W	1.1	m
Bird flight speed	v	8	m s-1
Flight type, flapping or gliding		flapping	
% of flights upwind/downwind		50%	50%
Nocturnal activity ranking 1-5		1	
Nocturnal activity factor	f_{night}	0%	

Windfarm data		Value	Units
Site name		North Sea	
Latitude		56.5	degrees
No of turbines	T	46	
Width of windfarm	w	3	km

Turbine data		Value	Units
Model		3.2MW tupe	
Hub height		90	m
Rotor radius	R	57	m
No of blades	b	3	
Rotation speed	Ω	9.87	rpm
Max blade width	C	4.2	m
Blade pitch	λ	15	degrees
Risk height range		33-147	m

normal approach

Set to 'normal approach' to use survey data on bird density
Set to 'birds on migration' to use 'Migrant collision risk' sheet in place of Stage A

Stage A

			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year avge
Daytime bird density	D_A	birds/km2	0.0133	0.0133	0.033	0.0528	0.0528	0.0528	0.0528	0.0528	0.0528	0.0133	0.0133	0.0133	0.0347
Proportion at rotor risk height	Q_{2R}	14.50%													
At latitude 56.5		Daylight hours per month	234.7	265.5	365.4	425.8	507.5	528.8	529.7	470.1	385.2	324.2	247.6	216.0	4500.2
		Nighttime hours per month	509.3	406.5	378.6	294.2	236.5	191.2	214.3	273.9	334.8	419.8	472.4	528.0	4259.8

Stage B

			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year total
No of turbines	T	46													
Rotor radius	R	57 m													
		Total rotor frontal are 469524													
Nocturnal activity factor	f_{night}	0%													
Bird flight speed	v	8 m s-1													
		Projected number of rotor transits	53.7	60.7	207.4	386.6	460.9	480.2	481.0	426.9	349.8	74.2	56.6	49.4	3087

Stage C

No of blades	b	3				
Rotation speed	Ω	9.87	rpm			
Rotor radius	R	57	m			
Max blade width	C	4.2	m			
Pitch	λ	15	degrees			
Blade profile		see Blade profile sheet				
Single transit risk		upwind	#NAME?			
		downwind	#NAME?			
		weighted mean	######			

Bird length	l	0.48	m	
Wingspan	w	1.1	m	
Bird flight speed	v	8	m s-1	
Flight type		flapping		
% of flights upwind/downwind		50%	50%	

BLADE PROFILE

This table lists the chord widths of the blade, relative to the maximum chord width, at intervals of 1/20 of its length.

The table accompanying the guidance shows the blade profile for a large modern turbine ~ 3MW

The figures in the c/C column may be revised to reflect the blade shape of the turbine used

The data must occupy cells d4:d24

r/R	c/C
0	0.690
0.050	0.730
0.100	0.790
0.150	0.880
0.200	0.960
0.250	1.000
0.300	0.980
0.350	0.920
0.400	0.850
0.450	0.800
0.500	0.750
0.550	0.700
0.600	0.640
0.650	0.580
0.700	0.520
0.750	0.470
0.800	0.410
0.850	0.370
0.900	0.300
0.950	0.240
1.000	0.000

SINGLE TRANSIT RISK AS A FUNCTION OF r/R

p(r) up	p(r) down
#NAME?	#NAME?
#NAME?	#NAME?
#NAME?	#NAME?
#NAME?	#NAME?
#NAME?	#NAME?
#NAME?	#NAME?
#NAME?	#NAME?
#NAME?	#NAME?
#NAME?	#NAME?
#NAME?	#NAME?
#NAME?	#NAME?
#NAME?	#NAME?
#NAME?	#NAME?
#NAME?	#NAME?
#NAME?	#NAME?
#NAME?	#NAME?
#NAME?	#NAME?
#NAME?	#NAME?
#NAME?	#NAME?
#NAME?	#NAME?
#NAME?	#NAME?
#NAME?	**#NAME?** Average collision risks for flight through disk
50%	50% Proportions upwind/downwind flight

COLLISION RISK ASSESSMENT

Daylight and night hours

Latitude = 56.50 **central latitude of the proposal, copied from the input data shoet: do not enter here**

Taken from Forsythe *et al.* (1995) A model comparison for daylength as a function of latitude and day of year. Ecological Modelling. 80: 87 - 95

	P	Daylength	
1	-0.402701	6.9402739	01-Jan
2	-0.401298	6.9643198	02-Jan
3	-0.399762	6.9905519	03-Jan
4	-0.398094	7.0189318	04-Jan
5	-0.396293	7.0494188	05-Jan
6	-0.394362	7.0819698	06-Jan
7	-0.392301	7.1165397	07-Jan
8	-0.390111	7.1530817	08-Jan
9	-0.387794	7.1915473	09-Jan
10	-0.385349	7.2318865	10-Jan
11	-0.382779	7.2740483	11-Jan
12	-0.380085	7.3179807	12-Jan
13	-0.377268	7.363631	13-Jan
14	-0.374329	7.4109458	14-Jan
15	-0.37127	7.4598716	15-Jan
16	-0.368092	7.5103545	16-Jan
17	-0.364797	7.5623406	17-Jan
18	-0.361386	7.6157764	18-Jan
19	-0.357861	7.6706085	19-Jan
20	-0.354223	7.7267839	20-Jan
21	-0.350474	7.7842505	21-Jan
22	-0.346616	7.8429565	22-Jan
23	-0.342651	7.902851	23-Jan
24	-0.338579	7.9638843	24-Jan
25	-0.334404	8.0260072	25-Jan
26	-0.330126	8.0891718	26-Jan
27	-0.325748	8.1533314	27-Jan
28	-0.321271	8.2184402	28-Jan
29	-0.316697	8.2844539	29-Jan
30	-0.312029	8.3513291	30-Jan
31	-0.307268	8.4190239	31-Jan
32	-0.302416	8.4874978	01-Feb
33	-0.297475	8.5567114	02-Feb
34	-0.292446	8.6266265	03-Feb
35	-0.287333	8.6972067	04-Feb

Monthly available daylight hours

Jan	Feb	March	April	May	June	July	August	Sept	Oct	Nov	Dec
234.7	265.5	365.4	425.8	507.5	528.8	529.7	470.1	385.2	324.2	247.6	216.0

Monthly available nocturnal hours

Jan	Feb	March	April	May	June	July	August	Sept	Oct	Nov	Dec
509.3	406.5	378.6	294.2	236.5	191.2	214.3	273.9	334.8	419.8	472.4	528.0

Monthly available total hours

Jan	Feb	March	April	May	June	July	August	Sept	Oct	Nov	Dec
744.0	672.0	744.0	720.0	744.0	720.0	744.0	744.0	720.0	744.0	720.0	744.0

these data are copied automatically to the 'collision risk' sheet

Collision Risk Model Calculations : For target species at the proposed Tirawley Wind Farm.

1 General Description

The Vestas V117-4.0/4.2 MW wind turbine is a pitch regulated upwind turbine with active yaw and a three-blade rotor. The Vestas V117-4.0/4.2 MW turbine has a rotor diameter of 117 m and a rated power of 4.0 MW.

Response from MLavelle: "Rated Power" is not POWER OUTPUT.

Wind Climate	IEC IB	IEC IB S	IEC IIA
Power Rating	**4.0MW**	**4.2MW**	**4.0/4.2MW**
Extr Wind Speed (10 min average), V_{50}	50.0 m/s	50.0 m/s	42.5 m/s
Survival Wind Speed (3 s gust), V_{e50}	70.0 m/s	70.0 m/s	59.5 m/s
Turbulence Intensity, I_{V50}	11%	11%	11%

Table 3-1: Extreme design parameters – IEC

Conditions for Power Curve and C_t Values (at Hub Height)	
Wind Shear, α	0.00-0.30 (10 minute average)
Turbulence Intensity, I	6-12% (10 minute average)
Blades	Clean
Rain	No
Ice/Snow on Blades	No
Leading Edge	No damage
Terrain	IEC 61400-12-1
Inflow Angle (Vertical)	0 ±2°
Grid Voltage	Nominal Voltage ±2.5%
Grid Frequency	Nominal Frequency ±0.5 Hz
Grid Active Power (at LV-side of turbine transformer)	As per tabulated values in Section 6 and later sections
Grid Reactive Power (at LV-side of turbine transformer)	Power Factor 1.0

Table 3-5: Conditions for power curve and Ct values

Vestas Wind Systems A/S · Hedeager 42 · 8200 Arhus N · Denmark · www.vestas.com

Vestas

Table 1.1: Wind turbine specification and parameters for the proposed wind farm development.

Wind Farm Components/Turbine Parameters	
Technical Information and Wind Farm Component	**Data used/Scenario Modelled**
Turbine model	Vestas V117
Number of turbines	16
Number of blades per turbine rotor	3
Rotor blade maximum chord (m) (i.e., depth of blade)	4
Rotor Radius (m)	58.5
Rotor Diameter (m)	117
Circumference of blade tip (m) (Pi x Rotor Diameter)	367.6
Swept area (m^2) (Pi x Rotor $Radius^2$)	10751
Turbine blade tip height (m)	135
Hub height (m)	76.5
Swept height (m)	18 - 135
Maximum height to blade tip (m)	135
Minimum height to blade tip (m)	18
Speed (Dynamic Operation Range) (m/s)	6.7 - 17.5
Turbine operation time*	85%
Average blade pitch (degrees)**	15°
Mean rotational speed (rpm)***	12.1
Average Rotational period (s) (60/12.1)	4.959

Table 6.16: Collision risk model outputs for Kestrel.

COLLISION RISK MODEL

Required input data is in orange boxes
Calculated output is in blue boxes
green boxes are for information only, to show variables used at each stage

Bird data		Value	Units
Species name		Kestrel	
Bird length	L	0.34	m
Wingspan	W	0.76	m
Bird flight speed	v	10.1	m s^{-1}
Flight type, flapping or gliding		flapping	
% of flights upwind/downwind		50%	50%
Nocturnal activity ranking 1-5		1	
Nocturnal activity factor	f_{night}	0%	

Windfarm data		Value	Units
Site name		Tirawley	
Latitude		54.25	degrees
No of turbines	T	16	
Width of windfarm	w	5.5	km

Turbine data		Value	Units
Model		4.3 MW type	
Hub height		76.5	m
Rotor radius	R	58.5	m
No of blades	b	3	
Rotation speed	Ω	12.1	rpm
Max blade width	C	4	m
Blade pitch	λ	15	degrees
Risk height range		18-135	m

normal approach

Set to 'normal approach' to use survey data on bird density
Set to 'birds on migration' to use 'Migrant collision risk' sheet in place of Stage A

Stage A

			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year avge
Daytime bird density	D_A	birds/km^2	0.0005	0.0005	0.0005	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0005	0.0005	0.0005	0.0005
Proportion at rotor risk height	Q_{ch}	84.00%													
At latitude 54.3		Daylight hours per month	247.2	271.5	366.1	420.5	495.6	512.7	515.2	461.9	383.3	328.3	257.6	230.6	4490.3
		Nighttime hours per month	496.8	400.5	377.9	299.5	248.4	207.3	228.8	282.1	336.7	415.7	462.4	513.4	4269.7

Stage B

				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year total
No of turbines	T	16														
Rotor radius	R	58.5	m													
		Total rotor frontal area m^2	172021													
Nocturnal activity factor	f_{night}	0%														
Bird flight speed	v	10.1	m s^{-1}													
		Projected number of rotor transits		5.6	6.1	8.2	7.6	8.9	9.2	9.3	8.3	6.9	7.4	5.8	5.2	88

Stage C

No of blades	b	3		Bird length	l	0.34	m
Rotation speed	Ω	12.1	rpm	Wingspan	w	0.76	m
Rotor radius	R	58.5	m	Bird flight speed	v	10.1	m s^{-1}
Max blade width	C	4	m	Flight type		flapping	
Pitch	λ	15	degrees	% of flights upwind/downwind		50%	50%
Blade profile		see Blade profile sheet					
		Single transit risk	upwind	9.60%			
			downwind	3.98%			
			weighted mean	6.79%			

Stage D

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year avge
Proportion of time operational	Q_{tt}	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%
		Collision rates before avoidance												year total
		0.32	0.35	0.47	0.44	0.51	0.53	0.53	0.48	0.40	0.43	0.33	0.30	5

Stage E

Allow for large array correction? No
Width of windfarm w 5.5 km

		large array correction	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	per year
			Collision rates allowing for avoidance												
Avoidance rates modelled	95.00%	100.00%	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.01	0.3
	98.00%	100.00%	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.1
	99.00%	100.00%	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.1
	99.50%	100.00%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0

Table 6.17: Collision risk model outputs for Buzzard.

COLLISION RISK MODEL

Required input data is in orange boxes
Calculated output is in blue boxes
green boxes are for information only, to show variables used at each stage

Bird data		Value	Units
Species name		Buzzard	
Bird length	L	0.54	m
Wingspan	W	1.2	m
Bird flight speed	v	13.3	m s^{-1}
Flight type, flapping or gliding		flapping	
% of flights upwind/downwind		50%	50%
Nocturnal activity ranking 1-5		1	
Nocturnal activity factor	f_{night}	0%	

Windfarm data		Value	Units
Site name		Tirawley	
Latitude		54.25	degrees
No of turbines	T	16	
Width of windfarm	w	5.5	km

Turbine data		Value	Units
Model		4.3 MW type	
Hub height		76.5	m
Rotor radius	R	58.5	m
No of blades	b	3	
Rotation speed	Ω	12.1	rpm
Max blade width	C	4	m
Blade pitch	λ	15	degrees
Risk height range		18-135	m

normal approach

Set to 'normal approach' to use survey data on bird density
Set to 'birds on migration' to use 'Migrant collision risk' sheet in place of Stage A

Stage A

			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year avge
Daytime bird density	D_A	birds/km^2	0.0006	0.0006	0.0006	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0006	0.0006	0.0006	0.0007
Proportion at rotor risk height	Q_{ch}	95.70%													
At latitude 54.3		Daylight hours per month	247.2	271.5	366.1	420.5	495.6	512.7	515.2	461.9	383.3	328.3	257.6	230.6	4490.3
		Nighttime hours per month	496.8	400.5	377.9	299.5	248.4	207.3	228.8	282.1	336.7	415.7	462.4	513.4	4269.7

Stage B

				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year total
No of turbines	T	16														
Rotor radius	R	58.5	m													
		Total rotor frontal area m^2	172021													
Nocturnal activity factor	f_{night}	0%														
Bird flight speed	v	13.3	m s^{-1}													
		Projected number of rotor transits		10.0	11.0	14.8	22.7	26.7	27.6	27.8	24.9	20.7	13.3	10.4	9.3	219

Stage C

No of blades	b	3		Bird length	l	0.54	m
Rotation speed	Ω	12.1	rpm	Wingspan	w	1.2	m
Rotor radius	R	58.5	m	Bird flight speed	v	13.3	m s^{-1}
Max blade width	C	4	m	Flight type		flapping	
Pitch	λ	15	degrees	% of flights upwind/downwind		50%	50%
Blade profile		see Blade profile sheet					
		Single transit risk	upwind	9.40%			
			downwind	4.62%			
			weighted mean	7.01%			

Stage D

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year avge
Proportion of time operational	Q_{tt}	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%
		Collision rates before avoidance												year total
		0.60	0.65	0.88	1.35	1.59	1.65	1.65	1.48	1.23	0.79	0.62	0.56	13

Stage E

Allow for large array correction? No
Width of windfarm w 5.5 km

		large array correction	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	per year
			Collision rates allowing for avoidance												
Avoidance rates modelled	95.00%	100.00%	0.03	0.03	0.04	0.07	0.08	0.08	0.08	0.07	0.06	0.04	0.03	0.03	0.7
	98.00%	100.00%	0.01	0.01	0.02	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.01	0.01	0.3
	99.00%	100.00%	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.1
	99.50%	100.00%	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.1

6.18: Collision risk model outputs for Lesser Black-backed Gull.

COLLISION RISK MODEL

Required input data is in orange boxes
Calculated output is in blue boxes
green boxes are for information only, to show variables used at each stage

Bird data		Value	Units
Species name		esser Black-backed Gull	
Bird length	l	0.58	m
Wingspan	w	1.43	m
Bird flight speed	v	11.9	m s^{-1}
Flight type, flapping or gliding		flapping	
% of flights upwind/downwind		50%	50%
Nocturnal activity ranking 1-5		1	
Nocturnal activity factor	f_{night}	0%	

Windfarm data		Value	Units
Site name		Tirawley	
Latitude		54.25	degrees
No of turbines	T	16	
Width of windfarm	w	5.5	km

Turbine data		Value	Units
Model		4.3 MW type	
Hub height		76.5	m
Rotor radius	R	58.5	m
No of blades	b	3	
Rotation speed	Ω	12.1	rpm
Max blade width	C	4	m
Blade pitch	λ	15	degrees
Risk height range		18-135	m

normal approach

Set to 'normal approach' to use survey data on bird density
Set to 'birds on migration' to use 'Migrant collision risk' sheet in place of Stage A

Stage A

			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year avge
Daytime bird density	D_A	birds/km^2	0	0	0	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0	0	0	0.0006
Proportion at rotor risk height	Q_{2D}	94.00%													
At latitude 54.3		Daylight hours per month	247.2	271.5	366.1	420.5	495.6	512.7	515.2	461.9	383.3	328.3	257.6	230.6	4490.3
		Night time hours per month	496.8	400.5	377.9	299.5	248.4	207.3	228.8	282.1	336.7	415.7	462.4	513.4	4269.7

Stage B

					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year total
No of turbines	T	16															
Rotor radius	R	58.5	m														
		Total rotor frontal area m^2	172021														
Nocturnal activity factor	f_{night}	0%															
Bird flight speed	v	11.9	m s^{-1}														
		Projected number of rotor transits			0.0	0.0	0.0	27.4	32.3	33.4	33.6	30.1	25.0	0.0	0.0	0.0	182

Stage C

No of blades	b	3		Bird length	l	0.58	m
Rotation speed	Ω	12.1	rpm	Wingspan	w	1.43	m
Rotor radius	R	58.5	m	Bird flight speed	v	11.9	m s^{-1}
Max blade width	C	4	m	Flight type		flapping	
Pitch	λ	15	degrees	% of flights upwind/downwind		50%	50%
Blade profile		see Blade profile sheet					
		Single transit risk	upwind	10.25%			
			downwind	5.11%			
			weighted mean	7.68%			

Stage D

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year avge
Proportion of time operational	Q_{tt}	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%
		Collision rates before avoidance												year total
		0.00	0.00	0.00	1.79	2.11	2.18	2.19	1.96	1.63	0.00	0.00	0.00	12

Stage E

Allow for large array correction? No
Width of windfarm w 5.5 km

			large array correction	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	per year
				Collision rates allowing for avoidance												
Avoidance rates modelled		95.00%	100.00%	0.00	0.00	0.00	0.09	0.11	0.11	0.11	0.10	0.08	0.00	0.00	0.00	0.6
		98.00%	100.00%	0.00	0.00	0.00	0.04	0.04	0.04	0.04	0.04	0.03	0.00	0.00	0.00	0.2
		99.00%	100.00%	0.00	0.00	0.00	0.02	0.02	0.02	0.02	0.02	0.02	0.00	0.00	0.00	0.1
		99.50%	100.00%	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.1

Table 6.19: Collision risk model outputs for Sparrowhawk

COLLISION RISK MODEL

Required input data is in orange boxes
Calculated output is in blue boxes
green boxes are for information only, to show variables used at each stage

Bird data		Value	Units
Species name		Sparrowhawk	
Bird length	l	0.33	m
Wingspan	W	0.67	m
Bird flight speed	v	10	m s^{-1}
Flight type, flapping or gliding		flapping	
% of flights upwind/downwind		50%	50%
Nocturnal activity ranking 1-5		1	
Nocturnal activity factor	f_{night}	0%	

Windfarm data		Value	Units
Site name		Tirawley	
Latitude		54.25	degrees
No of turbines	T	16	
Width of windfarm	w	5.5	km

Turbine data		Value	Units
Model		4.3 MW type	
Hub height		76.5	m
Rotor radius	R	58.5	m
No of blades	b	3	
Rotation speed	Ω	12.1	rpm
Max blade width	C	4	m
Blade pitch	λ	15	degrees
Risk height range		18-135	m

normal approach

Set to 'normal approach' to use survey data on bird density
Set to 'birds on migration' to use 'Migrant collision risk' sheet in place of Stage A

Stage A

			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year avge
Daytime bird density	D_A	birds/km^2	0.0001	0.0001	0.0001	0	0	0	0	0	0	0.0001	0.0001	0.0001	0.0001
Proportion at rotor risk height	Q_{2D}	60.70%													
At latitude 54.3		Daylight hours per month	247.2	271.5	366.1	420.5	495.6	512.7	515.2	461.9	383.3	328.3	257.6	230.6	4490.3
		Night time hours per month	496.8	400.5	377.9	299.5	248.4	207.3	228.8	282.1	336.7	415.7	462.4	513.4	4269.7

Stage B

					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year total
No of turbines	T	16															
Rotor radius	R	58.5	m														
		Total rotor frontal area m^2	172021														
Nocturnal activity factor	f_{night}	0%															
Bird flight speed	v	10	m s^{-1}														
		Projected number of rotor transits			0.8	0.9	1.2	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.8	0.7	5

Stage C

No of blades	b	3		Bird length	l	0.33	m
Rotation speed	Ω	12.1	rpm	Wingspan	w	0.67	m
Rotor radius	R	58.5	m	Bird flight speed	v	10	m s^{-1}
Max blade width	C	4	m	Flight type		flapping	
Pitch	λ	15	degrees	% of flights upwind/downwind		50%	50%
Blade profile		see Blade profile sheet					
		Single transit risk	upwind	9.56%			
			downwind	3.91%			
			weighted mean	6.73%			

Stage D

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year avge
Proportion of time operational	Q_{tt}	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%
		Collision rates before avoidance												year total
		0.05	0.05	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.05	0.04	0

Stage E

Allow for large array correction? No
Width of windfarm w 5.5 km

			large array correction	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	per year
				Collision rates allowing for avoidance												
Avoidance rates modelled		95.00%	100.00%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		98.00%	100.00%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		99.00%	100.00%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		99.50%	100.00%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0

Table 6.20: Collision risk model outputs for Hen Harrier.

COLLISION RISK MODEL

Required input data is in orange boxes
Calculated output is in blue boxes
green boxes are for information only, to show variables used at each stage

Bird data		Value	Units
Species name		Hen Harrier	
Bird length	L	0.48	m
Wingspan	W	1.1	m
Bird flight speed	v	9.1	m s^{-1}
Flight type, flapping or gliding		flapping	
% of flights upwind/downwind		50%	50%
Nocturnal activity ranking 1-5		1	
Nocturnal activity factor	I_{night}	0%	

Windfarm data		Value	Units
Site name		Tirawley	
Latitude		54.25	degrees
No of turbines	T	16	
Width of windfarm	w	5.5	km

Turbine data		Value	Units
Model		4.3 MW type	
Hub height		76.5	m
Rotor radius	R	58.5	m
No of blades	b	3	
Rotation speed	Ω	12.1	rpm
Max blade width	C	4	m
Blade pitch	λ	15	degrees
Risk height range		18-135	m

normal approach

Set to 'normal approach' to use survey data on bird density
Set to 'birds on migration' to use 'Migrant collision risk' sheet in place of Stage A

Stage A

			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year avge
Daytime bird density	D_A	birds/km^2	0.0001	0.0001	0.0001	0	0	0	0	0	0	0.0001	0.0001	0.0001	0.0001
Proportion at rotor risk height	Q_{ra}	48.60%													
At latitude 54.3		Daylight hours per month	247.2	271.5	366.1	420.5	495.6	512.7	515.2	461.9	383.3	328.3	257.6	230.6	4490.3
		Nighttime hours per month	496.8	400.5	377.9	299.5	248.4	207.3	228.8	282.1	336.7	415.7	462.4	513.4	4269.7

Stage B

				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year total
No of turbines	T	16														
Rotor radius	R	58.5 m														
		Total rotor frontal area m^2	172021													
Nocturnal activity factor	I_{night}	0%														
Bird flight speed	v	9.1 m s^{-1}														
		Projected number of rotor transits		0.6	0.6	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.6	0.6	4

Stage C

No of blades	b	3	Bird length	l	0.48	m
Rotation speed	Ω	12.1 rpm	Wingspan	w	1.1	m
Rotor radius	R	58.5 m	Bird flight speed	v	9.1	m s^{-1}
Max blade width	C	4 m	Flight type		flapping	
Pitch	λ	15 degrees	% of flights upwind/downwind		50%	50%
Blade profile		see Blade profile sheet				
		Single transit risk	upwind	11.17%		
			downwind	5.27%		
			weighted mean	8.22%		

Stage D

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year avge
Proportion of time operational	Q_{ra}	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%
		Collision rates before avoidance												year total
		0.04	0.05	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.04	0.04	0

Stage E

Allow for large array correction? No
Width of windfarm w 5.5 km

		large array correction	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	per year
			Collision rates allowing for avoidance												
Avoidance rates modelled	95.00%	100.00%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
	98.00%	100.00%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
	99.00%	100.00%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
	99.50%	100.00%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0

Table 6.21: Collision risk model outputs for Peregrine.

COLLISION RISK MODEL

Required input data is in orange boxes
Calculated output is in blue boxes
green boxes are for information only, to show variables used at each stage

Bird data		Value	Units
Species name		Peregrine	
Bird length	L	0.42	m
Wingspan	W	1.02	m
Bird flight speed	v	12.1	m s^{-1}
Flight type, flapping or gliding		flapping	
% of flights upwind/downwind		50%	50%
Nocturnal activity ranking 1-5		1	
Nocturnal activity factor	I_{night}	0%	

Windfarm data		Value	Units
Site name		Tirawley	
Latitude		54.25	degrees
No of turbines	T	16	
Width of windfarm	w	5.5	km

Turbine data		Value	Units
Model		4.3 MW type	
Hub height		76.5	m
Rotor radius	R	58.5	m
No of blades	b	3	
Rotation speed	Ω	12.1	rpm
Max blade width	C	4	m
Blade pitch	λ	15	degrees
Risk height range		18-135	m

normal approach

Set to 'normal approach' to use survey data on bird density
Set to 'birds on migration' to use 'Migrant collision risk' sheet in place of Stage A

Stage A

			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year avge
Daytime bird density	D_A	birds/km^2	0	0	0	0	0	0	0	0	0	0	0	0	0.0000
Proportion at rotor risk height	Q_{ra}	100.00%													
At latitude 54.3		Daylight hours per month	247.2	271.5	366.1	420.5	495.6	512.7	515.2	461.9	383.3	328.3	257.6	230.6	4490.3
		Nighttime hours per month	496.8	400.5	377.9	299.5	248.4	207.3	228.8	282.1	336.7	415.7	462.4	513.4	4269.7

Stage B

				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year total
No of turbines	T	16														
Rotor radius	R	58.5 m														
		Total rotor frontal area m^2	172021													
Nocturnal activity factor	I_{night}	0%														
Bird flight speed	v	12.1 m s^{-1}														
		Projected number of rotor transits		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0

Stage C

No of blades	b	3	Bird length	l	0.42	m
Rotation speed	Ω	12.1 rpm	Wingspan	w	1.02	m
Rotor radius	R	58.5 m	Bird flight speed	v	12.1	m s^{-1}
Max blade width	C	4 m	Flight type		flapping	
Pitch	λ	15 degrees	% of flights upwind/downwind		50%	50%
Blade profile		see Blade profile sheet				
		Single transit risk	upwind	9.24%		
			downwind	4.16%		
			weighted mean	6.70%		

Stage D

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year avge
Proportion of time operational	Q_{ra}	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%
		Collision rates before avoidance												year total
		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0

Stage E

Allow for large array correction? No
Width of windfarm w 5.5 km

		large array correction	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	per year
			Collision rates allowing for avoidance												
Avoidance rates modelled	95.00%	100.00%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
	98.00%	100.00%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
	99.00%	100.00%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
	99.50%	100.00%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0

Appendix 4. COLLISION RISK ASSESSMENT CALCULATIONS

Table 6.7: Avian biometric data and avoidance rates.

Avian Biometric Data & Avoidance Rates				
Species Name	Length (m)	Wingspan (m)	Mean flight speed (m/s)	Avoidance rates (%)
Kestrel	0.34	0.76	10.1	95
Buzzard	0.54	1.2	13.3	98
Lesser Black-backed Gull	0.58	1.43	11.9	98
Sparrowhawk	0.33	0.67	10	98
Hen Harrier	0.48	1.1	9.1	99
Peregrine	0.42	1.02	12.1	98

Response from MLavelle: Thus we can assume that no species-specific avoidance rates are available for Buzzard, Lesser Black-backed Gull, Sparrowhawk, & Peregrine Falcon. Using a bird speed of 12.1m/s upwind is not reasonable when the EIAR indicates wind speed of 9.1m/s. As Bird speed decreases, probability of avoidance decreases. Birds having to cross a 5.5km wide windfarm, upwind with turbulence to/from the West/Southwest will have slow speeds.

Reference 2025 : System impacts of wind energy developments: Key research challenges and opportunities. Russell McKenna, Johan Lilliestam, Heidi U. Heinrichs, Jann Weinand, Johannes Schmidt, Iain Staffell, Andrea N. Hahmann, Peter Burgherr, Arne Burdack, Monika Bucha, Ruihong Chen, Michael Klingler, Paul Lehmann, Jens Lowitzsch, Riccardo Novo, James Price, Romain Sacchi, Patrick Scherhaufer, Eva M. Scho¨ Piero Visconti, Paola Velasco-Herrejo´ Marianne Zeyringer, and Luis Ramirez Camargo. Joule 9, January 15, 2025

Onshore wind power deployment primarily affects bird and bat populations, even though wind turbines may also disturb and displace terrestrial mammals. Although there are no global estimates of yearly bird and bat fatalities caused by wind turbines, in the United States, with an installed capacity of 112 GW as of 2021, bird fatalities from turbine collisions number in the several hundreds of thousands annually. Species at higher risk are typically migratory, soaring raptors, or bats; the additional mortality due to collisions can be particularly relevant for populations of long-lived and slow-reproducing species, and collision with rotor blades and wind turbine towers might further endanger species already threatened with extinction.

Although previous research suggested bat fatalities caused by barotrauma, more recent studies identify direct blade and tower collisions as the main cause of fatalities

Despite the growing body of literature on bird strikes in open landscapes, there is a significant lack of research on these impacts in shrub- and woodland environments.

Furthermore, noise pollution from wind turbine operations can negatively affect birds, bats, and non-volant and marine mammals, disrupting their nesting, breeding, and movement patterns, which may result in population decline and displacement. Some species avoid wind turbines due to noise, specifically during construction, whereas others avoid areas with shadow flicker (see section health and annoyance). Although not a bat attractant, low-frequency noise emissions can disorientate bats, which makes hunting difficult. Land transformation related to the construction of wind farms can also affect habitat suitability for wildlife species. Landscape connectivity between habitats can become disrupted if wind farms are built in existing dispersal corridors. Already-isolated populations can face a reduced gene flow if areas in the vicinity of wind farms are avoided and alternative dispersal corridors are rare. In addition, direct mortality due to collisions with wind farms can affect population dynamics on a large scale. Some species might be able to adapt to altered habitat conditions after wind farm construction, whereas others might not become habituated. However, effects on population trends are difficult to assess because effects are highly site and species specific and long-term studies are rare.

Many species' habitat requirements change in the course of a year, it remains a challenging task, especially when considering ecological corridors and stepping stones. Micro-siting to avoid areas with high collision risk can reduce risks for birds, but it is more challenging for bats. A promising solution for on-site impact mitigation is to increase the cut-in wind speed from 3 to 4 m/s to 6 and 8 m/s for bats and soaring birds, respectively, as these animals have the highest flight activities at low wind speeds, while the production losses would remain modest. Temporary shut-downs triggered by visual or radar observations are also effective solutions to minimize collisions.

The increasing number and size of wind farms can affect local weather and climate patterns, though the magnitude of these effects is debated. There is broad evidence based on photographs, satellite imagery, measurements, and modeling. Wind turbines extract kinetic energy from the wind flowing through their rotors, replenished downstream of the flow above the wind farm. In large wind farms, the latter process cannot supply enough energy to compensate for lowered wind speeds, especially offshore. Hence, a large wind farm can significantly lower the wind speeds in its vicinity, up to a distance of tens of kilometres, thereby suppressing generation from nearby wind farms.

Wind turbines face several challenges in their end-of-life phase, inevitably resulting in final disposal. By 2030, around 60,000 wind turbines are expected to reach the end of their first life worldwide, two-thirds of which are in Europe Several options exist to delay final disposal, from extending the lifetime and reusing or repurposing components to recovering or recycling different parts of the wind turbine, each bearing its challenges.

Recycling components attract the most attention in scientific publications and media. Although the recycling of permanent magnets is widely covered in the media and policies in the context of security of supply for critical raw materials (cf. section policy and regulation), the challenge of rotor blade recycling is intensely debated by the public, questioning the benefits of wind energy in general (cf. section social, economic, and health impacts).

Structural health monitoring and digital twins to extend the lifetime of wind turbines are still not implemented at scale, despite extensive industrial interest in the latter. Although a recent review posits that the reuse and repurposing of old turbines is minimal and not expected to grow in the future, the waste management company Veolia recently signed a contract to repurpose GE wind turbine blades into a raw material for cement in the US.

Regarding recycling, suitable processes and related challenges differ for each part of a wind turbine

Although recycling steel towers, gearboxes, and traditional generators is well established, recycling concrete (esp. foundations) in some locations might be environmentally and economically challenging due to the trade-off between soil disruption, transport distances and material circularity. A geopolitical challenge around the recycling of the generator system arises through the trend toward direct drives, with their permanent magnets containing rare earth elements, such as neodymium, praseodymium, and dysprosium, considered critical raw materials by the EU.

Nonetheless, less than 1% of rare earth elements are recycled because of the low technology readiness level (TRL), glued structures and comparably cheaper virgin counterparts. At the same time, global demand for rare earth elements contained in wind turbines could rise from 52 kt/a in 2018 to 236 kt/a by 2030.

Expected demand in 2030 and 2050 from the wind turbine industry for a selection of rare earth metals, relative to the 2018 global supply for all applications

A central end-of-life challenge arises from the turbine blades containing glass fiber reinforcement plastics (GFRPs). Although some major wind turbine manufacturers have announced nearly 100% recyclable wind turbine blades between 2030 and 2040, and the first recyclable blades were launched in 2021, almost all current end-of-life blades are landfilled or temporarily stored, raising much attention in the media. Some regions with high wind energy capacities, like Germany, have already banned their landfilling and incineration, while currently only a negligible fraction is mechanically recycled as filling materials. Thermal and chemical recycling options are evolving but are still at low TRLs and have a high energy demand. For example, pyrolysis (TRL 7), fluidized bed or microwave pyrolysis (TRL 5/4), and solvolysis (TRL 5–6) come with a high upfront investment, low quality of fibers, and potential greenhouse gas emissions by the unavoidable decomposition of products.

Notably, the recycling challenge is not limited to wind turbines but applies to many activities in the building, electronics, and transportation sectors for composites and electric motors, as well as domestic appliances and smartphones for permanent magnets, so considerable sectoral spillovers in solving recycling problems are possible.

The diverse impacts of wind power development on land appropriation and control, which affect the rights of traditional communities to territory and livelihoods, need to be linked to a set of compliance rules. These include procedural aspects such as securing their free, prior, and informed consent, addressing information asymmetries about the project's specific local impacts, and offering fair and legally approved land leasing

contracts as well as legal advice on land use. The issue of land ownership and rights is a key challenge to a just energy transition.

Another public concern is that wind turbines negatively impact the perception of landscapes, particularly untouched nature. This visual landscape impact is one of main reasons for local opposition to onshore and offshore wind installations.

Acceptance of wind turbines is higher when they are placed in already unattractive landscapes, far from viewpoints, and with a limited number of turbines, but the cumulative effects may vary by location. Several studies have employed national datasets of landscape aesthetic quality (so-called "scenicness"), based on survey-based ratings of representative landscape photographs, to quantify the costs incurred to power systems when excluding onshore wind potentials in landscapes with high aesthetic quality, showing a large range of impacts between countries.

In addition, viewshed analyses, in which a three-dimensional space (the viewshed) within which one or more hypothetical wind turbines are visible, can aid in understanding the potential visual impact on sensitive receptors; however, these disregard people's visual preference for certain landscapes over others. They may, therefore, be combined with measurements of visual features of landscapes, as a correlation between such metrics and rated landscape qualities has been found. Moreover, RE infrastructure such as wind turbines and power lines strongly influence the rated landscape coherence.

Quantifying the landscape impact of wind turbines to improve placement decisions requires that both visibility and landscape quality are considered. Whereas the latter refer to changes in landscape quality and character, visibility impacts relate to (perceived) changes in views (of the landscape) and how these affect people.

Noise emissions and the "flicker" of the rotating shadow from wind turbines are frequently discussed as negative impacts of wind farms. Although current evidence suggests that noise emissions from wind farms do not have a significant direct impact on nearby populations' health, some studies have noted a correlation between noise-related annoyance and potential indirect effects on quality of life, such as sleep disturbance, increased stress, and related health concerns (e.g., elevated blood pressure and psychological distress). However, the causality and directionality of these effects remain unproven and require further research. The perception of noise seems higher in rural areas and around flat terrains. Although low-frequency noise emissions cannot be heard, they may still lead to annoyance, but the link between wind turbines and low-frequency noise has not yet been established. In addition, many studies show that only a small fraction of the population living near wind farms is disturbed by shadow flicker. Shadow flicker exposure does not necessarily lead to self-reported annoyance but rather subjective factors such as project appearance and general annoyance. However, the disturbance attributed to wind turbine noise emissions should be evaluated compared with other routine noise sources.

In a controlled study, although subjects reported annoyance from the acoustic emissions of nearby wind turbines, health-related effects were specifically attributed to noise pollution from road traffic.

Noise impacts can be mitigated by appropriate wind farm planning and simulations, and it is suggested that a certain noise threshold be respected (e.g., 35–45 dB(a)), as is currently enforced in some countries. Likewise, for cases where high levels of modelled shadow flicker exposure and self-reported annoyance correlate, easy-to-implement solutions exist, such as curtailment after specific exposure thresholds. However, the probability of that correlation occurring is low because detailed shadow flicker simulations are an integral part of planning processes for wind farms and permission might not be granted in case thresholds would be exceeded (see, e.g., the German BImSchg). Nevertheless, the studies leading to that regulation were performed over 20 years ago when turbines were considerably smaller than today and were capable of generating a flickering effect of higher frequency.

Grid strengthening and expansion are essential to address mismatches between supply and demand. But these measures have significant implications for public acceptance, landscape impacts, and potential health impacts. Though, as we discuss in the section social, economic, and health impacts, the direction and magnitude of these health impacts are far from clear.

Table 1. Overview of key systemic wind impacts, potential solutions, and research priorities emerging from this comprehensive review

Category	Impact	Description	Spatial diversity[a]	Potential solutions	Research priorities
Environment and climate	(1) impacts on ecosystems and wildlife	impacts such as direct collision, causing mortality of birds and bats, or noise pollution, causing population decline and displacement of birds, bats, and non-volant and marine mammals by disrupting their nesting, breeding, and movement patterns	high	strategic placement of wind farms, regulating cut-in speeds, temporary curtailment, visual cues, and painting one turbine blade	empirical research and observation: • impacts in shrub- and woodland • multi-annual and multi-site studies (before-after control-impact study design) • net ecological impacts of wind energy compared with alternatives • longitudinal studies in wind energy locations
	(2) impacts on weather and climate	the operation of wind farms can cause a local change in surface temperature and other weather parameters, such as precipitation and evaporation; large wind farms can affect the wind resources for tens of kilometers downstream	medium	wind power siting, integration measures (e.g., storage, grids, etc.), appropriate wind park layouts, consider efficiency losses in wind farm planning	• further measurements and empirical data, especially for large wind farms and local weather effects • net climate effects of wind energy compared with alternatives
	(3) end-of-life treatment of turbine blades	the fiber binding resin challenges the recycling of wind turbine blades; as a result, blades are currently not recycled but instead go to landfills or unofficial "temporary storage sites"	low	prevention, refurbishing or reusing, repurposing, recycling	• address the waste hierarchy through innovative design for recycling and disassembly • improve thermal and chemical recycling processes to higher TRLs and exploit sectoral spillovers • increase coordination and standardization between manufacturers and developers
	(4) rare earth elements	the trend toward direct drives with permanent magnets containing critical rare earth materials for the EU results in a geopolitical challenge, yet less than 1% of the rare earth elements are recycled	low	recycling of permanent magnets, alternatives for permanent magnet wind turbine generators, diversifying supply chains	
Social, economic, health	(5) land governance and tenure (in)security	land requirements for wind power can come at the cost of prior land users due to land tenure insecurity, increasing the vulnerability of traditional rural communities and Indigenous groups	high	recognition of common lands and traditional communal land-use rights, improved planning and coordination of spatial energy planning with land tenure issues, participatory planning, legal advice, creating co-benefits	• understand best practice for wind energy planning to reflect community needs • develop collaborative planning, governance, and business models ensure co-benefits
	(6) local monetary costs and benefits	wind turbines can create either positive or negative impacts on neighboring real estate value and tourism, depending on the perception	high	fostering community participation from the projects' planning stages, improving the understanding of wind power as a key technology to achieve the energy transition and monetary compensation	• elaborate models of acceptance and willingness to pay in order to quantify compensation measures • quantify net economic impacts based on improved data bases/availability
	(7) landscape impacts	the local opposition toward wind projects due to the negative visual impact on wild landscape aesthetic value	high	improved planning, participative processes	• enhance concepts of social acceptance to consider frequency of encounters with and quality of landscapes • extend quantitative empirical research on local economic impacts of wind farms
	(8) local health impacts	noise emissions and shadow flicker from wind turbines can cause neighbors' annoyance, which may correlate with deteriorating quality of life, increased stress, and resulting health issues	high	appropriate planning, periodic curtailment and noise threshold and attenuation options (e.g., serrated trailing edge, sinusoidal leading edge, blended winglet)	• build on existing noise models to (i) enhance understanding of wind energy impacts in relation to other local sources of noise and (ii) connect acoustin emissions with annoyance • extend shadow flicker research to consider night-time effects with artificial lighting
Techno-economic	(9) energy system impacts	wind-dominated energy systems may become highly weather dependent and lack inertia due to a prevalence of inverter-based resources (IBRs) forming the grid	medium/ high	grid densification and expansion, use of storage, increasing flexibility and sector coupling, development of smart grids; low carbon provision of key ancillary services, such as inertia, operating reserve, and frequency response	• align modeling with empirical data on energy system transitions to high wind shares • improve techno-economic modeling to reflect social and environmental impacts and constraints
	(10) market and price impacts	integrating wind power into markets creates two key opposing issues: ancillary service costs increase due to increased supply variability, and the "merit order effect" depresses wholesale market prices and increases their volatility	medium	market and regulatory changes that either bring more flexible capacity online or allow the existing system to react more efficiently to wind power volatility, e.g., enhanced frequency response service in Britain	• develop advanced models of market actors, storage, and interactions • derive best practice for wind energy subsidies, depending on energy-political contexts • quantify whole system costs of wind energy integration for diverse systems and contexts

Policy and regulation	(11) financing and controlling the IP	political, economic, and national security concerns, as well as possible resulting shifts in market power due to industry leaders seeking dominance	medium	balance investment opportunities and national security interests	• develop open data and associated research on investments, ownership, and acquisitions through FDI to assess geopolitical and geoeconomic risks • influence political and regulatory processes connected to (wind) energy infrastructure
	(12) supply chain disruptions	energy disruption as a geopolitical weapon has a long history for oil and gas, but it recently shifted to a focus on geopolitics of the energy transition and resurging concerns over the weaponization of energy	medium	increase domestic exploration and production to re-shore and near-shore supply chains	• design robust and resilient supply chains for wind energy • enforce international technology standards and certification schemes • identify the pathways and understand the major implications for developing a domestic (offshore) wind supply chain that can manufacture and deploy the major components needed
	(13) cyber security and hybrid threats	wind farms are exposed to challenges on existing infrastructure security that depends on complex control and monitoring systems, as well as disinformation that can affect news credibility	low	secure technologies and resilient designs	• understand how disinformation can be used to compromise the security of critical infrastructure • understand the potential vulnerability and attack landscape related to control and information systems, including the connected supplier and third-party systems
	(14) planning and permitting	lengthy permitting processes due to increasingly complex formal requirements combined with insufficiently specific legal guidelines and responsibilities for permitting authorities, as well as understaffed authorities and overloaded judicial systems	high	regulatory changes, "go-to areas," financial participation of communities, more resources for authorities	• determine best practice for planning and permitting • observe effects of ongoing/upcoming regulatory changes, including side-effects on acceptance • reflect spatial trade-offs in wind power legislation (centralized vs. decentralized)

Reference : Moorland Association. The Impact of Wind Farms on Moorland Birds in the UK. Dr. Jennifer Brewin

There are over 1000 onshore wind farms already operational in the UK, many of which are in the uplands. However, those who spend time on our moors will know that they are far from empty, hosting many bird species in particular that are threatened and struggling elsewhere.

Although wind power can offer a good source of clean energy, wind turbines must share the air space, and this overlap can have negative effects on birds in several different ways.

Worldwide, there is a large body of work looking at the impact of wind farms on birds, but not all these are relevant to the UK moorland environment. Some useful studies have been carried out on the UK uplands however, and important lessons have come from those.

Global lessons

In general, there are several ways in which birds can be affected by wind farms. These include:

- **direct impacts through collision with the rotor blades.**
- **indirect impacts through habitat loss, disturbance displacement, or barrier effects.**

Most papers agree that wind farms can have negative effects on bird species, with different risks to different groups – for example, high-flying, larger, less manoeuvrable species are at greater risk of collision with rotor blades, whereas those more averse to disturbance are more likely to be displaced during construction.

Lots of work has been done in Spain and the Americas looking at impacts on both migrating birds and large raptors such as vultures and birds of prey, finding that wind farms can have significant impacts for some species. Raptors are generally acknowledged to be most at risk from collisions with turbines, particularly soaring raptors. These species are often long-lived and slow to reproduce, so impacts on adult mortality can have a profound effect on local populations.

UK wind farms

Findings from studies in the UK and Ireland confirm that some of these themes also apply to our upland environments and species.

- Disturbance/displacement: this is the main mechanism for impacts on UK moorland species. The construction or presence of wind turbines can drive birds away from certain areas, essentially reducing the amount of habitat that is available for them.

- Direct collisions: while deaths due to collision with rotor blades do occur in the UK, the rate seems to be lower than that seen worldwide.

Displacement effects

On UK moorland, breeding waders appear to be most impacted by wind turbines. Several studies have found lower bird densities near to wind farm sites, particularly lower densities of breeding birds. For some species such as curlew and snipe, the construction phase of wind farms seems to have the most impact, with bird densities dropping during the building phase and not recovering afterwards.

The numbers

We know that several species have significantly lower breeding density within 500m of a wind turbine. One study published in 2009 looked at twelve moorland bird species and found that seven were affected by the presence of turbines. Across these species, the density of breeding birds was between 15 and 53% lower within 500m of the turbines, compared to further away. The effect was most marked for buzzard, hen harrier, golden plover, snipe, curlew and wheatear.

Findings from specific studies have shown:

- 79% fewer golden plover within 400m of turbines4.
- Declines in curlew (40%), snipe (53%), and red grouse during wind farm construction. Red grouse numbers recovered, but curlew and snipe numbers did not.
- Habitat use by golden plovers within wind farm areas significantly reduced up to at least 200 m from the turbines, and breeding density lower than predicted at wind farm sites.
- Total bird densities 0.3-1.3 birds/ha lower at wind farm sites compared to reference areas.

Focus: Hen Harriers

As a flagship species on UK moorland, and a focus for conservation efforts, the hen harrier is a species of particular interest when it comes to the impact of wind turbines. The WINDHARRIER project in Ireland has spent several years studying interactions between wind turbines and hen harriers, and has published a wealth of papers and information.

Wind turbines can affect hen harriers through collision risk, disturbance, and loss of foraging habitat, but current evidence suggests that although a raptor species, harrier collision risk is lower than might be expected. Perhaps because of their relatively low flight height, along with effective avoidance behaviour, hen harrier collisions with wind turbines are rare. WINDHARRIER finds a collision likelihood of 0.8-2.5 collisions over the 25-year operational lifespan of a wind farm.

However, additional findings from the project reveal that proximity to wind turbines decreases hen harrier breeding success by reducing both the proportion of successful nests, and the number of chicks per nesting attempt:

	Within 1km of turbine	Over 1km to turbine
Nesting success (proportion of nests to fledge a chick)	33.3%	56%
Productivity (number of chicks per nesting attempt)	0.78	1.23-1.55

There is as yet little evidence to understand the mechanisms for, or importance of, these effects at population level, especially when weighing up the contributions of wind power to a more sustainable future and the likely impacts of climate change on bird populations, including the hen harrier. Careful siting of wind farms will certainly contribute to successful coexistence between renewable energy and hen harrier conservation.

Mitigation options

Wind power is an important tool for the UK to reach its energy commitments, and as such it is important to understand how to limit the potential impacts of onshore wind power on local biodiversity, including birds, bats, and insects. Much work worldwide is focussed on how to mitigate this threat, including the French EU funded project MAPE (https://mape.cnrs.fr/). There are various approaches to reduce the risk posed to bird populations from wind turbines. These include:

Placement and site assessment

1. Logic suggests that birds faced with an object in their flight path must either avoid or collide. However, placing a turbine in a particular area does not *always* result in one of these outcomes – careful turbine siting to place them in lesser used areas, considering species flight height, common routes, eg between roosting/nesting and foraging areas, and landscape features such as steep slopes or ridges can all reduce risk to or impact on birds. Doing all we can to reduce the overlap between turbine sweep zones and areas that are heavily used by birds can minimise impacts.

2. Local landscape affects collision risk, especially for soaring raptors which use thermal air currents to gain height. For example, placing turbines on ridge lines or areas that birds use to gain altitude increases the risk of collision.

3. Careful analysis of the local bird population is critical. Siting turbines at or between nesting, foraging, roosting, or hunting sites is likely to increase collision risk. It is compulsory in the UK and EU to carry out bird surveys for potential sites before construction.

Turbine characteristics

1. Greater rotor blade width and lower clearance to the ground both increase the likelihood of collision. However, these impacts can differ between species, for example raising the areas swept by the blades to reduce risk to some species may risk placing it in the flight zone of higher-flying species such as larger raptors.

2. Alterations to the turbine itself such as painting one of the rotor blades a contrasting colour or pattern has been shown to reduce collision occurrence by up to 70%.

3. Some turbines are fitted with automatic detection systems which identify birds approaching and react in a number of ways, including emitting an audio or visual deterrent, or stopping the rotor blades until the bird has left the area. These automatic detection systems reduce collisions, but they do still occur.

Conclusion

It is clear that poorly sited wind turbines can have negative impacts on some species of bird in the local area. However, mitigation options can minimise these effects, and turbine characteristics such as painted blades and automatic responses to bird presence can reduce collision risk even further.

It is mandatory in Europe and North America to take steps to mitigate the likelihood of impacts on bird populations from wind energy projects. Guidance is available from NatureScot.

We don't yet know how significant these effects might be in the context of local or UK-wide species populations, but this is an important question as a small additional mortality can lead to significant population effects for some species.

We are fully supportive of renewable energy solutions, and wind power is an important component of the UK's energy mix, but it is important to fully understand the biodiversity impacts of these developments. We believe that wind power can coexist with successful local bird populations when turbines are well designed and carefully sited.

However, turbines located inappropriately, especially on sensitive moorlands can cause significant habitat displacement for ground-nesting birds and potential collision risks for raptors.

References

1. Fernández-Bellon, D., Wilson, M. W., Irwin, S. & O'Halloran, J. Effects of development of wind energy and associated changes in land use on bird densities in upland areas. *Conservation Biology* 33, 413–422 (2019).
2. Pearce-Higgins, J. W., Stephen, L., Langston, R. H. W., Bainbridge, I. P. & Bullman, R. The distribution of breeding birds around upland wind farms. *Journal of Applied Ecology* 46, 1323–1331 (2009).
3. Pearce-Higgins, J. W., Stephen, L., Douse, A. & Langston, R. H. W. Greater impacts of wind farms on bird populations during construction than subsequent operation: results of a multi-site and multi-species analysis. *Journal of Applied Ecology* 49, 386–394 (2012).

4. Sansom, A., Pearce-Higgins, J. W. & Douglas, D. J. T. Negative impact of wind energy development on a breeding shorebird assessed with a BACI study design. *Ibis* 158, 541–555 (2016).
5. Pearce-Higgins, J. W., Stephen, L., Langston, R. H. W. & Bright, J. A. Assessing the cumulative impacts of wind farms on peatland birds: a case study of golden plover Pluvialis apricaria in Scotland. *Mires and Peat* 4, 01 (2008).
6. Fernández-Bellon, D., Irwin, S., Wilson, M. & O'Halloran, M. Reproductive output of Hen Harriers Circus cyaneus in relation to wind turbine proximity. *Irish Birds* 10, 143–150 (2015).
7. Wilson, M. W., Fernandez-Bellon, D., Irwin, S. & O'Halloran, J. *The Interactions between Hen Harriers and Wind Turbines. WINDHARRIER Final Project Report.* https://www.ucc.ie/en/media/research/planforbio/forestecology/WINDHARRIERFinalProjectReport.pdf (2015).
8. Wilson, M. W., Fernández-Bellon, D., Irwin, S. & O'Halloran, J. Hen Harrier Circus cyaneus population trends in relation to wind farms. *Bird Study* 64, 20–29 (2017).
9. Bright, J. A. *et al.* Spatial overlap of wind farms on peatland with sensitive areas for birds. *Mires and Peat* 4, 07 (2008).
10. Drewitt, A. L. & Langston, R. H. W. Assessing the impacts of wind farms on birds. *Ibis* 148, 29–42 (2006).
11. Péron, G. *et al.* The energy landscape predicts flight height and wind turbine collision hazard in three species of large soaring raptor. *Journal of Applied Ecology* 54, 1895–1906 (2017).
12. Škrábal, J. *et al.* Red kite (*Milvus milvus*) collision risk is higher at wind turbines with larger rotors and lower clearance, evidenced by GPS tracking. *Biological Conservation* 312, 111482 (2025).
13. May, R. *et al.* Paint it black: Efficacy of increased wind turbine rotor blade visibility to reduce avian fatalities. *Ecology and Evolution* 10, 8927–8935 (2020).
14. Hancock, G. R. *et al.* Biologically inspired warning patterns deter birds from wind turbines. *bioRxiv* 2025–04 (2025).
15. Gémard, C., Duriez, O., Chappe, O., Duclos, G. & Besnard, A. Towards a better understanding of avian collision in wind energy facilities using automatic detection systems. *Journal of Applied Ecology* 62, 1437–1448 (2025).
16. Schippers, P. *et al.* Mortality limits used in wind energy impact assessment underestimate impacts of wind farms on bird populations. *Ecology and Evolution* 10, 6274–6287 (2020).

Reference: Oriel Windfarm ACP Response - Ornithology

From the information presented, the Board note concerns that there is an over- reliance on baseline surveys to include, and exclude, important ecological features potentially affected by the project. It is noted that species "recorded in very small numbers or very infrequently during the baseline surveys are excluded because the risk of impact to their populations is considered negligible." The Board requires that a clear, evidence-based justification for the inclusion and/or exclusion of species is submitted, particularly given the risk of excluding species that are less readily sampled by the particular survey methodologies applied and given the location of the site partially within the North-west Irish Sea cSPA, and location relative to bird colonies at Rockabill SPA, Lambay Island SPA & Irelands Eye SPA.

It is noted that the surveys were undertaken prior to the 2022 Highly Pathogenic Avian Influenza (HPAI) season, which is known to have had significant negative impacts on range of seabird species. The applicant is requested to provide justification that the original digital area surveys and boat-based data remain relevant and appropriate at the point of submitting additional information to support the proposed development.

Reference Population

The robustness of population calculations used within Chapter 11: Offshore Ornithology, and associated appendices, is important in assessing the potential effects of the proposed development. While the Board notes the approach of estimating reference populations employed in the EIAR, the applicant is requested to provide further detail on the breeding season populations used - including both breeding adults and juveniles / immature birds - and how the

treated in the population estimates. The applicant should provide evidence-based justification for the method applied, which should comprise the most appropriate and precautionary method for estimating the breeding season populations to inform assessment conclusions.

The applicant is requested to clearly present the values and equations used to derive the population estimates, including their sources (e.g. a list of colonies or sites included within the reference populations), to allow validation of the methodology. The applicant should also address this issue in the Cumulative Impact Assessment.

Disturbance & Displacement

The rationale for decisions to screen out bird species for assessment of disturbance and displacement if determined to have a low sensitivity to disturbance and displacement or which were recorded in low numbers is not clear, giving rise to concerns regarding the robustness of the conclusions in the EIAR and NIS. The applicant is requested to provide justification for the approaches taken for screening out in such instances.

The Board notes the submission of Appendix 11- 07: Offshore Ornithology Apportioning Impacts to Individual Colonies of the EIAR which seeks to apportion predicted mortalities from displacement and collisions of the project to seabird colonies. In terms of disturbance and displacement, fours species have been identified as potentially at risk: Common Guillemot (*Uria aalge*);

Razorbill (*Alca torda*);

Great northern Diver (*Gavia immer*); and

Northern Gannet (*Morus bassanus);*

The Board notes that the applicant has assessed predicted annual mortalities for a number of species based on a single mortality rate, rather than the industry recommended range of mortality rates. Chapter 11 of the EIAR bases conclusions on a rate of 50% displacement and 1% mortality rate for auks1

1 The SNCB (2022) recommend a displacement rate of between 30% and 70% and a mortality rate of 1% and Nature Scot 60% and 1% respectively, 100% displacement and 0.5% mortality for GND and 60% to 80% displacement and 1% mortality rate for gannet during the operational phase of the project. Given the location of the site partially within the North-west Irish Sea SPA (and proximity to colonies at Rockabill SPA, Lambay Island SPA & Irelands Eye SPA) the applicant is requested to update the EIAR to adopt a range of relevant mortality rates in the estimates of predicted mortalities for relevant species, and that these be clearly presented in the EIAR.

Dundalk Bay is noted to be a very important foraging area for birds, likely linked to the prey resources known to exist there, including spawning habitat of the Atlantic Herring *Clupea harengus*. The rate of displacement does not appear to have been fully considered in the context of potential indirect and cumulative effects of the project on birds, such as Manx Shearwater, who forage in Dundalk Bay in large numbers, where a low rate of displacement may induce a population-scale impact. The applicant is requested to address potential changes in the distribution and abundance of important prey populations on birds.

Collision Risk

The Board notes the submission of Appendix 11-4 – Offshore Ornithology Collision Risk Modelling (CRM) which identifies five seabird species as potentially at risk due to their recorded abundance in the offshore wind farm area and their likelihood of flying at potential collision height (PCH) between the lowest and highest sweep of the WTG rotor blades above sea level: Northern Gannet (*Morus bassanus*);

Kittiwake (*Rissa tridactyla*);

Common gull (*Larus canus*);

Herring gull *(Larus argentatus*); and

Great black-backed gull (*Larus marinus*).

It is noted that the findings of the CRM rely on limited empirical data and avoidance rates for waterbirds which are not up to date. The level of confidence with regard to avoidance rates for a significant proportion of waterbirds is very low and this should be given due consideration when drawing conclusions on impacts. The use of the original Band (2012) model in its various forms may not be justified, and the Board is concerned that the conclusion of the applicants' assessment is not supported given the limitations identified. It is recommended that more appropriate methodologies are developed and implemented to gather relevant empirical data to support the assessment of effects, including

updating all parameters using the most up to date empirical data, or if not appropriate, provide comprehensive justification for the methodology employed.

In terms of the estimated collisions for the above bird species, the Board notes that Natural England have accepted a 70% reduction in Northern Gannet collision mortality estimates to account for macro-avoidance at previous developments, such as Hornsea 4. However, this is applied where developments are much further from the coast and from Northern Gannet colonies. Given the proximity of the project to the coast and to the gannet colony at Ireland's Eye SPA and Lambay SPA, approximately 52km to the south of the project site and within the foraging range of this species, a more precautionary approach is recommended. The applicant is requested to consider the approach taken in relation to Northern Gannet collision estimates, so they are not reduced by 70% to account for macro-avoidance.

The Board notes that a number of species have been screened out as being vulnerable to collision risk, where abundances are noted to be high or very high due to their flight behaviours and responses, particularly, tending to fly below the sweep of the turbine blades. It is noted that those include species associated with nearby SPAs. The applicant is requested to provide further information on the rationale to exclude certain species in terms of the abundances identified and where, in certain conditions, they may fly higher than expected. Where a species is numerous, modelling of collision risk may produce fatality estimates that are concerning for particular populations, the Manx Shearwater *(Puffinus puffinus)* for example (a Qualifying Interest (QI) of the North-west Irish Sea SPA and the second most frequently recorded species within the Offshore Ornithological Study. Accordingly, Any potential specific mitigation measures to minimise the effects of the project on birds, such as painting of turbine blades, the use of curtailment systems in particular conditions or at particular times etc, if considered appropriate, should also be included and addressed in the application documentation.

Combined Disturbance and Displacement and Collision Risk:

Northern Gannet (*Morus bassanus*) - The Board notes that the overall impacts to species in terms of the predicted mortalities arising from displacement and/or collision events, are contextualised using the BDMPS as set out in Furness (2015). This area is significantly larger than the western Irish Sea and it is requested that the EIAR is revised to ensure that the assessment of predicted annual mortalities uses the western Irish Sea for context.

Red-throated diver (*Gavia stellata*) - Red-throated diver is identified as a QI for the Northwest Irish Sea SPA and a species known to be highly sensitive to offshore wind farm developments due to displacement effects. Recent empirical evidence indicates that the species avoids a larger area than the 4km buffer afforded in the EIAR and NIS, with a 10 km buffer being recommended as per UK Joint SNCB Interim Displacement Advice Note (2022). The EIAR indicates that the species was identified in low abundance (106 birds) in the north and west of the study area during the surveys. While noting the high sensitivity of the species to disturbance and displacement however, the low abundance recorded during site-specific surveys resulted in the species being screened out for EIA purposes. However, the 'Digital video aerial survey of birds in intertidal habitats of Gormanstown December 2018 to March 2019' (HiDef, 2019), commissioned by the Marine Institute, indicates the known extent of Red-throated Diver and their densities and shows the species concentrating in the shallow Dundalk Bay waters and in and around the proposed Oriel Project area. This survey data (HiDef, 2019) suggest that notable densities of the species may be present within

km of the array area. In this regard, the Board is concerned that the EIAR does not set out the recorded density values for this species and scopes out red-throated diver for further consideration in terms of disturbance, displacement and mortality. The applicant is requested to include the HiDef surveys in the assessment of potential impacts on red-throated diver and other North-west Irish Sea SPA QI species sensitive to displacement during both construction and operational phases of the project (e.g. Great Northern Diver *Gavia immer*, Common Scoter *Melanitta nigra*), in terms of predicted mortalities based on a displacement buffer of 10km with regard to the North-west Irish Sea SPA and consider the significance of the effects on this species for all seasons, individually and combined.

Black-legged Kittiwake (*Rissa tridactyla*) - The Board note that Black-legged kittiwake, a species identified as being in decline, is a QI for North-west Irish Sea cSPA, as well as Lambay Island SPA and Ireland's Eye SPA, and that Black-legged Kittiwake has variable responses to offshore wind farms (OWFs). There is a colony in Northern Ireland which may also forage in this area. In this regard, the Board requests that the applicant include this species as a receptor of disturbance and displacement impacts during operation and maintenance. The scoping out of the species is considered to run contrary to the advice of NatureScot (2023) for species where both collision risk and displacement are considered. The applicant is requested to submit further information to identify and evaluate the impact of

displacement of Black-legged Kittiwake in conjunction with collision risk. The application documentation should be revised to fully address the potential for significant impacts on this species.

Great Northern Diver (*Gavia immer*) – The Board note that the application area is important for wintering Great Northern Divers, a species known to be vulnerable to disturbance, including from construction activities and associated vessel movements as well as during the operational phase of the project. Bird Watch Ireland raise concerns about this Annex I species who consider that the

international importance. A 'no mitigation' approach as proposed, particularly during the construction and operational phases is not considered appropriate. The applicant is requested to address these concerns, particularly in terms of the cumulative unknowns identified in the EIAR.

Colonies at Rockabill – the applicant is requested to provide additional information on the movement of auks (Guillemots *(Uria aalge)* and Razorbills (*Alca torda*)) from Lambay to show that there is no significant impact on the Rockabill, Lambay and Irelands Eye populations, given their range of foraging grounds, including the area of the project.

Other - The waters in and adjacent to the proposed Oriel Wind Farm are an important resource for the western Irish Seas marine bird populations. The passage of marine birds through the development area does not appear to have been fully characterised because of the data regime adopted. It is requested that the EIAR adopt a range of relevant mortality rates in the estimates of predicted mortalities for relevant species and that the EIAR is revised to ensure that the assessment of predicted annual mortalities uses the western Irish Sea for context. It is recommended that the developer cross reference to NPWS Article 12 reports which provide information on the current status, pressures and future prospects for sea birds.

The applicant is requested to provide further analysis of the potential effects of the proposed development in relation to predicted mortalities from both collision and displacement impacts for relevant species. This should, at a minimum, incorporate the relevant available data including for example, HiDef (2019) and ObSERVE Phase II data where appropriate. Graphical representation Population Variability Analysis (PVA) results are considered to be of assistance to interpret model outputs where appropriate.

Light-bellied Brent Goose (*Branta bernicla hrota*) - The Board notes the results of the vantage point surveys undertaken to establish the migratory movements of Light-Bellied Brent Geese across Dundalk Bay during the spring

-3: Migratory Geese Survey Report). The observed movements of birds, low and close to the shoreline, likely reflect commuting movements of flocks aligned to tidal cycles and movement between established foraging areas in Dundalk Bay and Carlingford Lough, while the significant migratory move of the 14/15th April would coincide with the northern migration of light-bellied brent geese. Autumn movements are noted to be different to the spring movements, particularly in terms of the volume of birds and sites being used from Strangford Lough and south towards Dublin and Wexford. The Board note the primary survey method of coastal vantage point surveys by human observers, at a distance of between 6-12km from the project site, and which the DAU have considered to be insufficient, with concerns that this methodology could discount the potential for the geese, and other species, to fly through the proposed array area. Reliance on published literature does not provide detailed or precise data movements, and as many of these movements occur overnight, the routes taken are not known. Therefore, and based on known flight heights and potential flightlines between the major concentrations in Strangford Lough and sites along the East Coast of Ireland, there is potential for there to be a significant potential for large numbers of Brent geese flying through the proposed array area during both day and night, over very short timescales, and particularly in autumn. The potential impact of siting wind turbines on a migratory route for this species without appropriate mitigation during such short-term events could be potentially catastrophic for Light-Bellied Brent Geese populations, the vast majority of which winter in Ireland. The applicant is requested to address these concerns in relation potential effects of the project on migrating geese. Any potential specific adaptive mitigation measures to minimise the effects of the project, particularly during the Spring and Autumn migrations and which identify the timings of the migrations, depletion of food supply etc, should also be included and addressed in the EIAR.

Migratory Species – Non seabirds

The Board notes the international importance of Ireland, including Dundalk Bay SPA, for a range of waterbird species. The AA screening report does not detail the potential impacts upon and interactions of the proposed

project with migratory waterbirds, with a focus on foraging and breeding birds only. It is noted that all migrating birds have been scoped in for further assessment, which is welcome, but the applicant is requested to update the AA to include a reference to potential impacts and interactions with regard to migratory waterbirds which are SCIs of SPAs. A review of the screened-out Natura 2000 sites and water bodies is required to be undertaken to ensure that the NIS has considered all relevant pathways appropriately, as well as migratory or normal flight paths of avian species.

The applicant is further requested to clearly address the potential for ex situ impacts upon species listed for Dundalk Bay SPA that occur outside the red-line boundary.

The Board has concerns regarding the methodologies employed with regard to the survey and monitoring of the movement of migratory waterbirds at key migration times. The primary survey method of coastal vantage point surveys by human observers, at a distance of between 6-12km from the project site, and which appear to primarily focus on geese, is considered to be insufficient and inappropriate to assess the migratory movements of birds through the array area, and the potential impacts on these species. In addition, the reliance on literature to fill knowledge gaps, while useful, does not provide adequate data to ensure a comprehensive assessment of potential effects on birds. The applicant is requested, having regard to the comments above, to address the purported existing data gap to enable the assessment of potential impacts of the proposed development on migratory birds. Radar (horizontal and vertical surveys) or similar at the Array Area during peak migration periods might be utilised to provide site-specific data, which could be used to support the applicant's current assessment and provide quantitative information on passage of birds to feed into collision modelling. Should radar not be conducted and an alternative survey methodology utilised, comprehensive justification for the alternative should be provided. Peak migration periods during which data are to be collected can be further informed through review of existing data and
makes reference to the key migration times being spring and autumn, the Board considers that migration information during the winter months would also be of assistance to the assessment (e.g. irruptive cold weather movements from the continent and UK). The applicant is invited consider this aspect for inclusion also.
In terms of the findings of the Migratory Non-Seabirds Collision Risk Modelling (Appendix 11-06 of the EIAR), and noting the comments in the DAU submission, the conclusions arrived at in this regard, may rely on limited empirical data and the avoidance rates applied in the model for waterbirds are not up to date. The level of confidence with regard to avoidance rates for a significant proportion of waterbirds is very low and as such, the validity of the conclusions arrived at are potentially understated. It appears therefore, that the conclusion of the NIS may not be fully supported given the limitations identified. The applicant is requested to address these concerns, having regard to the DAU submission.
The applicant is requested to justify the screening out for further assessment of all passerines (Table 11-15 of the EIAR), which considers the risks to migrating passerines as negligible 'due to the relative size of the project and the behaviour of the birds (e.g. passage movements restricted to twice annual events, large population sizes and flight heights typically above risk height)'. It is noted that many hundreds of thousands of migrants come to Ireland for the winter, moving west as autumn progresses and returning north and east as spring advances. The applicant is requested to provide more information and assessment with regard to these species and to consider the potential effects of the development at the project level as well as cumulatively.

Terrestrial Bird Species:

Chapter 19 of the EIAR considers the potential effects of the project on onshore birds and intertidal birds and includes Appendix 19-02: Intertidal Bird Survey and Onshore Bird Survey Reports. The DAU note that the focus of data collection to support the application has been on marine-dwelling avifauna as opposed to land-based avifauna, with knowledge gaps with respect to transboundary and migratory movements of land-based avifauna in Irish waters and beyond. As such, it is noted that no new empirical data have been collected for land-based migratory birds as part of the monitoring programme, to detect and assess the
This would provide a better understanding of the potential impact and cumulative impacts of the project, and other ORE developments in terms of the Irish Sea. The applicant is requested to address these concerns, including those raised in the DAU submission on the project.
The CRM identifies 3 terrestrial bird species as being vulnerable to wind turbines, including Corncrake (*Crex crex)*, Merlin (*Falco columbarius)* and Hen Harrier (*Circus cyaneus)*. However, the predictive power of the model employed is low, particularly for species that are not foraging in the offshore area. As such, the use of SOSS2
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Migration Assessment Tool (SOSSMAT) may not have incorporated the most up-to-date estimates of flight speeds for migrating species and may not provide robust yearly collision estimates for land-based birds with a high degree of confidence. It is requested that the potential operational impacts of the project on migratory movements/passage of land-based birds and potential options for on-site monitoring of species, etc be addressed within the application documentation.
In terms of proposed works within the intertidal environment, the applicant is requested to clarify the timing of works, particularly in relation to the landfall location. The Board notes that the summary of potential environment effects, mitigation and monitoring (Table 19-18 of Chapter 19: Onshore Biodiversity of the EIAR) indicates that timing of the construction/operational works may influence the magnitude in terms of commuting, foraging, breeding and migratory birds in terms of disturbance and loss or fragmentation of habitat. Noting the measures included in the project, it would appear that the timing of works will be restricted to a very short window. The applicant is therefore requested to submit a draft programme of works which provide a clear intention in terms of mitigating effects on birds.

Cumulative & Transboundary Effects

Migratory Waterbird Species: Migratory birds have not been included in the Cumulative Impact Assessment presented in the application documentation. As previously (Migratory Species – Non seabirds points S to W and Terrestrial Bird Species points X to Z), the assessment of the impact on migratory birds (both terrestrial and waterbird groups) arising from the project alone appears to be insufficient, and that further data should be provided to inform the assessment. The applicant is requested to assesses cumulative impacts to migratory bird populations, considering effects of the Irish Sea Phase 1 ORE projects and other existing or currently proposed plans and projects that may affect the same migratory populations.

14. Bats

The Board notes the submission of the DAU in relation to bats, both offshore and migratory, noting the effort to collect bat data both offshore and on coastal headlands. The applicant is requested to respond to the submission made by the DAU and address concerns raised. The applicant is requested to submit the following further information:
The applicant is requested to provide clarity in terms of the surveys undertaken, particularly within the landfall location, and confirm the dates of the most recent surveys for bat activity in this area. Bat surveys are required to be undertaken at coastal headlands proximate to the project site in order to provide data on the potential migratory movements of bats identified within the EIAR, particularly within an established migratory period.
In view of the identified significance of impacts associated with the proposed development in terms of the operational and maintenance phase of the project, due to barotrauma and collision risk, and in the absence of published empirical data, further information is required to be provided on the details of the proposed (detection and active response curtailment (DARC)) and evidence of its effectiveness in the off-shore environment in mitigating potential impacts on bats to ensure an assessment of impacts on bats can be undertaken in terms of potential mortality and disturbance.
The Board notes that the EIAR has scoped out disturbance from lighting for bats. However, the applicant is requested to provide an assessment (with regard to appropriate lux contours) having regard to the lighting and marking plan, to determine the extent, if any, to which lighting in the offshore array area, including turbines and the offshore substation platform, may result in the vertical displacement of bats, and potentially increasing activity within the swept zone.
The Isle of Man has made a submission in terms of potential transboundary effects noting its the exclusion as a potential migratory route for bats. The applicant is requested to comment on this submission.
In terms of the impacts to terrestrial bats, the Board notes the high activity for bats at the eastern crossing of the River Dee. It is further noted that the development will include the felling of 7 mature trees – BT4, BT5, BT14-18 – all of which have been identified as having low suitability for roosting bats. The Board notes that trees BT14-18 are located within close proximity to the identified 'hotspot' at the eastern crossing of the River Dee. While potential direct effects have been identified to bats in the EIAR, and notwithstanding the disturbance measures included in Table 19-12 of Chapter 19: Onshore Biodiversity of the EIAR, the Board requests further justification in terms of the removal of the above 5 trees which are clustered proximate to this hotspot, together with the removal of the other trees identified, with regard to potential impacts to bats. The potential location for bat boxes, as indicated as an enhancement measure, should also be identified.

18. Roads & Traffic

The applicant is requested to address the submission made by Transport Infrastructure Ireland (TII), which raises concerns with regard to the proposed onshore elements of the project, and in particular, the impacts, both directly and indirectly, on the N33 and the M1 routes. The applicant is requested to assess the project in terms of the provisions of national policy and the Section 28 Ministerial Guidelines 'Spatial Planning and National Roads Guidelines for Planning Authorities' (DoECLG, 2012), which seeks to avoid the creation of new accesses or the generation of increased traffic from existing accesses to national roads with a speed limit greater than 50kph. The applicant will also note the submissions made by TII and the Louth County Councils Senior Engineer in relation to the location of the proposed site compound off the N33, temporary access tracks and the crossing of the M1 motorway. The applicant is requested to address the submissions in terms of the completion of a Road Safety Audit and Design Report for the access to the N33 for the Onshore Substation and construction compound, as well as the temporary access tracks to the N33 and Junction 14 of the M1.

The applicant is requested to address the submission by TII, which raises concerns with regard to the acceptance of a Design Report and demonstration that all works to the national road comply with TII Publications and technical design standards for national roads. The applicant is also requested to submit proposals confirming the approach to be taken should any damage be caused to the pavement of the existing national road due to the construction activities, including the laying of cable on the N33, the proposed M1 motorway crossing at Junction 14 and the N33 Dee River crossing.
Prior to submitting a response to the roads and traffic concerns raised in the submissions above, the applicant is requested to consult with Louth County Council as the relevant Roads Authority and TII as appropriate.

Technical Note on Models and Submitting Model Outputs
The information provided should include full details on the models themselves to include the model name, resolution, relevant pressure, purpose, summary of activities, assumptions, justification, limitations (if any), validation, post construction infrastructure included, along with any other relevant information. A concise description of the model outputs (including pressure modelled, units, background level, change relative to baseline (e.g. %), list of activities assessed, as well as construction, operational and decommissioning phase consideration) should also be included.

Heat and contour maps showing the distribution of pressure (static or dispersive) over space and/or time should be produced and provided in paper format and also in high-quality Tagged Image File Format (TIFF) of minimum 300dpi and include suitable location identifying information. The resolution of the underlying grid used to produce heatmaps should be appropriate to visualise patterns and/or presented at scale(s) relevant to a particular feature of interest. It is anticipated that multiple heatmaps (and associated data) may be required to adequately visualise all modelled output scenarios.

Reference 2023 : Effects of wind turbine noise on songbird behavior during nonbreeding season Yael Lehnardt, Jesse R. Barber, Oded Berger-Tal Conservation Biology. DOI: 10.1111/cobi.14188. Accepted: 7 September 2023
Anthropogenic noise is one of the fastest growing, globally widespread pollutants, affecting countless species worldwide. Despite accumulating evidence of the negative impacts of wind turbines on wildlife, little is known about how the noise they generate affects ecological systems. Songbirds may be susceptible to noise pollution due to their reliance on vocal communication and thus, in this field study, we examined how songbirds are affected by wind turbine noise. We broadcasted noise produced by one wind turbine in a migratory stopover site during the nonbreeding season. Throughout the study, we repeatedly monitored the acoustic environment and songbird community before, during, and after the noise treatments with passive acoustic monitoring and mist netting. We employed generalized linear mixed effects models to assess the impact of experimental noise treatment on birds' behaviour and likelihood ratio tests to compare models with variables of interest with null models. The daily number of birds in the presence of wind turbine noise **decreased by approximately 30%** compared with the before and after phases. This reduction had a significant spatial pattern; the largest decrease was closer to the speaker and on its downwind side, fitting measured sound propagation. Although we found no impact on species diversity, two out of three most common species showed clear avoidance behaviour: 45% and 36% decrease in abundance for the lesser whitethroat (*Sylvia curruca*) and Sardinian warbler (*Sylvia melanocephala momus*), respectively. In the after phase, there were lingering effects on the lesser whitethroat. The age structure of the lesser whitethroat population was affected because only juvenile birds showed avoidance behavior. No difference in avoidance extent was found between migratory and nonmigratory

species, but the impacts of displacement on migrants during stopover are especially troubling from a conservation perspective. Our results stress the need to address the impacts of noise pollution on wildlife when planning noise-generating infrastructures, such as wind turbines, to allow for sustainable development without threatening already declining songbird populations.

Black Headed Gull

10.8 Sensitivity to development of wind energy.

Adult annual survival of this species is high compared to other species at 90% (Prévot-Julliard et al. 1998), thus exposing individuals to the potential effects of collision mortality across numerous years (Garthe & Hüppop 2004). Contrary to this, Winkelman (1992) found no disturbance of Black-headed Gull feeding and roosting by the presence of operational wind farms. In fact, previous studies have found increases in populations of this species around wind energy installations (Winkelman 1989), possibly through ecological release of resources due to reduced competition. Further, the flight height of Black-headed Gulls below 15 m has been shown to reduce their susceptibility to collision with operating wind turbine rotors (Still et al. 1996). Despite this, measurements at Zeebrugge in Belgium (Everaert et al. 2002) found that Herring, Lesser Black-backed and Black-headed Gulls all exhibited significantly higher mortality by collision than other species present. This report also showed a significant reduction in flights of Black-headed Gulls between the rotor heights of turbines present (36-85 m). Furthermore, the risk of collision was found to be significantly higher at night than during the day (Everaert 2002).

10.9 Zone of Sensitivity

The high mortality of the Black-headed Gull as a result of wind turbine collision (Everaert 2002), combined with the steep observed drop in the species' population within Ireland (Boland & Crowe 2012; Mitchell et al. 2004), justifies a zone of sensitivity being imposed around its current distribution. This is defined by several important breeding colonies at coastal and inland lakes of the Republic of Ireland, with frequent feeding flights across and around potential locations for wind turbines. Given observed flying heights and associated higher risk of collision than other species, a zone of sensitivity of 1km was imposed for this species

14.8 Sensitivity to development of wind energy

In general, this species has been identified as being at particular risk of disturbance displacement and collision as a result of wind energy development (Langston & Pullan 2003). In particular, exclusion from habitat around wind turbines has been identified (Larsen & Clausen 2002), in some cases up to 300 m from wind energy installations.

(Percival 2003). Observations of swan nonbreeding activity from 8 European studies have given a mean minimum distance of 150 m from the base of wind turbines (Hötker et al. 2006), while other studies have shown a reduction of 1-2.5% in available habitat through disturbance displacement (Larsen & Clausen 1998). Whooper Swans have the highest recorded migratory flight height of any species of bird, at up to 8km above sea level (Elkins 1983). However, while moving between roosting and feeding sites, most flocks travel at between 5 and 30 m, putting this species at a much higher risk of collision with medium and large turbines, especially when the size and reduced manoeuvrability of this species is considered (Larsen & Clausen 2002). Though Whooper Swans can avoid turbines and have been known to habituate to these (especially resident birds) their risk of collision is much greater than that of other species. In addition to collisions with turbines themselves, swans have a high observed collision rate with overhead power lines, which may be associated with these installations (Langston & Pullan 2003). Despite this, observed collision rates for Whooper Swans have remained low around the wind energy installations of Europe (Hötker et al. 2006). It is therefore claimed that Whooper Swans are most susceptible to collision with medium sized turbines (10 – 50 m blade height) in the low light conditions of mornings and evenings during winter (Larsen & Clausen 2002). There may also be seasonal variation in this exposure, as flight times have been shown to vary across over-wintering periods (Larsen & Clausen 2002).

14.9 Zone of Sensitivity

Given the high risk of collision with wind turbines in comparison to other species and the observed disturbance to occupied habitat up to 300 m (Percival 2003), Whooper Swans have been assigned a zone of sensitivity of radius 600 m around occupied I-WeBS subsites. A more conservative approach has been taken in this instance given the international importance of the Irish distribution of this species.

4.8 Sensitivity to development of wind energy

In general, breeding waders were identified by an EU assessment of wind energy impacts as being particularly susceptible to disturbance displacement and barriers to movement (Commission 2011). Collision risk for waders is generally deemed to be low, due to a relatively low cursory flight path, coupled with high flight manoeuvrability. A review of pan-European collision assessments revealed much lower Golden Plover collision records than other species, though this was not controlled for survey effort or corpse recovery rates (Hötker et al. 2006). An assessment of disturbance to Golden Plover nesting sites by walking tourists revealed substantially reduced habitat use with 200 m of unimproved paths and to within 50 m of improved paths which contained tourists more effectively. Generally, reduced use of suitable habitat surrounding operating turbines, to within 200 m of the turbine base, has been recorded (Pearce-Higgins et al. 2009). Additionally, a review of 29 other studies suggests Golden Plover will approach wind turbines to an average distance of 175 m in non-breeding season (Hötker et al. 2006), with turbine height positively correlated with displacement distance. Further, modelling of wind energy developments and potential Golden Plover habitat found a negative relationship between wind farms and predicted populations of this species (Pearce-Higgins et al. 2008). However, a recent paper by Douglas et al. (2011) revealed that the installation of wind farms had no observable effect on populations or distributions of breeding Golden Plover up to three years after the completion and operation of turbines. Conversely, disturbance effects observed by Hötker et al. (Hötker et al. 2006) were found in 72% of Golden Plover sites, though these data pertained to non-breeding birds only. This is supported by a longitudinal study of British Golden Plover in the Pennines which revealed that, though birds were disturbed often, reproductive performance did not fall (Finney et al. 2005). Furthermore, post-construction monitoring at 15 upland wind farms showed no significant decline in populations (Pearce-Higgins et al. 2012). Most disturbance effects were measured during the construction phase of these projects. Thus, current research indicates that care be taken in the planning of turbine height and with due diligence during construction of wind farms, especially when positioned on habitat known to support breeding Golden Plovers.

4.9 Zone of Sensitivity

Avoidance of wind turbines and associated infrastructure by breeding Golden Plovers has been observed at distances of at least 200 m (Pearce-Higgins et al. 2008; Finney et al. 2005), with strong correlation between turbine height and disturbance displacement (Hötker et al. 2006). Previous sensitivity mapping assessments have used no zone of sensitivity around Golden Plover habitat, instead demarcating Special Protected Areas (SPAs), within which this species occurs, as an indication of potential distribution. Additional to displacement, collision and barriers effects while migrating for forage up to 10km from nesting sites (Pearce-Higgins & Yalden 2003), as well as consideration of expert opinion, have resulted in the zone of sensitivity for this species being assigned a radius of 800 m around known breeding sites. Though this exceeds smaller recommended distances, the assigned radius allows for ranging around point locations and accounts for increased disturbance. In addition, Irish breeding populations of waders are at greater threat generally through habitat loss and disturbance.

8 Sensitivity to development of wind energy

In general, highly sensitive raptors (such as Hen Harriers) are regarded as being threatened by wind energy development through disturbance displacement and collision (Langston & Pullan 2003). However, limited research exists on the direct effects of wind energy infrastructure on populations of this species, particularly in an Irish context. In terms of collision, the common flight height of Hen Harriers while feeding has been measured at a mean of 10-20 m above the ground, largely ruling out the possibility of collision with active turbines. One study revealed that between 60 – 80% of a Hen Harrier's flight was less than 2 m (Whitfield & Madders 2006). This species may be at greater risk, however, during display flights and inexperienced fledgling flight (Madders 2004). A recent assessment of the effects of a wind farm on an existing population of breeding Hen Harriers reported regular flights at close proximity to turbine bases, some of which were at rotor height (Madden & Porter 2007). This same report revealed that, although reductions in flight activity around turbines were observed during the construction phase, the activity of bird populations quickly returned to pre-construction levels. Aside from collision risk, turbine avoidance by Hen Harriers observed at one wind farm installation extended to within 250 m of turbines (PearceHiggins et al. 2009). Though this study found a halving of flight activity within 500 m of a wind energy array, it found no significant modification in flight height near turbines, although this study also predicted a 52% reduction in breeding population within 500 m of a wind energy array. Madden and Porter thus posit that Hen Harriers will continue to use wind farm sites post-construction, at least in the short-term (Madden & Porter 2007). Further, a recent assessment of Scottish bird

populations and their sensitivity to wind energy development found that over 10% of estimated Hen Harrier range already overlaps with existing wind energy installations (Bright et al. 2008). Having said this, in an Irish context, concern has been expressed surrounding the wide ranging behaviour of Hen Harriers, potentially resulting in overlap of more than one wind farm (Percival 2003).

6.9 Zone of Sensitivity

Within Scottish SPAs, Male harriers travel up to 9km from nesting sites, though home-range size was estimated as 8km2 compared to female home-range of 4.5km2 . Despite this, most hunting by males and females was carried out within 2 and 1km from nests, respectively (Arroyo et al. 2014). From engagement with Irish Hen Harrier experts, observations have shown breeding home ranges up to a radius of 12-15km (O'Donoghue, unpublished satellite tracking data). Across various studies (Clarke et al. 1997; Watson 1977) these Irish ranges are not assumed to be either constant or circular in nature. Therefore, imposing very large circular zones of sensitivity around wintering roosts or breeding locations may devalue such protection measures, especially given that most activity is believed to occur within a central "core" area. Previous sensitivity mapping projects in relation to bird populations have imposed a buffer of 2 km around known Hen Harrier breeding sites (Bright et al. 2009). Further, a safe working distance from nesting Hen Harriers has been delineated at 500 – 1000 m by the Forestry Commission of Scotland (Forestry Commission Scotland 2006). Consequently, a conservative zone of sensitivity of 2km has been delineated around the summer breeding point locations of this species. However, given the sensitive nature of these roost locations, these have been obscured through the random offsetting of an expanded zone of sensitivity, following the protocol outlined in Appendix 3 of this document.

Reference 2023 : Sensitivity analysis of collision risk at wind turbines based on flight altitude of migratory waterbirds. Taito Kamata, Hitomi Sato, Haruka Mukai, Takahiro Sato, Shintaro Yamada, Tsuneo Sekijima. ***Ecol Solut Evid.*** **2023;4:e12222. https://doi.org/10.1002/2688-8319.12222. wileyonlinelibrary.com/journal/eso3**
There are concerns that the construction of wind farms leads to the degradation of landscapes and the natural environment. In particular, impacts on birds and bats, that is, collisions with wind turbines, increased detour costs due to avoidance of wind turbines, and habitat abandonment, are serious problems worldwide (Amorim et al., 2012; Erickson et al., 2014; Harrison et al., 2018; Marques et al., 2019; Masden et al., 2009; Smallwood, 2013). Smallwood (2013) estimated that 573,000 birds and 888,000 bats per year would be killed in installed wind energy capacity by 2012, in the United States, which represented 16.5% of the world's installed wind power (GWEC, 2017).
Bird collisions are influenced by the landscape, terrain and weather in which wind farms are constructed. They are often reported in ecologically sensitive locations such as along flight paths between roosting and foraging areas and on slopes over which the updrafts occur that are used by soaring birds (Drewitt & Langston, 2006; Johnson et al., 2002; Kitano & Shiraki, 2013; Murgatroyd et al., 2021; Peron et al., 2017).
Avoiding selecting areas for the construction of wind farms that are likely to have a strong impact on birds is part of efficient site selection. To this end, the development and introduction of sensitivity maps in advance of planning wind farms have been promoted mainly in Europe and the United States in order to prevent bird collisions (Bright et al., 2009; Garthe & Hüppop, 2004; McGuinness et al., 2015; Retief et al., 2010). Basic information that contributes to creating such sensitivity maps for birds includes major wintering areas and stopover sites, the main habitats of key species and key migration routes (Bright et al., 2009; Garthe & Hüppop, 2004; Retief et al., 2010). Previously proposed sensitivity maps were often based on two-dimensional information concerning the main habitats and distributions of target species (Bright et al., 2009; McGuinness et al., 2015; Retief et al., 2010). Recently, for large raptors, collision risk has been visualized by predicting the area where they fly below the height of the wind turbine based on spatial factors such as slope and distance from the nest (Murgatroyd et al., 2021). However, few research cases have reflected three-dimensional information such as flight altitude, which may vary depending on environmental characteristics, making it impossible to identify high-collision- risk areas.

Greenland White-fronted Geese
13.8 Sensitivity to development of wind energy In general,

Greenland White-fronted Geese are regarded as being threatened by wind energy development through disturbance displacement and collision (Langston & Pullan 2003; Stroud et al. 2012). In some studies, disturbance displacement of this species has been observed up to 600 m, with significantly lower feeding closer to turbines (Kruckenberg & Jaene 1999). Avoidance of roads has also been noted for this species (Mooij 1982), suggesting that infrastructure associated with turbines may also negatively impact this species. Similarly, although collision and disturbance effects are poorly

recorded for this species, a recent assessment of goose feeding found that significantly fewer birds were observed grazing within 40-80 m of low level power lines, though this effect was not observed with higher voltage lines mounted at greater heights (Ballasus & Sassinka 1997). A review of more generalised collision risk with turbines was inconclusive, though examples of flocks flying within large turbine rotor heights have been recorded, particularly in coastal regions (Langston & Pullan 2003). As a result, in a recent species action plan (Stroud et al. 2012) collision with turbines and power lines has been highlighted as a significant threat to the conservation of Greenland Whitefronted Geese.

13.9 Zone of Sensitivity

Little research has been conducted on the disturbance distances of this species. However, reduced numbers of this species have been observed feeding up to 600 m from wind turbines (Kruckenberg & Jaene 1999). Additionally, a review of various assessments by Langston and Pullan (2003) indicated that distances of up to 600 m should be used in any exclusion for geese. The zone of sensitivity for this species has thus been set at 600 m, demarcated around the Special Protected Areas (SPAs) within which the major flocks of wintering Greenland White-fronted Geese are found.

Appendix 7.1 VP Survey Details, 2021-2023.pdf [PDF]
Appendix 7.2 Bird Survey VP Flight Line Data, 2021-2023 .pdf [PDF]
Appendix 7.3a Summer 2021 Flightlines.pdf [PDF]
Appendix 7.3b Winter 2021-2022 Flightlines.pdf [PDF]
Appendix 7.3c Summer 2022 Flightlines.pdf [PDF]
Appendix 7.3d Winter 2022-2023 Flightlines.pdf [PDF]
Appendix 7.4 Lackan Bay Shoreline Surveys Details, 2021-2023.pdf [PDF]
Appendix 7.5 Transect Surveys - Survey Details, 2022-2023.pdf [PDF]
Appendix 7.6 Transect Surveys - Results, 2022-2023.pdf [PDF]
Appendix 7.7 Merlin, Woodcock and Waders Breeding Survey Details 2023.pdf [PDF]
Appendix 7.8 Winter Hen Harrier Roost Survey Details, 2022-2023.pdf [PDF]

Our Case Number: ABP-319307-24

Your Reference: Laurclavagh Limited

Date: 14 May 2026

Re: Proposed no 8 wind turbines and associated works.
Laurclavagh and adjacent townlands, Co. Galway. (www.laurclavaghplanning.com)

Item 1: Ornithology (EIAR & NIS)

1.1 Black-headed Gull – Collision Risk Assessment Against SPA Population

Notwithstanding the updated collision risk assessment provided in the EIAR Addendum, the Department of Housing, Local Government and Heritage (DHLGH/DAU), in its post-Further Information submission dated 4 December 2025, has confirmed that the revised NIS continues to contextualise Black-headed Gull collision mortality against county-level population figures rather than against the relevant breeding population of Lough Corrib SPA.

You are requested to provide the following:

i) A revised collision risk assessment for Black-headed Gull that expresses projected annual collision mortality as a proportion of the Lough Corrib SPA breeding colony population, consistent with the requirements of Percival (2003) as clarified by the DHLGH in its submissions of 9 May 2024 and 4 December 2025.

ii) Confidence intervals (at minimum 95% confidence level) around all CRM output figures for Black-headed Gull, including both the stochastic and

extended stochastic model outputs, with a commentary on the implications of the confidence interval for the conclusion of no adverse effect.

iii) Evidence demonstrating whether Black-headed Gulls recorded on or in transit through the proposed wind farm site during the breeding season (April to August inclusive) have been assessed as associated with the Lough Corrib SPA breeding colonies, with reference to the 18.5 km mean maximum foraging range specified in the NPWS conservation objectives for the SPA (NPWS, 2023). If such an assumption is contested you must provide scientific justification to support an alternative population attribution.

iv) Confirmation of the total breeding population figure used as the denominator in the revised CRM and the source documentation for that figure. Where this figure is based on NPWS survey data the relevant survey year and methodology must be cited.

1.2 Black-headed Gull – In-Combination Cumulative Collision Risk

The DHLGH has confirmed in its post-Further Information submission that the additive cumulative collision risk assessment for Black-headed Gull requested in the original Further Information request has not been provided.

You are requested to provide the following:

i) An additive in-combination cumulative collision risk assessment for Black-headed Gull, incorporating all wind farm developments (consented, under construction or with applications lodged) whose footprints fall within the 18.5 km mean maximum foraging range of the Lough Corrib SPA Black-headed Gull breeding colonies, regardless of the distance of those developments from the Laurclavagh site. This assessment must present the cumulative projected annual mortality as a proportion of the SPA breeding population.

ii) An assessment of the in-combination effect of the cumulative projected mortality on the ability of the Lough Corrib SPA Black-headed Gull population to maintain or recover to favourable conservation status, with reference to the population viability analysis or equivalent demographic assessment required to support a conclusion of no adverse effect on site integrity under Article 6(3) of the Habitats Directive.

1.3 Nocturnal and Crepuscular Bird Surveys

The collision risk modelling for Whooper Swan and for other species with primarily nocturnal or crepuscular activity patterns is based exclusively on daytime vantage point survey data. This represents a potential systematic underestimation of collision fatality for those species whose transit activity is concentrated outside the hours during which surveys were conducted.

You are requested to provide the following:

i) A written assessment of the potential for underestimation of Whooper Swan collision fatality arising from the exclusive reliance on daytime vantage point surveys. This assessment must address: (a) the proportion of Whooper Swan activity at this site that is likely to occur during nocturnal and crepuscular periods, with reference to the known roosting and feeding ecology of the species and the documented use of the surrounding wetland network; (b) the implications of this temporal survey gap for the CRM output and whether the point estimate presented can be considered a reasonable approximation of total risk or represents a lower bound only; and (c) whether you consider additional targeted survey effort necessary to adequately characterise nocturnal collision risk, with clear reasoning provided in either case.

ii) The same assessment must address any other species recorded in the EIAR surveys for which nocturnal or crepuscular activity represents a primary or significant risk period, including Barn Owl, setting out in each case whether the absence of nocturnal survey data affects the reliability of the collision or disturbance assessment for that species.

Item 2: Bats (EIAR & NIS)

2.1 A bat collision risk analysis should be undertaken based on Table 3-6 and Table 3-7 of the Bat Report (Appendix 6-2). Collision risk analysis should be based on worst case scenarios and the collision risk calculations should be revised, where applicable.

2.2 You should clarify the presence of any Lesser Horseshoe Bat roosts within the site vicinity. Consultation in relation to this matter should be carried out with NPWS and submitted in any response.

Item 3: Hydrology / Hydrogeology (EIAR & NIS)

Our Case Number: ABP-320089-24

Your Reference: Clonberne Windfarm Limited

Date: 04 June 2026

Hydrology/Hydrogeology

Point 6 under the heading 'Procedural/Administrative Issues' in the Commission's request for further information dated 15th May 2025 sought a detailed response to the submissions received from observers, prescribed bodies and the local authority to the application.

Having reviewed the further information submission received on the 5th December 2025 the Commission considers that the material submitted does not provide the requisite level of detail or reasoned justification necessary to demonstrate that the issues raised specifically with respect to hydrology and hydrogeology in the 3rd party submissions have been fully considered, appropriately addressed or satisfactorily clarified. It is considered that the evidence presented does not robustly support the lack of potential effects on Levally Lough SAC and Lough Corrib SAC due to a low confidence in the interpretation of the water level data and the generation of water level contours, the lack of field based evidence on permeability and vertical hydraulic gradients, and the paucity of groundwater level data in some areas and the surface water connections to the SAC features.

Accordingly you are requested to provide clarification on the points set out below to resolve the outstanding matters arising from the further information response:

(1) Full details of the construction of purpose drilled monitoring boreholes and third party boreholes to understand which hydrogeological layer the water level data pertains to.

(2) Full details of the water level monitoring including quality control procedures, details of vertically stable elevation reference points (to ensure that any movement in the bog surface is taken account of), barometric correction of electronic data (if appropriate), and manual measurements.

(3) Re-analysis of groundwater contours to include all contours and contour closure, and extrapolation to all turbine bases and the Kilmurray (Gortagarraun) Turlough.

(4) Provide field evidence of vertical hydraulic gradients and groundwater head profile in the principal hydrostratigraphic layers.

(5) Provide field evidence of the hydraulic conductivity of the limestone Till.

(6) Extrapolate the thickness of the limestone Till across the site to encompass all the turbine locations and principle water courses.

(7) Provide conceptual cross sections to illustrate the hydrogeological conceptual model, including the groundwater head profile and hydraulic conductivities, between the site, the Dunmore/Glenamaddy PWS, Kilmurray (Gortagarraun) Turlough and the Levally Stream.

(8) Provide conceptual cross sections to illustrate the hydrogeological conceptual model, between the site, the Sinking River, the Grange (Galway) River and the Levally Turlough.

(9) Provide a technical analysis to assess the risk of heave / breakthrough due to high groundwater heads below the limestone Till (if present) at the gravity foundation pit locations.

(10) Provide a technical assessment of the risks associated with increased Dissolved Organic Carbon in runoff from peat areas disturbed by the development and the peat stockpile.

(11) Provide details of walk over surveys and corroborative data such as (but not limited to) LiDAR, aerial imagery or similar to evidence the assertion that no point recharge features such as swallow holes, dolines etc are present at the ground surface on the Wind Farm site.

Ornithology

Having reviewed the further information submission received on the 5th December 2025 the Commission considers that the material provided does not adequately address or sufficiently clarify several matters with respect to ornithology.

On this basis it is considered that there is lacunae in the information before the Commission which precludes a full and proper assessment. Accordingly, you are requested to provide clarification on the points set out below to resolve the outstanding matters:

1. ***Eurasian Curlew***

Eurasian Curlew is an Annex 1 species under the EU Birds Directive and is Red Listed in Ireland. The applicant's Further Information response characterises Clonberne as a site of no ecological importance to the species on the basis of six VP observations at or within 500m of the wind farm site. It is considered that a narrative conclusion that the site is of no ecological importance to the species does not constitute a sufficient justification in the absence of engagement with all available evidence. The

characterisation does not engage with: (i) a June 2023 breeding walkover observation of 11 Curlew on the site, consistent with a post-breeding congregation that may include recently fledged young; (ii) a March 2023 National Biodiversity Data Centre record describing possible breeding behaviour in the vicinity; or (iii) peak counts of 280 individuals at nearby wetland sites during the 2023 waterbird distribution surveys. No targeted Curlew breeding survey was conducted and no Collision Risk Model was produced for this species. VP surveys, being primarily daylight watches, are not the optimal methodology for detecting peak crepuscular Curlew activity and this needs to be addressed in this response.

(a) Provide a reasoned assessment of the breeding status of Curlew within and immediately adjacent to the wind farm site, engaging specifically with each of the lines of evidence identified above. Confirm whether the absence of a targeted breeding survey is consistent with the precautionary approach required under the Habitats and Birds Directives given the national conservation status of the species.

(b) Provide either: (i) a Collision Risk Model for Curlew as a Key Ornithological Receptor, using all available VP records of Curlew flight at Potential Collision Height; or (ii) a fully reasoned justification, supported by VP data, for the exclusion of this species from the CRM.

2. *Golden Plover and Lapwing*

The Collision Risk Model predicts 7.6 to 15.1 Golden Plover fatalities and approximately 20.6 Lapwing fatalities per year from the proposed development alone. Golden Plover is Annex I listed. Lapwing is Red-listed in Ireland with a documented severe national decline. The EIAR asserts no significant population-level effects for either species, but this assertion is not supported by any quantitative analysis of population-level significance. The applicant notes that the individual site Golden Plover rate is small relative to the Irish wintering population, but no comparable contextualisation is provided for Lapwing, and neither species is assessed in quantitative cumulative terms across the broader wind energy development cluster in the area. Multiple wind energy projects are known to be at various stages of development in the wider area, some of which are not included in your cumulative baseline.

(a) Provide a more detailed assessment of the significance of the predicted annual collision mortality for Lapwing, having regard to national population trends, regional abundance data and the proportion of the relevant population potentially affected. The significance conclusion should follow from the analysis rather than precede it.

(b) Provide a quantitative cumulative collision mortality assessment for Golden Plover and Lapwing, combining the predicted annual mortality from the proposed development with estimated annual mortality (where available) from each of the existing and consented wind energy developments included in the cumulative baseline. Where collision data for those developments is unavailable, a justified estimation methodology should be applied and stated. The scope of the cumulative baseline should be confirmed and the basis for including or excluding individual projects stated.

(c) Confirm whether overhead line developments in the area were included in the cumulative assessment as required by Further Information Item 5. If not, provide the required assessment.

3. *Kiltullagh Lough pNHA*

Table 6-3 of the EIAR concluded that a pathway of likely significant effect existed between the proposed development and Kiltullagh Lough pNHA, and the Commission's Further Information Item 8 required the site to be included as a Key Ecological Receptor (KER) on that basis. Your response does not add Kiltullagh Lough pNHA as a KER. Your statement that the concluding sentence of Table 6-3 was a

scrivenors error that contradicted the preceding screening text and that the correct conclusion should record no pathway and no requirement for further assessment is noted. Kiltullagh Lough holds nationally important concentrations of waterbirds: IWeBS peak counts include 1,700 Golden Plover (exceeding the 1% national threshold of 920 individuals) and 1,850 Lapwing (exceeding the 1% national threshold of 850 individuals).

(a) You are requested to confirm unambiguously which version of the Table 6-3 conclusion is correct. If you maintain that the pathway conclusion was an error, provide a clear statement of the reasoning that was intended to appear in Table 6-3, such that the Commission can assess whether the intended reasoning, rather than the text as published, justifies the screening-out conclusion.

(b) Irrespective of the Commission's determination on the scrivenors error question, provide an assessment of the degree of ornithological connectivity between Kiltullagh Lough and the wind farm site, having regard to the nationally important waterbird concentrations recorded at the lough. Specifically, confirm whether the movement of Golden Plover and Lapwing between this site and the wind farm area has been assessed in Chapter 7 of the EIAR to a standard adequate for the Commission's purposes.

4. Wake effects on birds

Further Information Item 6 required the applicant to clarify whether wake effects from the proposed turbines will affect birds. Your response refers to the original EIAR assessment and characterises the existing research literature as limited and largely dated, without providing new site-specific analysis. This response is considered inadequate in the context of the specific clarification sought.

Provide a site-specific assessment of the potential for wake turbulence from the proposed turbines to affect the flight behaviour, energy budgets or collision risk of bird species recorded using the site and its immediate surrounds, in particular species moving between the wind farm area and adjacent wetland habitats. The assessment should address both direct aerodynamic effects on individual birds and any potential barrier effect on flight corridors. Where published evidence is relied upon, it should be current and clearly referenced.

Age of Survey Data and Validity of Reports

You are invited to respond to the submission received by the Commission from the Department of Housing, Local Government and Heritage dated 4th March 2026 in response to the further information response (copy attached) in which the age of survey data and consequent validity of reports has been raised.

Provide a formal written statement(s), signed by the responsible professional(s), confirming the validity or otherwise of the survey dataset in accordance with CIEEM (2019) Advice Note on the Lifespan of Ecological Reports and Surveys. The statement(s) should: (i) confirm the date on which the site visit for the purposes of this statement was undertaken; (ii) identify which surveys within the dataset remain valid without update; (iii) identify which surveys require updating and why; and (iv) specify the scope, timing and methodology of any update surveys required, together with a programme for their completion

The further information referred to above should be received by the Commission within 4 months from the date of this notice (i.e. no later than the 5th of October 2026)

In this regard, please submit 2 hard copies and one electronic copy of the above information.

Please note that following its examination of any information lodged in response to this request for additional information, the Commission will then decide whether or not to invoke its powers under section 37F(2) of the Planning and Development Act 2000, as amended, requiring you to publish notice of the furnishing of any additional information and to allow for inspection or purchase of same and the making of further written submissions in relation to same to the Commission.

If you have any queries in relation to the matter please contact the undersigned officer of the Commission. Please quote the above mentioned An Coimisiún Pleanála reference number in any correspondence or telephone contact with the Commission.

Yours faithfully.

Sinead White

Sinead White
Executive Officer
Direct Line: 01-8737202

PA11

An Roinn Tithiochta,
Rialtais Áitiúil agus Oidhreachta
Department of Housing,
Local Government and Heritage

Planning Ref: PA07.320089
(Please quote in all related correspondence)

4th March 2026

Secretary
An Bord Pleanála,
64 Marlborough Street,
Dublin 1
D01 V902

Via email: laps@pleanala.ie

Re: Notification to the Minister for Housing, Local Government and Heritage under the Planning and Development Act, 2000, as amended.

Proposed Development: SID application for windfarm development consisting of up to 11 Wind Turbines in the Townlands of Townlands of Killavoher, Kilmurry, Gortagarraun, Cloonarkan, Clonberne, Laughil, Lomaunaghroe and Ballyedmond, Co. Galway

A chara

I refer to correspondence received in connection with the above. Outlined below are the Heritage related observations/recommendations co-ordinated by the Development Applications Unit under the stated headings.

Archaeology

It is noted that the Environmental Impact Assessment Report (EIAR) submitted as part of the planning application includes a desk-based Archaeological Impact Assessment (AIA) which was carried out in relation to the proposed development by Tobar Archaeological Services (EIAR Chapter 13; date 20 June 2024).

It is noted that an Advance Archaeological Geophysical Survey (Detection Device Consent 25E0306) has now been carried out at the proposed location for turbine T2 and its associated infrastructure. This additional survey was carried out in response to a Request for Further Information from An Bord Pleanála (now An Commisiún Pleanála).

The proposed development is located in proximity to a number of Recorded Monuments which are subject to statutory protection under Section 12 of the National Monuments (Amendment) Act 1930-2014. The EIAR acknowledges that there is a potential that previously unknown sub-surface archaeological features or deposits may be present

within the proposed development site (PDS). The Department notes that no advance archaeological investigations have been carried out within the PDS to inform the EIAR, other than a walkover survey and the localised Advance Archaeological Geophysical Survey (limited to T2 and its environs). It is advised that comprehensive advance archaeological test excavation should be carried out in advance of any development to determine if previously unknown sub-surface archaeological features or deposits are present. If such material is present, then additional mitigation measures to ensure the preservation in situ or preservation by record (i.e. full archaeological excavation) of such discoveries will be necessary. This can be addressed by the inclusion of an appropriate condition, if the development is permitted.

In that regard, it is noted that Recorded Monument GA030-073---- (Enclosure) is located c. 22m to the east of the hardstand for T2 and as a result may be particularly vulnerable to impact from the proposed development. While this monument is partially upstanding and visible in the landscape it may have a larger sub-surface extent. The results of the Advance Archaeological Geophysical Survey did not identify any potential archaeological features related to the monument within the area surveyed. It did identify some possible pit-features within the footprint of proposed T2, which would be directly impacted by the development if permitted. The advance archaeological geophysical survey has provided the required information to the design of an appropriate exclusion zone to protect this vulnerable monument at both construction and decommissioning phases. This can be addressed by the inclusion of an appropriate condition, if the development is permitted.

Advance archaeological test excavation will be needed to confirm if the possible pit-features within the footprint of proposed T2 are indeed sub-surface archaeological features. If this proves to be the case, then additional mitigation measures to ensure the preservation in situ or preservation by record (i.e. full archaeological excavation) of will be necessary. This can be addressed by the inclusion of an appropriate condition, if the development is permitted.

The Department notes that exclusion zones may be necessary to protect vulnerable heritage assets located in proximity to the proposed development site (PDS) and ensure that they are safely preserved in situ during the construction phase. In that regard, it is advised that similar measures may be required at decommissioning phase also and that the advice of a suitably qualified archaeologist may be needed to inform any plan for decommissioning of the development in due course. This can be addressed by the inclusion of an appropriate condition if the development is permitted.

The Department has reviewed the EIAR and advises that the following should be included as a condition of any grant of permission. Note these recommended conditions align with Sample Conditions C3, C5 and C6 as set out in *OPR Practice Note PN03: Planning Conditions* (October 2022), with appropriate site-specific additions/adaptations based on the particular characteristics of this development and informed by the findings of the EIAR.

Archaeological Requirements:

1. All mitigation measures in relation to archaeology and cultural heritage as set out in Chapter 13 of the EIAR (Tobar Archaeological Services; date 20 June 2024) shall

be implemented in full, except as may otherwise be required in order to comply with the conditions of this Order.

2. The developer shall engage a suitably qualified archaeologist (licensed under the National Monuments Acts) to carry out pre-development archaeological testing in areas of proposed ground disturbance and to submit an archaeological impact assessment report for the written agreement of the planning authority, following consultation with the Department of Housing, Local Government and Heritage, in advance of any site preparation works or groundworks, including site investigation works/topsoil stripping/site clearance and/or construction works.

   a. The results of the advance geophysical survey shall inform the design of any trench array to assess the location of Turbine 2 and its associated infrastructure as part of the overall testing programme.

   b. The report shall include an archaeological impact statement and mitigation strategy. Where archaeological material is shown to be present, avoidance, preservation in-situ, preservation by record (archaeological excavation) and/or monitoring may be required.

   c. Any further archaeological mitigation requirements specified by the planning authority, following consultation with the Department of Housing, Local Government and Heritage, shall be complied with by the developer.

   d. No site preparation and/or construction works shall be carried out on site until the archaeologist's report has been submitted to and approval to proceed is agreed in writing with the planning authority.

3. A suitably qualified archaeologist shall be retained to advise on, and establish appropriate Exclusion Zones around the external-most elements of vulnerable Heritage Assets (as identified in Chapter 13 of the EIAR or by any subsequent investigations associated with the project).

   a. The Exclusion Zone to protect Recorded Monument GA030-073---- (Enclosure) shall extend a minimum of 20m from the known extent of the monument as established by field survey and the Advance Geophysical Survey.

   b. Exclusion Zones shall be fenced off or appropriately demarcated for the duration of construction works in the vicinity of the monuments. The location and extent of each Exclusion Zone and the appropriate methodology for fencing off or demarcating at each location shall be agreed in advance with the Department of Housing, Local Government and Heritage and the planning authority.

   c. No groundworks of any kind (including but not limited to advance geotechnical site investigations) and no machinery, storage of materials or any other activity related to construction will be permitted within Exclusion Zones.

4. The Construction Environment Management Plan (CEMP) shall include the location of any and all archaeological or cultural heritage constraints relevant to the proposed development as set out in Chapter 13 of the EIAR and by any subsequent archaeological investigations associated with the project. The CEMP shall clearly describe all identified likely archaeological impacts, both direct and indirect, and all

mitigation measures to be employed to protect the archaeological or cultural heritage environment during all phases of site preparation and construction activity.

5. The applicant shall retain the services of a suitably qualified archaeologist to advise on an archaeological mitigation plan for decommissioning of the development, to include mitigation measures for the removal of the turbines and the protection of any archaeological sites and monuments that are *in situ* at the site. The *Decommissioning Plan* shall be updated to include the location of any archaeological or cultural heritage constraints as set out in Chapter 13 of the EIAR and by any subsequent archaeological investigations associated with the project. It shall clearly describe all identified likely impacts from decommissioning—both direct and indirect—and all mitigation measures to be employed to protect the archaeological or cultural heritage environment during decommissioning works.
6. The planning authority and the Department of Housing, Local Government and Heritage shall be furnished with a final archaeological report describing the results of all archaeological monitoring and any archaeological investigative work/excavation required, following the completion of all archaeological work on site and any necessary post-excavation specialist analysis. All resulting and associated archaeological costs shall be borne by the developer

Reason: To ensure the continued preservation (either *in situ* or by record) of places, caves, sites, features or other objects of archaeological interest.

Nature Conservation

The following observations are made by the Department in its role as a prescribed body under planning legislation and as the authority with overarching responsibility for nature conservation and the nature directives (i.e. the Birds and Habitats Directives) and wider biodiversity.

It is noted that multidisciplinary walkover surveys were undertaken on the 28th June 2019, 15th July 2019, 19th August 2019, 5th August 2021, 24th August 2021, 25th August 2021, 24th January 2022, 30th September 2022, 1st October 2022, 26th June 2023, 1st September 2023, 23rd November 2023 and the 18th January 2024. Therefore the survey data is mostly 3-4 years old. Chartered Institute of Ecology and Environmental Management (CIEEM) advice[1] in relation to surveys more than 3 years old is that the report is unlikely to still be valid and most, if not all, of the surveys are likely to need to be updated (subject to an assessment by a professional ecologist).

Rivers and Wetlands

It is noted that surveys of the watercourses within the vicinity of the proposed wind farm project were conducted in August 2021 by Triturus Environmental Ltd. Therefore, the survey data is now mostly 4 years old. Chartered Institute of Ecology and Environmental Management (CIEEM) advice[2] in relation to surveys more than 3 years old is that the report

[1] CIEEM Advice Note on the Lifespan of Ecological Reports & Surveys, April 2019 https://cieem.net/wp-content/uploads/2019/04/Advice-Note.pdf

[2] CIEEM Advice Note on the Lifespan of Ecological Reports & Surveys, April 2019 https://cieem.net/wp-content/uploads/2019/04/Advice-Note.pdf

is unlikely to still be valid and most, if not all, of the surveys are likely to need to be updated (subject to an assessment by a professional ecologist).

Bats
It is noted that a comprehensive suite of bat surveys was undertaken at the Proposed Project site in 2022. Therefore, the survey data is now mostly 3 years old. Chartered Institute of Ecology and Environmental Management (CIEEM) advice[3] in relation to surveys up to 3 years old is that a professional ecologist will need to undertake a site visit and may also need to update desk study information (effectively updating the Preliminary Ecological Appraisal) and then review the validity of the report. Some or all of the ecological surveys may need to be updated. The professional ecologist will need to issue a clear statement, with appropriate justification, on:

- The validity of the report;
- Which, if any, of the surveys need to be updated; and
- The appropriate scope, timing and methods for the update survey(s).

Bird Surveys
It is noted that breeding and wintering bird surveys were undertaken during the period October 2017 to March 2020 and October 2022 to September 2023, encompassing three full breeding seasons and four full winter seasons, as well as autumn and spring migration periods. Therefore the survey data is 18 months to 3 years old. Chartered Institute of Ecology and Environmental Management (CIEEM) advice[4] in relation to surveys between 18 months and 3 years old is that a professional ecologist will need to undertake a site visit and may also need to update desk study information (effectively updating the Preliminary Ecological Appraisal) and then review the validity of the report. Some or all of the ecological surveys may need to be updated. The professional ecologist will need to issue a clear statement, with appropriate justification, on:

- The validity of the report;
- Which, if any, of the surveys need to be updated; and
- The appropriate scope, timing and methods for the update survey(s).

You are requested to send any further communications to this Department's Development Applications Unit (DAU) at manager.dau@npws.gov.ie where used, or to the following address:

The Manager,
Development Applications Unit (DAU),
Government Offices,
Newtown Road,
Wexford,Y35 AP90

Is mise, le meas

[3] CIEEM Advice Note on the Lifespan of Ecological Reports & Surveys, April 2019 https://cieem.net/wp-content/uploads/2019/04/Advice-Note.pdf
[4] CIEEM Advice Note on the Lifespan of Ecological Reports & Surveys, April 2019 https://cieem.net/wp-content/uploads/2019/04/Advice-Note.pdf

Simon Dolan
Development Applications Unit
Administration

9 LAND, SOILS & GEOLOGY

Chapter 8: Soils & Geology, of the EIAR evaluates the effects of the Proposed Development arising from the construction/decommissioning and operational phases on the land, soils and geology within and surrounding the Redline Boundary. The assessment is based on desk studies and Site surveys.

The Proposed Development is situated within an area comprised of agricultural livestock grazing farmland, cutaway bog and conifer forestry plantation.

Subsoils underlying the Site are characterised generally as cutover peat. Peat depth across the Site is generally shallow to moderately deep with isolated pockets of deeper peat. The bedrock underlying the proposed wind farm includes sandstones, siltstones and shales of the Downpatrick Formation and the Mullaghmore Sandstone Formation, whilst limestone pertaining to the Ballina Limestone Formation underlies parts of the Grid Connection. There are no karst features located in the vicinity of any of the main structural elements of the Proposed Development.

Reference 2022 : Groundwater Resources in a Complex Karst Environment Involved by Wind Power Farm Construction Alessio Valente , Vittorio Catani, Libera Esposito, Guido Leone , Mauro Pagnozzi and Francesco Fiorillo. Sustainability 2022, 14, 11975. https://doi.org/10.3390/ su141911975 326

When wind farms are built in karst areas, the major interest for researchers, communities and economies is to evaluate the impacts on the quantity and the quality of groundwater. This is because karst areas are of fundamental importance to people since they hold huge groundwater reservoirs, which feed springs and represent the main source of fresh water in many areas of the world.
The recharge of the groundwater resources is produced by the infiltration of the surface water into the underground, which occurs in a concentrated or diffuse manner. Concentrated infiltration occurs at points, such as sinkholes/shafts and swallow holes, and allows for the fast transfer of water from the surface to the underground. On the other hand, diffuse infiltration occurs via the soil mantle or fractures in the outcropping karst rocks, and generates percolation, which can take a significant amount of time before water reaches the water table.
In karst areas, infiltration is strongly controlled by the features of the topographic surface, which is generally characterized by peculiar landforms called endorheic areas. These are closed depressions where the internal runoff is completely absorbed by one or more sinkholes or swallow holes. Endorheic areas represent important recharge areas for groundwater, and are often connected to one or more springs.
In such an environment, wind farms can affect groundwater resources in several different ways. Water quantity and quality may change due to alterations in the natural surface and subsurface flow paths and the interactions between the groundwater and surface water. Water can be diverted by road systems or systems for collecting rainwater, avoiding the supply to endorheic areas and sinking streams. The excavation and extraction of geological material can also alter the surface and groundwater flow, draining water and moving it away from the springs. Water quality can be affected by activities that aggravate soil erosion and alter the surface conditions, such as heavy equipment traffic, rock and soil extraction/accumulation for the construction of access roads to work sites, as well as the excavation of deep foundations.

Geological Survey of Ireland (GSI) online mapping records the Proposed Development to be located predominantly on lands of 'Low to Moderate' landslide susceptibility, with isolated areas in the north mapped as having 'Moderately High' susceptibility. However, GSI mapping records no incidents of a peat landslide occurrence either within the Project or within the 2 km Study Area buffer. The closest recorded incident, in this respect occurred at Shanettra in 2000, approximately 8 km to the south west of the site. No indications of existing stability issues or historic mass movement were observed on the Site during site surveys.

Site specific detailed Peat Landslide Hazard Assessment has also been undertaken for the Proposed Development. This assessment has determined there to be either 'Low' or 'Negligible' hazard in relation to peat stability issues at the

main infrastructure prior to application of mitigation. Proposed mitigation will result in an overall reduction to 'Negligible' hazard, in respect to Peat Landslide hazard.

The likely potential effects on land, soils and geology *(along with their pre-mitigation significance)* arising during the construction phase as a result of the Project have been identified as follows;

- Land take (temporary and permanent) **Not Significant** (Moderate)
- Compaction, erosion and degradation of soils. **Not Significant** (Moderate)
- Subsoil and bedrock removal **Not Significant** (Moderate)
- Stability issues (excavations, peat, spoil storage) **Significant** (Significant)
- Soil contamination **Significant** (Moderate)

No new significant effects are anticipated during the operational phase. These will be the same as for the construction phase, but of a reduced magnitude.

No new significant effects are anticipated during the decommissioning phase. These will be the same as for the construction phase, but of a reduced magnitude.

The potential effects in relation to land soils and geology are considered localised, direct effects. However, there is also the potential for soils and geology to intercept downstream receptors such as surface water and groundwater or ecology as indirect or secondary effects. Such indirect effects have also been considered during the assessment process.

The cumulative effects of the soils and geology of the Project consider the importance of soils and peatlands in particular, in terms of ecological value and carbon value. Aims and objectives for soil quality and soil health are outlined in the EU Soil Strategy (EC, 2021), which includes for protecting and reducing degradation of soils. The Project will have a positive benefit in this respect, by limiting drainage of wetlands and organic soils as well as restoring managed and drained peatlands, reducing erosion and restoring degraded soils.

Mitigation measures presented and detailed in the Chapter address the likely effects identified and include key design and management principals in line with cited industry Best Practice and Guidance. Mitigation in summary includes:

- Mitigation by design, including mitigation by avoidance and reduction

Infrastructure designed to avoid potentially hazardous areas such as areas with deeper peat or shallow bedrock as far as possible and within the constraints of other environmental receptors.

Floating tracks where suitable and geotechnically feasible to reduce the excavation of peat.

Minimising the amount of soils and bedrock to be excavated / disturbed through design

- Mitigation by best practice

Minimising disturbance of soils by limiting vehicular movements and restricting spoil storage to within the footprint of the development.

Minimising the potential for stability issues by controlling vehicular movements and the careful siting of soil storage on suitable lands within the development.

Spoil Management: excavated material will be appropriately segregated for reinstatement and stored appropriately to reduce the potential of erosion and degradation of soils.

- Mitigation by reuse

Spoil Management: whenever possible, soil and rock will be reused immediately. Any surplus spoil will be appropriately stored in designated storage areas and retained on-site for the duration of the Project. This material will be reused during reinstatement and restoration works during the decommissioning phase.

Excavated bedrock will be reused for access tracks or hardstand fill material.

Mitigation measures outlined in **Chapter 8** are imbedded into the CEMP. This CEMP will be updated by the civil engineering contractor and agreed prior to any works commencing on Site.

The unavoidable residual effects on the soils and geology environment as a function of the Development is that there will be a change in ground conditions at the Site, during the construction phase, with natural materials such as peat, subsoil and bedrock being replaced by concrete, subgrade and surfacing materials. The long-term or permanent residual effects on the geological receiving environment resulting from the construction phase of the Project is at most Moderate / **Not Significant** with respect to EIA.

The long-term residual effects associated with the operational phase will be Slight / **Not Significant** with respect to EIA, following the adoption of mitigation through good site practice in relation to vehicular movement controls, hydrocarbon and other pollution prevention controls, sustainable use of natural resources and protection measures for human health.

The main residual effects associated with decommissioning include waste generation, potential hydrocarbon spills and erosion of soil and rock. Following reinstatement works, it is expected that the Project will be returned as close to its present condition as possible. In particular, areas of peat and current drainage regimes will be reinstated and left to revegetate naturally with the passage of time and the Site will revert over time to a more natural drainage regime. It is expected that the long-term residual effects associated with the Project will therefore be Slight / **Not Significant** with respect to EIA.

Response from MLavelle: The changes in ground temperatures will have a lasting effect on surrounding farming activities, with animal effects & crop losses. The proposed site area has historic bog landslide issues.

10 HYDROLOGY, HYDROGEOLOGY

Chapter 9: Hydrology & Hydrogeology, of the EIAR assesses all elements of the Proposed Development and potential effects arising from the construction/ decommissioning and operational phases.

A comprehensive impact assessment of the proposed Tirawley Wind Farm development (i.e. the Proposed Development) on the hydrological and hydrogeological environment has been undertaken. The assessment is based on a desk study, walkover surveys, site investigations, baseline surface water quality and water flow monitoring. This chapter assesses the likely significant effects that the Proposed Development may have on the hydrological and hydrogeological environment and prescribes mitigation measures to avoid, reduce or offset any potential significant effects.

Regionally, the Wind Farm Site is located in the Blacksod-Broadhaven Bay surface water catchment and inside the Glencullin River sub-catchment. More locally, the majority of the Wind Farm Site is drained by the Cloonalaghan River which discharges into Lackan Bay. Some areas on the northeast of the Wind Farm Site are drained by small streams which flow directly into the sea.

Surface water drainage at the Wind Farm Site is currently enhanced by a network of manmade drains. The nature of these drains depends on the local land use. In agricultural areas, drainage is facilitated by manmade field drains that are typically routed along hedgerows and field boundaries and discharge locally to nearby streams. In the existing forestry plantations, a network of mound and ribbon drains run perpendicular to the local topographic contours and feed into interceptor drains downgradient of the forestry plantations. The forestry drainage system flows towards and discharges into natural streams located downgradient of the plantations.

In the vicinity of the Wind Farm Site, the Grid Connection is drained by the Cloonalaghan River. Further south, the Grid Connection is located in the Moy and Killala Bay surface water catchment and is drained by the Cloonaghmore River and its tributaries. Further east, in the vicinity of Killala Business Park the Grid Connection is drained by the Moyne Stream. There are a total of 10 no. watercourse crossings along the Grid Connection over natural watercourses. These are located at existing bridge and culvert locations.

A site-specific flood risk assessment was undertaken for the Proposed Development. The assessment concluded that the Proposed Development is not located in an area that is susceptible to flooding and is deemed to be suitable from a flood risk perspective, Drainage attenuation will be applied to ensure no impacts on downstream flooding will occur as a result of the Proposed Development.

In terms of the baseline hydrogeological environment, the Wind Farm Site is predominantly underlain by a Poor Aquifer associated with the Belmullet Groundwater Body. These rocks are devoid of intergranular permeability, groundwater flowpaths will be short (30-300 m) and will be concentrated in weathered zones. Some areas in the northeast and south of the Wind Farm Site are underlain by a Locally Important Aquifer and the Killala North Groundwater Body which is characterised by productive fissured bedrock.

Due to the nature of wind farm developments, being near surface construction activities, effects on groundwater are generally negligible and surface water is generally the main sensitive receptor assessed during impact assessments. The primary risk to groundwater would be from oil spillage and leakages at turbine foundations or during construction plant refuelling. These are common potential impacts to all construction sites (such as road works and industrial sites). These potential contamination sources are to be carefully managed at the during the construction and operational phases of the Proposed Development and measures are prescribed within the EIAR to deal with these potential minor local impacts.

During each phase of the Proposed Development (construction, operation, and decommissioning) a number of activities will take place at the Proposed Development site, some of which will have the potential to significantly affect the local and downstream hydrological regime and water quality. These significant potential effects generally arise from sediment input from runoff and other pollutants such as hydrocarbons and cement-based compounds.

Surface water drainage measures, pollution control and other preventative measures have been incorporated into the project design to minimise significant impacts on water quality and downstream designated sites. A self-imposed 50 m buffer from natural watercourses was used during the design of the Proposed Development, thereby avoiding sensitive hydrological features. The surface water drainage plan will be the principal means of significantly reducing sediment runoff arising from construction activities and to control runoff rates. The key surface water control measure is that there will be no direct discharge of wind farm runoff into local watercourses or into the existing site drainage network. This will be achieved by avoidance methods (i.e. stream buffers) and design methods (i.e. surface water drainage plan). Preventative measures also include fuel and concrete management and a waste management plan which will be incorporated into the Construction and Environmental Management Plan.

Detailed mitigation measures have also been prescribed where works in the Wind Farm Site and along the Grid Connection are proposed in close proximity to existing watercourses at existing and proposed watercourse crossings. These mitigations measures will ensure that there is no significant effect on downstream surface water quality and/or quantity.

No significant impacts to surface water (quality and flows) and groundwater (quality and quantity, and any local groundwater wells) will occur as a result of the Proposed Development provided the proposed mitigation measures are implemented. This EIAR presents proven and effective mitigation measures to mitigate the release of sediment which will reduce the concentration of suspended solids to acceptable levels. The storage and handling of hydrocarbons/chemicals will be carried out using best practice methods which will ensure the protection of surface and groundwater quality. The Proposed Development drainage system will be designed to slow surface water runoff from the Proposed Development Site by providing greater attenuation. This will ensure that the Proposed Development does not alter downstream surface water flows and will not contribute to downstream flooding.

An assessment of local water resources was completed as part of the impact assessment. There are no downstream surface water abstractions with the potential to be impacted by the Proposed Development. Similarly, there are no downgradient public or group scheme groundwater supplies that can be impacted by the Proposed Development. An assessment of the potential effects on local well supplies concluded that due to separation distances and the prevailing hydrogeological regime, no effects on local groundwater supplies will occur. Furthermore, the implementation of the prescribed mitigation measures will ensure that there is no deterioration in local groundwater quality.

A hydrological assessment of potential impacts on local designated sites was undertaken. The Lackan Saltmarsh and Kilcummin Head SAC/pNHA and the Killala Bay / Moy Estuary SAC, SPA and pNHA are considered to be hydrologically connected to the Proposed Development via the Cloonalaghan and Cloonaghmore River respectively. Furthermore, Killala Esker pNHA is located in close proximity to the Grid Connection and has been included in the impact assessment. With the implementation of the prescribed mitigation measures no significant impacts on these designated sites will occur as a result of the Proposed Development.

A Water Framework Directive (WFD) Compliance Assessment has been completed for all waterbodies (surface water and groundwater bodies) with the potential to be impacted by the Proposed Development. With the implementation of the mitigation measures detailed in this EIAR there will be no change in the WFD status of the underlying groundwater bodies or downstream surface waterbodies as a result of the Proposed Development. The Proposed Development has been found to be fully compliant with the WFD and will not prevent any waterbody from achieving its WFD objectives.

An assessment of potential cumulative effects associated with the Proposed Development and other developments on the hydrological and hydrogeological environment has been completed. With the implementation of the mitigation measures detailed in this EIAR, the cumulative assessment found that there will be no significant effects on the hydrological and hydrogeological environments.

11 AIR AND CLIMATE

This section assessed the effect of the Proposed Development on air quality, given the potential for dust emissions, and the likely carbon dioxide reduction effects of the Proposed Development in operation. Mitigation measures for the reduction of dust are outlined in the **EIAR Chapter 10: Air and Climate**.

For nuisance dust (larger dust particles) receptors situated within 250 m the Wind Farm Site infrastructure are defined as sensitive receptors based on IAQM 2024. Mitigation measures for the reduction of dust are outlined in the **EIAR Chapter 10: Air and Climate, Section 10.2.5**. The Proposed Development has been assessed as having no significant direct or indirect effects on air quality during the construction, operation or decommissioning phases of the Proposed Development.

Potential cumulative effects were assessed as having a cumulative long-term, significant, positive effect on air quality.

The layout of the Development has been designed to minimise the potential environmental effects of the wind farm while utilising the maximum energy yield from the site's wind resource. The selection of breaking new ground and impacting on natural habitat has been kept to a minimum.

The Proposed Development does not contain any element, which will produce Green House Gas (GHG) emissions or odorous emissions in operation. Indeed, the Proposed Development will contribute to a net national reduction in the emissions of greenhouse and other gases resulting from the combustion of fossil fuels.

Savings of carbon dioxide arise principally from the generation of electricity from the Proposed Development, such that generation from other sources (which emit carbon dioxide|) are offset. The estimated savings depend on the assumption of which source of electricity is displaced and the savings of approximately 49,719 tonnes of CO2 will be displaced per annum. In total, it is estimated that 1,740,156 tonnes of CO2 will be displaced over the proposed 35-year lifetime of the Proposed Development.

Ireland has set a target to achieve a 75% reduction in overall greenhouse gas emissions by 2030, setting a path to reach net-zero emissions by no later than 2050. The target for 2030 is to generate 80% of the country's electricity from renewable sources. The Proposed Development will contribute 68.8 MW of installed capacity. The cumulative effect with other Irish renewable generation is considered to be a fundamental change in the climate effects of Ireland's energy supply, which is a major, positive effect, that is significant under the EIA Regulations and will contribute to Ireland's binding emission reduction targets.

In isolation, the Proposed Development will have a significant positive effect on carbon savings and cumulatively, a significant positive effect when considered with Ireland's renewable energy deployment.

Response from MLavelle: Reducing the bog area from 195.38ha [Folio MY40485F]for 5 turbines down to c108ha for the 16turbines determines that the carbon losses will be far greater than calculated & brings doubt into the calculation of any carbon savings. The risk of bog slide will have a further impact on such calculations.

12 NOISE

This chapter of the EIAR assesses the effects of the Proposed Development from noise impacts. This Section has assessed the significance of the potential effects of the Proposed Development during operation, construction and decommissioning.

The effects of noise from the operation of the Proposed Development has been assessed using 2006 Guidelines with the methodology described in ETSU-R-97, the IOA Good Practice Guide and the NG4 Guidance document. Noise levels during operation of the Proposed Development have been predicted using the best practice of calculation technique. They have been compared with the noise limits in the 2006 Guidelines, recent 2021 An Bord Pleanála limits and the NG4 Guidance document and found to be compliant. Baseline noise monitoring was undertaken during two measurement periods, firstly between 20th April and 16th May 2023 and secondly between 22nd September 2023 and 12th October 2023 at the locations shown in **EIAR Appendix 11.1**. Two continuous measurement periods were undertaken in order to gather sufficient wind speed monitoring data, which was completed over the same period at the same 10-minute intervals using a Lidar located on Site. Noise data was recorded for a representative range of wind speeds during the monitoring period.

The eight noise monitoring locations are considered representative of the local noise environment. The propagation model calculates the predicted sound pressure levels by taking the source sound power level for each turbine in their respective octave bands and subtracting a number of attenuation factors. The standardised 10 m wind speed was plotted against the time synchronised background noise levels using a best-fit polynomial line.

Response from MLavelle: The average annual wind speed is 9.1m/s at this site. The cut off for these turbines is c25m/s. What is the synchronised background noise levels for speeds between 9m/s and 25m/s?

The predicted noise levels have been compared with the appropriate noise limits based on the 2006 Guidelines and taking into consideration the recent 2022 An Bord Pleanála decisions. **The predicted noise levels are higher than the night-time noise limit of 43 dB at six receptors, at various wind speeds – H3, H4, H6, H10, H11 and H13. It has been confirmed by the applicant that one of these receptors is financially involved with the Proposed Development, H8, to which a 45 dB limit may be applied; therefore, there are no exceedances at these receptors.**

Response from MLavelle: This statement is nonsense. The manufacturers wind tunnel data for single wind turbines does not refer to multiple turbines & their wake/turbulence effects. The applicant uses Windpro software or similar to design the layout. Windpro v4 has facilities to include turbulence measurements for small sites with squeezed turbines. Why isn't a screenshot provided of the Windpro constraints & outputs as part of the Lacunae?

When directivity is considered, there are no exceedances of the 45 dB daytime limit. However, there are exceedances of the night-time limit of 43 dB at three receptors after considering directivity: H3, H4, and H11. A curtailment strategy shall ensure compliance with the 43 dB night-time limit and shall be implemented during the following condition:

- **Turbines AT08, AT09 and AT10** shall be operated in Sound Optimized Mode SO2 during night-time period, from wind speeds of 7-12 m/s and for wind blowing towards the East.

- **Turbines AT08 and AT09** shall be operated in Sound Optimized Mode SO2 during night-time period, from wind speeds of 7-12 m/s and for wind blowing towards the North-East and South-East.

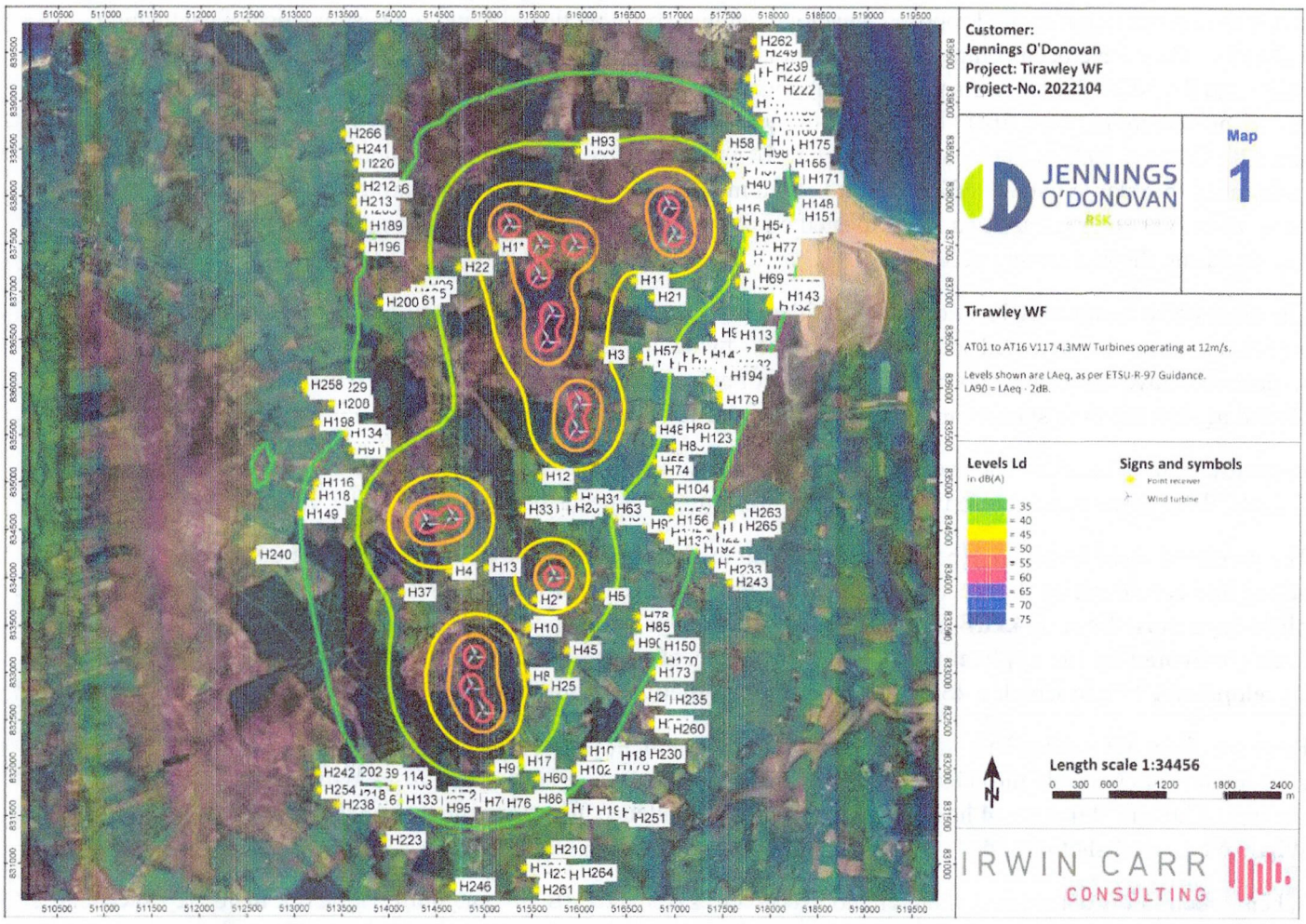
- **Turbine AT06** shall be operated in Sound Optimized Mode SO1 during night-time period, from wind speeds of 7-12 m/s and for wind blowing towards the South-West

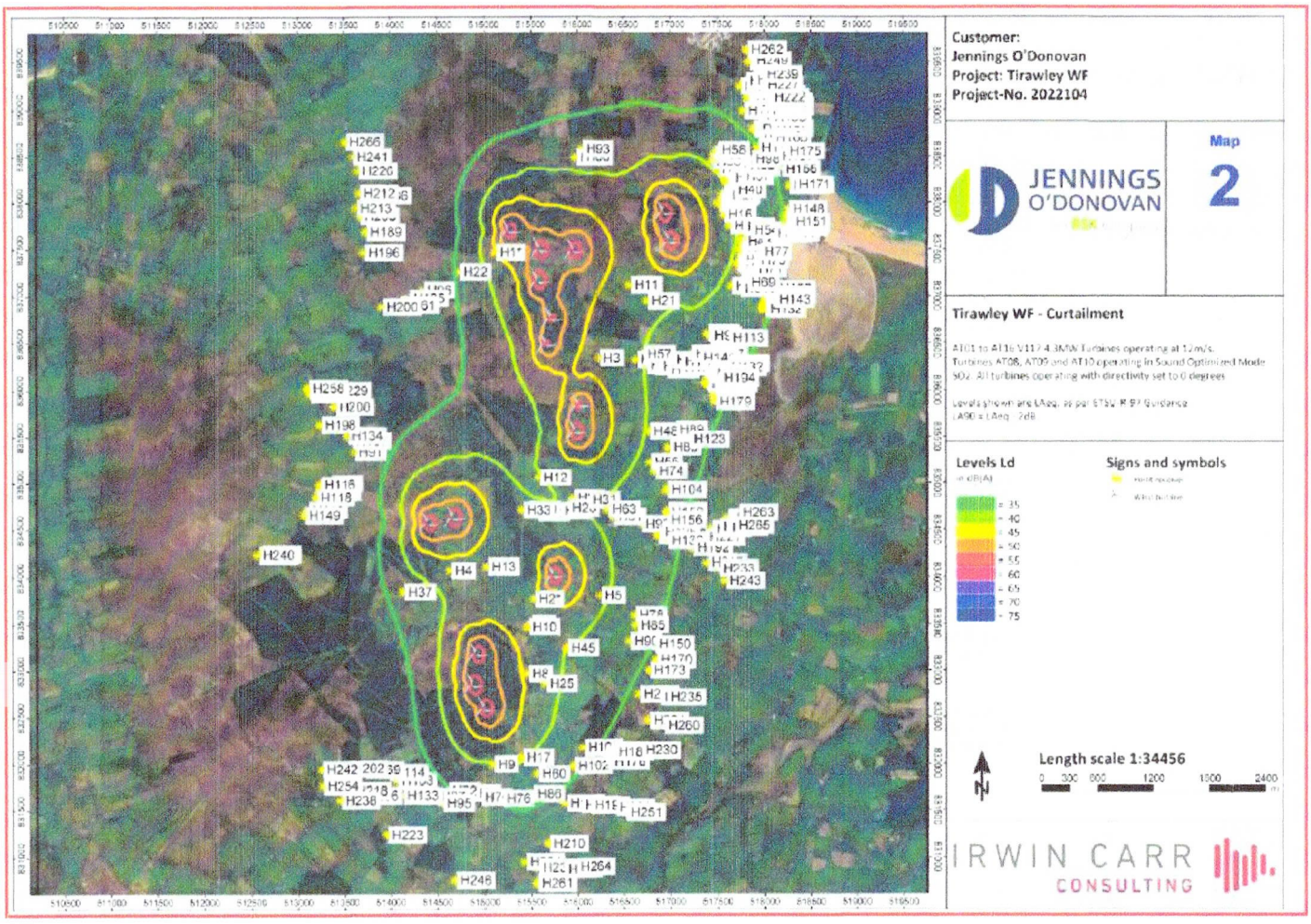
Response from MLavelle: Does this mean that the nighttime noise can be restricted to low background noise plus 5dBa?

There has been a consultation process in relation to the revision of the 2019 Wind Energy Development Guidelines. This document provided the basis for a discussion on amendments of the noise limits applicable to wind turbine developments. It is understood that there will be revisions to the draft consultation documents, however a mitigation strategy to incorporate a reduction in sound power level outputs with respect to directionality can be put in place to comply with any specific variation in noise limit levels if new more restrictive guidelines are adopted. All turbines have software incorporated so that the sound power levels can be reduced by direction and energy output.

The noise levels predicted at the nearest receptors are orders of magnitude below the level at which risk of hearing damage, or indeed negative health effects are possible. Noise during construction of the Proposed Development and decommissioning will be managed to comply with best practice, legislation and guidelines current at that time so that effects are not significant.

TECHNICAL APPENDIX 11.4 - SoundPLAN Noise Outputs




Customer:
Jennings O'Donovan
Project: Tirawley WF
Project-No. 2022104
JENNINGS O'DONOVAN
Map
2
Tirawley WF - Curtailment
AT01 to AT16 V117 4.3MW Turbines operating at 12 m/s.
Turbines AT08, AT09 and AT10 operating in Sound Optimized Mode SO2. All turbines operating with directivity set to 0 degrees
Levels shown are LAeq, as per ETSU R 97 Guidance
LA90 = LAeq - 2dB
Levels Ld
Signs and symbols
35
40
45
50
55
60
65
70
75
Length scale 1:34456
0
300
600
1200
1800
2400
IRWIN CARR
CONSULTING

TECHNICAL APPENDIX 11.6 : Candidate Turbine Manufacturer's Performance Specification.

Response from MLavelle: Note that the applicant includes some manufacturers parameters but excludes power outputs, which are included in the Manufacturers document. They are included by this author in this submission below & indicate power outputs c2Mw per turbine or 32mw for the 16 turbines. This application & its inclusion under SID's is in breach of the law.

TECHNICAL APPENDIX 11.6

Candidate Turbine Manufacturer's Performance Specification

RESTRICTED

4.3 Sound Curves, Power Optimized Mode PO2/PO2-0S; HWO Disabled

Sound Power Level at Hub Height		
Conditions for Sound Power Level:	**Measurement standard IEC 61400-11 ed. 3** **Maximum turbulence at hub height: 30%** **Inflow angle (vertical): 0 ±2°** **Air density: 1.225 kg/m³**	
Wind speed at hub height [m/s]	**Sound Power Level at Hub Height [dBA] Mode PO2 (Blades with serrated trailing edge)**	**Sound Power Level at Hub Height [dBA] Mode PO2-0S (Blades without serrated trailing edge)**
3	91.7	93.7
4	92.2	94.6
5	94	97.1
6	97	100.2
7	100	103.1
8	102.8	105.6
9	105.1	107.7
10	106	108.5
11	106	108.5
12	106	108.5
13	106	108.5
14	106	108.5
15	106	108.5
16	106	108.5
17	106	108.5
18	106	108.5
19	106	108.5
20	106	108.5
21	106	108.5
22	106	108.5
23	106	108.5
24	106	108.5
25	106	108.5
26	106	108.5
27	106	108.5

Table 4-3: Sound curves, Mode PO2/PO2-0S (High Wind Operation Disabled)

VESTAS PROPRIETARY NOTICE

Original instruction: T05 0080-2475 VER 02
T05 0080-2475 Ver 02 - Approved - Exported from DMS: 2020-01-29 by TLSRL

Candidate Turbine Manufacturer's Performance Specifications during Curtailment Strategy

10.3 Sound Curves, Sound Optimized Mode SO1

Sound Power Level at Hub Height	
Conditions for Sound Power Level:	**Measurement standard IEC 61400-11 ed. 3** **Maximum turbulence at hub height: 30%** **Inflow angle (vertical): 0 ±2°** **Air density: 1.225 kg/m³**
Wind speed at hub height [m/s]	**Sound Power Level at Hub Height [dBA]** **Sound Optimized Mode SO1 (Blades with serrated trailing edge)**
3	92.2
4	92.8
5	94.0
6	97.0
7	100.0
8	102.7
9	104.2
10	105.0
11	105.0
12	105.0
13	105.0
14	105.0
15	105.0
16	105.0
17	105.0
18	105.0
19	105.0
20	105.0

Table 10-3: Sound curves, Sound Optimized Mode SO1

12.3 Sound Curves, Sound Optimized Mode SO2

Sound Power Level at Hub Height	
Conditions for Sound Power Level:	**Measurement standard IEC 61400-11 ed. 3 Maximum turbulence at hub height: 30% Inflow angle (vertical): 0 ±2° Air density: 1.225 kg/m³**
Wind speed at hub height [m/s]	**Sound Power Level at Hub Height [dBA] Sound Optimized Mode SO2 (Blades with serrated trailing edge)**
3	92.2
4	92.8
5	94.0
6	97.0
7	99.9
8	101.6
9	102.3
10	102.3
11	102.4
12	102.7
13	103.0
14	103.0
15	103.0
16	103.0
17	103.0
18	103.0
19	103.0
20	103.0

Table 12-3. Sound curves, Sound Optimized Mode SO2

12.3 Sound Curves, Sound Optimized Mode SO2

Sound Power Level at Hub Height	
Conditions for Sound Power Level:	**Measurement standard IEC 61400-11 ed. 3 Maximum turbulence at hub height: 30% Inflow angle (vertical): 0 ±2° Air density: 1.225 kg/m³**
Wind speed at hub height [m/s]	**Sound Power Level at Hub Height [dBA] Sound Optimized Mode SO2 (Blades with serrated trailing edge)**
3	92.2
4	92.8
5	94.0
6	97.0
7	99.9
8	101.6
9	102.3
10	102.3
11	102.4
12	102.7
13	103.0
14	103.0
15	103.0
16	103.0
17	103.0
18	103.0
19	103.0
20	103.0

Table 12-3. Sound curves, Sound Optimized Mode SO2

Response from MLavelle: Wind Energy Guidelines 2006 & 2019 specify downwind separation distances of 7times rotor diameter, i.e. 7x117 = 819m. The separation distances provided in Table 2.3 are not compliant with this requirement for 9 of the proposed Turbines.

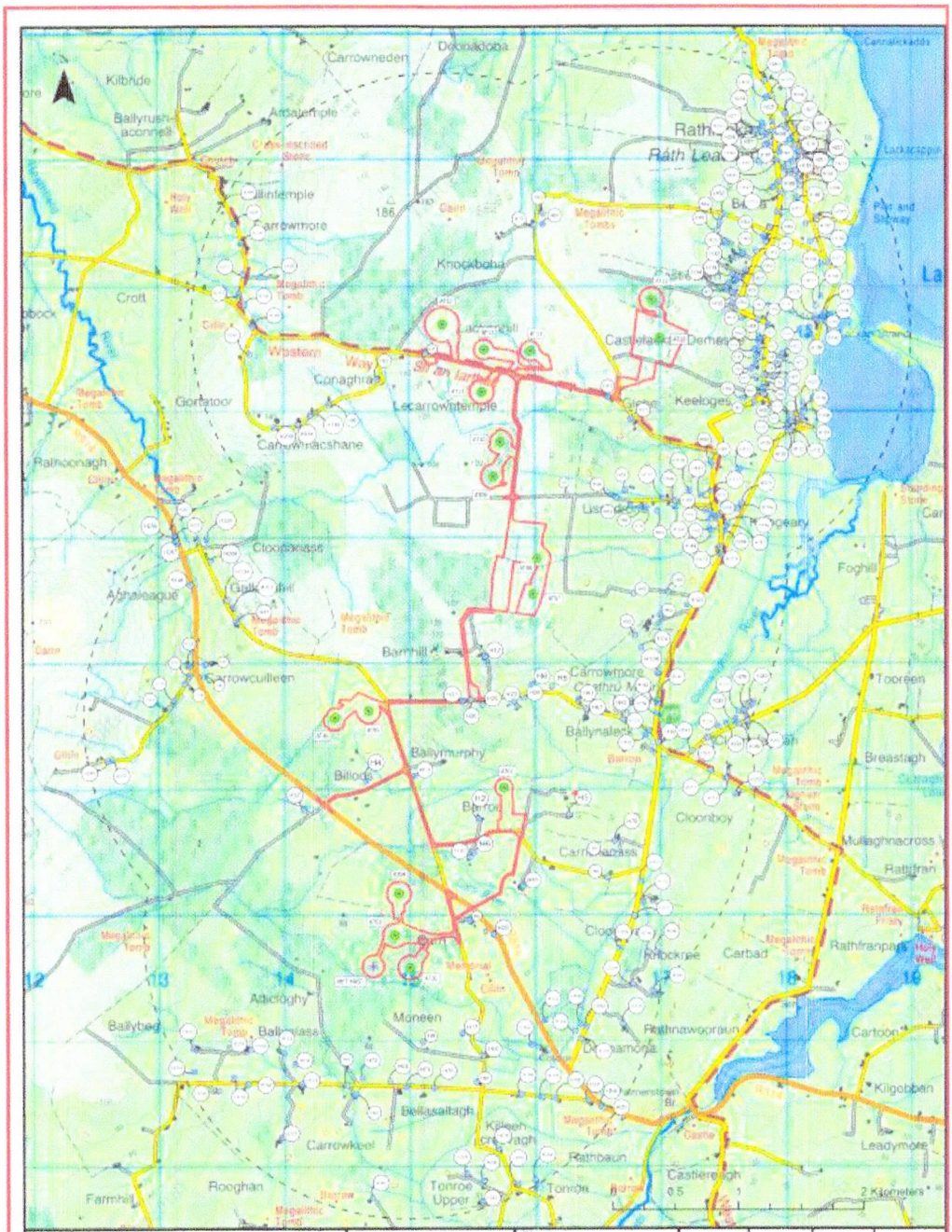
From the Table below using Pythagoras Theorem, it can be seen that Turbines AT03, AT04, AT06, AT08, AT10, AT11, AT13, AT14 & AT16 have to be omitted as the separation are far less than 819m & will create far greater noise levels than shown from manufacturers wind tunnel figures due to increased turbulence. This reduces the number of Turbines to 7 & means that it doesn't qualify as a SID application as 7x4.4Mw = 30.4Mw & as such is an invalid application.

Table 2.3: Turbine ITM Coordinates

Turbine No.	Turbine Type	ITM Easting [m]	ITM Northing [m]	Distance to Nearest Residential Receptor (m)*
AT01	V117	515725	834020	559.39 → H5
AT02	V117	514978	832589	601.59 → H8
AT03	V117	514857	832846	604.24 → H8
AT04	V117	514889	833179	601.51 → H8
AT05	V117	514649	834627	555.40 → H4
AT06	V117	514381	834572	557.68 → H4
AT07	V117	515958	835555	625.87 → H12
AT08	V117	515991	835837	554.71 → H3
AT09	V117	515645	836489	601.02 → H3
AT10	V117	515700	836763	676.40 → H3
AT11	V117	515557	837162	841.61 → H22
AT12	V117	515244	837695	680.90 → H22
AT13	V117	515574	837498	885.85 → H22
AT14	V117	515940	837488	722.87 → H11
AT15	V117	516909	837891	601.44 → H7
AT16	V117	516972	837587	623.60 → H11

*Nearest residential receptor not financially involved with the Proposed Development.

	ITM			ITM				Separation
Turbine	Easting	Difference	Square	Northing	Difference	square	sum of squares	Square-root
AT01	515725			834020				
AT02	514978	-747	558009	832589	-1431	2047761	2605770	2861
AT03	514857	-121	14641	832846	257	66049	80690	503
AT04	514889	32	1024	833179	333	110889	111913	593
AT05	514649	-240	57600	834627	1448	2096704	2154304	2602
AT06	514381	-268	71824	834572	-55	3025	74849	485
AT07	515958	1577	2486929	835555	983	966289	3453218	3294
AT08	515991	33	1089	835837	282	79524	80613	503
AT09	515645	-346	119716	836489	652	425104	544820	1308
AT10	515700	55	3025	836763	274	75076	78101	495
AT11	515557	-143	20449	837162	399	159201	179650	751
AT12	515244	-313	97969	837695	533	284089	382058	1096
AT13	515574	330	108900	837498	-197	38809	147709	681
AT14	515940	366	133956	837488	-10	100	134056	649
AT15	516909	969	938961	837891	403	162409	1101370	1860
AT16	516972	63	3969	837587	-304	92416	96385	550
AT11	515557			837162				
AT13	515574	17	289	837498	336	112896	113185	596
AT02	514978			832589				
ATO4	514889	-89	7921	833179	590	348100	356021	1058



LEGEND	Client Representative	Client	Drg. By	DT	Job No.	6289
Residential Curtilage Points	JENNINGS O'DONOVAN	CONSTANT ENERGY LIMITED	Checked By	MG	Figure	2.3
2km Buffer		Project	Approved	MG	Rev	1
Met Mast Location Point		TIRAWLEY WIND FARM CO. MAYO	Scale	1:26,000 (A3)		
Turbine Location Points		Title	Stage	Planning		
Wind Farm Site Redline		RESIDENTIAL DWELLINGS WITHIN 2KM OF THE WINDFARM SITE	Date	20/04/2026		

Table 11.16: Predicted Noise Levels as LA90 at Varying Wind Speeds from the Proposed Development

House ID	ING Easting	ING Northing	4 m/s dBA	5 m/s dBA	6 m/s dBA	7 m/s dBA	8 m/s dBA	9 m/s dBA
H1*	515110	837466	38.2	42.3	46.1	48.4	48.7	48.7
H2*	515526	833767	35.3	39.4	43.2	45.5	45.8	45.8
H3	516227	836339	34.4	38.5	42.3	44.6	44.9	44.9
H4	514628	834072	33.3	37.4	41.2	43.5	43.8	43.8
H5	516241	833804	30.4	34.5	38.3	40.6	40.9	40.9
H6	515489	833504	32.6	36.7	40.5	42.8	43.1	43.1
H7	517503	837983	31.2	35.3	39.1	41.4	41.7	41.7
H8*	515450	832962	33.3	37.4	41.2	43.5	43.8	43.8
H9	515080	831996	30.3	34.4	38.2	40.5	40.8	40.8
H10	515456	833467	32.6	36.7	40.5	42.8	43.1	43.1
H11	516561	837118	33.4	37.5	41.3	43.6	43.9	43.9
H12	515575	835060	31.8	35.9	39.7	42	42.3	42.3
H13	515019	834112	32.6	36.7	40.5	42.8	43.1	43.1
H14	517530	838028	30.6	34.7	38.5	40.8	41.1	41.1
H15	517553	837950	30.7	34.8	38.6	40.9	41.2	41.2
H16	517556	837865	31	35.1	38.9	41.2	41.5	41.5

	ING	ING	4 m/s	5 m/s	6 m/s	7 m/s	8 m/s	9+ m/s
House ID	Easting	Northing	dBA	dBA	dBA	dBA	dBA	dBA
H17	515390	832068	29.5	33.6	37.4	39.7	40	40
H18	517622	837746	30.2	34.3	38.1	40.4	40.7	40.7
H19	517552	838096	30	34.1	37.9	40.2	40.5	40.5
H20	515559	834678	31.3	35.4	39.2	41.5	41.8	41.8
H21	516744	836946	32	36.1	39.9	42.2	42.5	42.5
H22	514721	837259	31.8	35.9	39.7	42	42.3	42.3
H23	515805	834702	31	35.1	38.9	41.2	41.5	41.5
H24	517581	838054	29.9	34	37.8	40.1	40.4	40.4
H25	515641	832856	31.1	35.2	39	41.3	41.6	41.6
H26	515947	834836	30.8	34.9	38.7	41	41.3	41.3
H27	517606	838071	29.5	33.6	37.4	39.7	40	40
H28	515886	834729	30.8	34.9	38.7	41	41.3	41.3
H29	517490	838353	28.8	32.9	36.7	39	39.3	39.3
H30	515462	834716	31.3	35.4	39.2	41.5	41.8	41.8
H31	516107	834819	30.4	34.5	38.3	40.6	40.9	40.9
H32	517583	838226	28.9	33	36.8	39.1	39.4	39.4
H33	515398	834709	31.5	35.6	39.4	41.7	42	42
H34	517725	837501	28.6	32.7	36.5	38.8	39.1	39.1
H35	517434	838443	28.6	32.7	36.5	38.8	39.1	39.1
H36	517697	837346	28.5	32.6	36.4	38.7	39	39
H37	514129	833845	30.2	34.3	38.1	40.4	40.7	40.7
H38	517741	837449	28.3	32.4	36.2	38.5	38.8	38.8
H39	517762	837602	28.3	32.4	36.2	38.5	38.8	38.8
H40	517663	838130	28.6	32.7	36.5	38.8	39.1	39.1
H41	517766	837561	28.2	32.3	36.1	38.4	38.7	38.7
H42	517762	837501	28.2	32.3	36.1	38.4	38.7	38.7
H43	517767	837579	28.2	32.3	36.1	38.4	38.7	38.7
H44	517742	837383	28.2	32.3	36.1	38.4	38.7	38.7

	ING	ING	4 m/s	5 m/s	6 m/s	7 m/s	8 m/s	9+ m/s
House ID	Easting	Northing	dBA	dBA	dBA	dBA	dBA	dBA
H45	515873	833236	29.7	33.8	37.6	39.9	40.2	40.2
H46	516625	836322	31.2	35.3	39.1	41.4	41.7	41.7
H47	517758	837737	28.4	32.5	36.3	38.6	38.9	38.9
H48	516764	835557	29.8	33.9	37.7	40	40.3	40.3
H49	517632	838261	28.2	32.3	36.1	38.4	38.7	38.7
H50	517638	837109	28.3	32.4	36.2	38.5	38.8	38.8
H51	517742	837283	28	32.1	35.9	38.2	38.5	38.5
H52	517457	838516	27.8	31.9	35.7	38	38.3	38.3
H53	516738	836261	30.4	34.5	38.3	40.6	40.9	40.9
H54	517836	837697	27.6	31.7	35.5	37.8	38.1	38.1
H55	516774	835227	28.7	32.8	36.6	38.9	39.2	39.2
H56	517806	837295	27.5	31.6	35.4	37.7	38	38
H57	516697	836380	30.7	34.8	38.6	40.9	41.2	41.2
H58	517489	838569	27.2	31.3	35.1	37.4	37.7	37.7
H59	517798	837225	27.4	31.5	35.3	37.6	37.9	37.9
H60	515557	831893	26.9	31	34.8	37.1	37.4	37.4
H61	516384	834641	28.8	32.9	36.7	39	39.3	39.3
H62	517792	837189	27.4	31.5	35.3	37.6	37.9	37.9
H63	516320	834718	29.3	33.4	37.2	39.5	39.8	39.8
H64	517729	837077	27.5	31.6	35.4	37.7	38	38
H65	514818	831687	26.7	30.8	34.6	36.9	37.2	37.2
H66	516817	836244	29.8	33.9	37.7	40	40.3	40.3
H67	517748	838272	27.2	31.3	35.1	37.4	37.7	37.7
H68	517791	837155	27.3	31.4	35.2	37.5	37.8	37.8
H69	517804	837142	27.2	31.3	35.1	37.4	37.7	37.7
H70	514941	831643	26.3	30.4	34.2	36.5	36.8	36.8
H71	517884	837289	26.8	30.9	34.7	37	37.3	37.3
H72	514595	831709	26.4	30.5	34.3	36.6	36.9	36.9

	ING	ING	4 m/s	5 m/s	6 m/s	7 m/s	8 m/s	9+ m/s
House ID	Easting	Northing	dBA	dBA	dBA	dBA	dBA	dBA
H73	517910	837382	26.7	30.8	34.6	36.9	37.2	37.2
H74	516822	835130	28	32.1	35.9	38.2	38.5	38.5
H75	516865	836247	29.5	33.6	37.4	39.7	40	40
H76	515173	831629	26	30.1	33.9	36.2	36.5	36.5
H77	517945	837469	26.6	30.7	34.5	36.8	37.1	37.1
H78	516609	833595	26.3	30.4	34.2	36.5	36.8	36.8
H79	515971	838486	29.6	33.7	37.5	39.8	40.1	40.1
H80	516040	838493	29.5	33.6	37.4	39.7	40	40
H81	517816	838358	26.2	30.3	34.1	36.4	36.7	36.7
H82	517798	838402	26.1	30.2	34	36.3	36.6	36.6
H83	516975	835388	27.7	31.8	35.6	37.9	38.2	38.2
H84	516953	836216	29	33.1	36.9	39.2	39.5	39.5
H85	516624	833488	25.9	30	33.8	36.1	36.4	36.4
H86	515505	831678	25.4	29.5	33.3	35.6	35.9	35.9
H87	514472	831653	25.6	29.7	33.5	35.8	36.1	36.1
H88	517382	836605	27.6	31.7	35.5	37.8	38.1	38.1
H89	517041	835575	27.6	31.7	35.5	37.8	38.1	38.1
H90	516551	833308	25.8	29.9	33.7	36	36.3	36.3
H91	513601	835338	25.7	29.8	33.6	35.9	36.2	36.2
H92	516678	834560	27.1	31.2	35	37.3	37.6	37.6
H93	516041	838580	28.9	33	36.8	39.1	39.4	39.4
H94	513331	834901	25.6	29.7	33.5	35.8	36.1	36.1
H95	514539	831580	25.1	29.2	33	35.3	35.6	35.6
H96	514340	837065	28.3	32.4	36.2	38.5	38.8	38.8
H97	517409	836575	27.4	31.5	35.3	37.6	37.9	37.9
H98	517850	838466	25.5	29.6	33.4	35.7	36	36
H99	513352	834999	25.4	29.5	33.3	35.6	35.9	35.9
H100	518085	837658	25.3	29.4	33.2	35.5	35.8	35.8

	ING	ING	4 m/s	5 m/s	6 m/s	7 m/s	8 m/s	9+ m/s
House ID	Easting	Northing	dBA	dBA	dBA	dBA	dBA	dBA
H101	517007	836317	28.8	32.9	36.7	39	39.3	39.3
H102	515945	831977	25.1	29.2	33	35.3	35.6	35.6
H103	516052	832172	25.4	29.5	33.3	35.6	35.9	35.9
H104	516952	834926	26.4	30.5	34.3	36.6	36.9	36.9
H105	517096	836244	28.2	32.3	36.1	38.4	38.7	38.7
H106	518160	837673	24.7	28.8	32.6	34.9	35.2	35.2
H107	513577	835455	25.1	29.2	33	35.3	35.6	35.6
H108	514056	831821	24.9	29	32.8	35.1	35.4	35.4
H109	517099	836299	28.2	32.3	36.1	38.4	38.7	38.7
H110	518014	836990	25.2	29.3	33.1	35.4	35.7	35.7
H111	513225	834907	24.9	29	32.8	35.1	35.4	35.4
H112	516855	834435	26	30.1	33.9	36.2	36.5	36.5
H113	517606	836550	26.3	30.4	34.2	36.5	36.8	36.8
H114	513969	831910	24.9	29	32.8	35.1	35.4	35.4
H115	518001	836934	25.2	29.3	33.1	35.4	35.7	35.7
H116	513228	834982	24.8	28.9	32.7	35	35.3	35.3
H117	517915	838590	24.5	28.6	32.4	34.7	35	35
H118	513187	834847	24.8	28.9	32.7	35	35.3	35.3
H119	517212	836384	27.8	31.9	35.7	38	38.3	38.3
H120	517994	836903	25.2	29.3	33.1	35.4	35.7	35.7
H121	518017	836930	25.1	29.2	33	35.3	35.6	35.6
H122	517992	836890	25.2	29.3	33.1	35.4	35.7	35.7
H123	517191	835471	26.5	30.6	34.4	36.7	37	37
H124	517990	836877	25.1	29.2	33	35.3	35.6	35.6
H125	516884	834471	25.9	30	33.8	36.1	36.4	36.4
H126	517989	836869	25.1	29.2	33	35.3	35.6	35.6
H127	518108	837076	24.9	29	32.8	35.1	35.4	35.4
H128	517987	836860	25.1	29.2	33	35.3	35.6	35.6

	ING	ING	4 m/s	5 m/s	6 m/s	7 m/s	8 m/s	9+ m/s
House ID	Easting	Northing	dBA	dBA	dBA	dBA	dBA	dBA
H129	518208	837768	24.4	28.5	32.3	34.6	34.9	34.9
H130	518212	837742	24.4	28.5	32.3	34.6	34.9	34.9
H131	518212	837845	24.3	28.4	32.2	34.5	34.8	34.8
H132	518010	836858	25	29.1	32.9	35.2	35.5	35.5
H133	514113	831661	24.2	28.3	32.1	34.4	34.7	34.7
H134	513526	835513	24	28.1	31.9	34.2	34.5	34.5
H135	514190	836978	27.2	31.3	35.1	37.4	37.7	37.7
H136	518117	837019	24.6	28.7	32.5	34.8	35.1	35.1
H137	517388	836374	26.9	31	34.8	37.1	37.4	37.4
H138	518114	837000	24.6	28.7	32.5	34.8	35.1	35.1
H139	516958	834382	25.4	29.5	33.3	35.6	35.9	35.9
H140	513103	834713	24.4	28.5	32.3	34.6	34.9	34.9
H141	517296	836339	27.3	31.4	35.2	37.5	37.8	37.8
H142	518255	837722	24.1	28.2	32	34.3	34.6	34.6
H143	518102	836959	24.7	28.8	32.6	34.9	35.2	35.2
H144	518268	837758	24	28.1	31.9	34.2	34.5	34.5
H145	518273	837769	24	28.1	31.9	34.2	34.5	34.5
H146	516958	834700	26	30.1	33.9	36.2	36.5	36.5
H147	517873	838787	23.8	27.9	31.7	34	34.3	34.3
H148	518250	837922	23.9	28	31.8	34.1	34.4	34.4
H149	513062	834658	24.1	28.2	32	34.3	34.6	34.6
H150	516818	833276	24.3	28.4	32.2	34.5	34.8	34.8
H151	518279	837790	23.9	28	31.8	34.1	34.4	34.4
H152	516958	834683	25.9	30	33.8	36.1	36.4	36.4
H153	517935	838746	23.7	27.8	31.6	33.9	34.2	34.2
H154	515858	831578	23.3	27.4	31.2	33.5	33.8	33.8
H155	518171	838358	23.8	27.9	31.7	34	34.3	34.3
H156	516947	834602	25.8	29.9	33.7	36	36.3	36.3

	ING	ING	4 m/s	5 m/s	6 m/s	7 m/s	8 m/s	9+ m/s
House ID	Easting	Northing	dBA	dBA	dBA	dBA	dBA	dBA
H157	518134	838497	23.6	27.7	31.5	33.8	34.1	34.1
H158	518256	838176	23.6	27.7	31.5	33.8	34.1	34.1
H159	517925	838830	23.3	27.4	31.2	33.5	33.8	33.8
H160	517769	838987	23.3	27.4	31.2	33.5	33.8	33.8
H161	514091	836904	26.6	30.7	34.5	36.8	37.1	37.1
H162	517370	836081	26.4	30.5	34.3	36.6	36.9	36.9
H163	516288	832086	23.7	27.8	31.6	33.9	34.2	34.2
H164	517344	836221	26.8	30.9	34.7	37	37.3	37.3
H165	517385	836061	26.3	30.4	34.2	36.5	36.8	36.8
H166	518067	838701	23.2	27.3	31.1	33.4	33.7	33.7
H167	517378	836158	26.5	30.6	34.4	36.7	37	37
H168	516334	832143	23.6	27.7	31.5	33.8	34.1	34.1
H169	513704	831940	23.6	27.7	31.5	33.8	34.1	34.1
H170	516834	833111	23.9	28	31.8	34.1	34.4	34.4
H171	518315	838186	23.4	27.5	31.3	33.6	33.9	33.9
H172	517402	836199	26.5	30.6	34.4	36.7	37	37
H173	516765	832999	23.9	28	31.8	34.1	34.4	34.4
H174	517625	836280	25.6	29.7	33.5	35.8	36.1	36.1
H175	518215	838553	22.9	27	30.8	33.1	33.4	33.4
H176	516021	831560	22.6	26.7	30.5	32.8	33.1	33.1
H177	517457	835933	25.8	29.9	33.7	36	36.3	36.3
H178	516337	832024	23.2	27.3	31.1	33.4	33.7	33.7
H179	517465	835870	25.6	29.7	33.5	35.8	36.1	36.1
H180	516381	832122	23.3	27.4	31.2	33.5	33.8	33.8
H181	517966	838934	22.7	26.8	30.6	32.9	33.2	33.2
H182	517593	836238	25.6	29.7	33.5	35.8	36.1	36.1
H183	517440	836173	26.2	30.3	34.1	36.4	36.7	36.7
H184	518089	838799	22.7	26.8	30.6	32.9	33.2	33.2

	ING	ING	4 m/s	5 m/s	6 m/s	7 m/s	8 m/s	9+ m/s
House ID	Easting	Northing	dBA	dBA	dBA	dBA	dBA	dBA
H185	517905	839004	22.6	26.7	30.5	32.8	33.1	33.1
H186	513796	838073	22.4	26.5	30.3	32.6	32.9	32.9
H187	518071	838854	22.6	26.7	30.5	32.8	33.1	33.1
H188	517486	836057	25.8	29.9	33.7	36	36.3	36.3
H189	513730	837683	22.7	26.8	30.6	32.9	33.2	33.2
H190	517812	839121	22.4	26.5	30.3	32.6	32.9	32.9
H191	517497	836093	25.8	29.9	33.7	36	36.3	36.3
H192	517231	834307	24	28.1	31.9	34.2	34.5	34.5
H193	518054	838917	22.4	26.5	30.3	32.6	32.9	32.9
H194	517509	836126	25.8	29.9	33.7	36	36.3	36.3
H195	516125	831552	22.1	26.2	30	32.3	32.6	32.6
H196	513708	837466	23.9	28	31.8	34.1	34.4	34.4
H197	517922	839074	22.2	26.3	30.1	32.4	32.7	32.7
H198	513235	835631	23.4	27.5	31.3	33.6	33.9	33.9
H199	517856	839139	22.2	26.3	30.1	32.4	32.7	32.7
H200	513902	836884	25.5	29.6	33.4	35.7	36	36
H201	518030	838990	22.2	26.3	30.1	32.4	32.7	32.7
H202	513533	831954	22.7	26.8	30.6	32.9	33.2	33.2
H203	517735	839237	22.2	26.3	30.1	32.4	32.7	32.7
H204	516653	832742	23.8	27.9	31.7	34	34.3	34.3
H205	513667	837855	22.1	26.2	30	32.3	32.6	32.6
H206	513685	831661	22.3	26.4	30.2	32.5	32.8	32.8
H207	517822	839198	22.1	26.2	30	32.3	32.6	32.6
H208	513391	835822	22.7	26.8	30.6	32.9	33.2	33.2
H209	517791	839223	22	26.1	29.9	32.2	32.5	32.5
H210	515679	831145	21.4	25.5	29.3	31.6	31.9	31.9
H211	517793	839268	21.8	25.9	29.7	32	32.3	32.3
H212	513657	838098	21.5	25.6	29.4	31.7	32	32

	ING	ING	4 m/s	5 m/s	6 m/s	7 m/s	8 m/s	9+ m/s
House ID	Easting	Northing	dBA	dBA	dBA	dBA	dBA	dBA
H213	513622	837938	21.7	25.8	29.6	31.9	32.2	32.2
H214	518095	839027	21.8	25.9	29.7	32	32.3	32.3
H215	517878	839229	21.7	25.8	29.6	31.9	32.2	32.2
H216	517789	839294	21.7	25.8	29.6	31.9	32.2	32.2
H217	517378	834152	23.3	27.4	31.2	33.5	33.8	33.8
H218	513569	831714	22	26.1	29.9	32.2	32.5	32.5
H219	518078	839073	21.7	25.8	29.6	31.9	32.2	32.2
H220	518005	839159	21.6	25.7	29.5	31.8	32.1	32.1
H221	517355	834419	23.7	27.8	31.6	33.9	34.2	34.2
H222	518050	839123	21.6	25.7	29.5	31.8	32.1	32.1
H223	513951	831241	21.1	25.2	29	31.3	31.6	31.6
H224	515424	830951	20.8	24.9	28.7	31	31.3	31.3
H225	517868	839303	21.4	25.5	29.3	31.6	31.9	31.9
H226	513643	838342	20.9	25	28.8	31.1	31.4	31.4
H227	517980	839253	21.3	25.4	29.2	31.5	31.8	31.8
H228	516877	832711	22.7	26.8	30.6	32.9	33.2	33.2
H229	513365	835996	23.1	27.2	31	33.3	33.6	33.6
H230	516673	832142	22	26.1	29.9	32.2	32.5	32.5
H231	516393	831529	20.9	25	28.8	31.1	31.4	31.4
H232	517431	834508	23.5	27.6	31.4	33.7	34	34
H233	517503	834090	22.7	26.8	30.6	32.9	33.2	33.2
H234	516757	832459	22.5	26.6	30.4	32.7	33	33
H235	516938	832711	22.5	26.6	30.4	32.7	33	33
H236	515561	830891	20.3	24.4	28.2	30.5	30.8	30.8
H237	512604	834248	21.8	25.9	29.7	32	32.3	32.3
H238	513452	831612	21	25.1	28.9	31.2	31.5	31.5
H239	517973	839365	20.8	24.9	28.7	31	31.3	31.3
H240	512569	834235	21.7	25.8	29.6	31.9	32.2	32.2

House ID	ING Easting	ING Northing	4 m/s dBA	5 m/s dBA	6 m/s dBA	7 m/s dBA	8 m/s dBA	9+ m/s dBA
H241	513585	838498	20.3	24.4	28.2	30.5	30.8	30.8
H242	513247	831945	21.3	25.4	29.2	31.5	31.8	31.8
H243	517571	833961	22.3	26.4	30.2	32.5	32.8	32.8
H244	517504	834526	23.2	27.3	31.1	33.4	33.7	33.7
H245	517825	839498	20.7	24.8	28.6	30.9	31.2	31.2
H246	514677	830757	19.8	23.9	27.7	30	30.3	30.3
H247	513130	835959	22.7	26.8	30.6	32.9	33.2	33.2
H248	516499	831484	20.4	24.5	28.3	30.6	30.9	30.9
H249	517862	839512	20.6	24.7	28.5	30.8	31.1	31.1
H250	517596	834627	23.2	27.3	31.1	33.4	33.7	33.7
H251	516513	831474	20.3	24.4	28.2	30.5	30.8	30.8
H252	513118	835991	22.6	26.7	30.5	32.8	33.1	33.1
H253	517571	834542	23.2	27.3	31.1	33.4	33.7	33.7
H254	513257	831765	20.8	24.9	28.7	31	31.3	31.3
H255	515833	830871	19.8	23.9	27.7	30	30.3	30.3
H256	517644	834629	23.1	27.2	31	33.3	33.6	33.6
H257	513108	836017	22.6	26.7	30.5	32.8	33.1	33.1
H258	513105	836024	22.5	26.6	30.4	32.7	33	33
H259	517599	834519	23	27.1	30.9	33.2	33.5	33.5
H260	516912	832406	21.7	25.8	29.6	31.9	32.2	32.2
H261	515552	830724	19.3	23.4	27.2	29.5	29.8	29.8
H262	517807	839629	20.2	24.3	28.1	30.4	30.7	30.7
H263	517711	834681	22.9	27	30.8	33.1	33.4	33.4
H264	515967	830898	19.6	23.7	27.5	29.8	30.1	30.1
H265	517666	834544	22.8	26.9	30.7	33	33.3	33.3
H266	513505	838660	19.5	23.6	27.4	29.7	30	30

*(FI) – Financially Involved

13 LANDSCAPE AND VISUAL

Chapter 12 of the EIAR describes the landscape context of the proposed Tirawley Wind Farm and assesses the likely landscape and visual impacts of the scheme on the receiving environment. Although closely linked, landscape and visual impacts are assessed separately.

Landscape Impact Assessment (LIA): Relates to changes in the physical landscape brought about by the Proposed Development, which may alter its character and how it is experienced. This requires a detailed analysis of individual elements and characteristics that make up the overall landscape character of an area. It provides a measure of the landscape's ability to accommodate change without causing unacceptable adverse changes to its character.

Visual Impact Assessment (VIA): Relates to assessing effects on specific views and on the general visual amenity experienced by people. It deals with how surroundings are affected by changes in the content and character of views due to the loss of existing elements or the introduction of new ones. Visual impacts may occur from Visual Obstruction (blocking a view) or Visual Intrusion (interruption of a view without blocking).

In accordance with relevant guidelines, the study area used for the LVIA is 20 km. Production of the LVIA involved desktop studies and fieldwork followed by professional evaluation by qualified Landscape Architects. The landscape assessment considers potential effects with reference to landscape character areas and criteria. The visual assessment considers effects upon visual receptors including scenic amenity designations, centres of population, transport routes, and local community views using 36 viewpoints (VPs) from representative and sensitive locations. Photomontages have been prepared for these viewpoints, including existing views, wireframe views, and proposed views.

The Proposed Development is located across a plateau of low rolling hills that rise towards Knockboha Summit (186 m AOD), located immediately north of the Wind Farm Site. While lower rolling hills and ridges extend to the south, the terrain descends towards the coastline to the north, east, and west of Knockboha Summit. Knockaghaleague Hill is another prominent elevated hilltop within the southwest periphery. Notable watercourses include the Heathfield River, which intersects a section of the Wind Farm Site adjacent to the R314. The principal land use within the central and wider study area is agricultural farmland bound by mixed hedgerow vegetation, though extensive areas of bogland and large commercial conifer forest plantations also occupy large tracts. Elevated lands of the Wind Farm Site principally comprise boglands and commercial conifer forestry. The wider study area encompasses notable wind farm developments, with the largest agglomeration in the southwest quadrant. Linear land uses include the N26 national primary route and N59 national secondary route in the southern periphery, along with a network of regional roads.

Visual Baseline and Receptors

- Centres of Population: The principal settlement is Ballycastle, situated approximately 4 km west of the turbine array. The village of Kincon is located approximately 3 km south of the Wind Farm Site. The settlement of Killala is situated approximately 5.5 km southwest along Killala Bay.

- Transport Routes: The N59 is located approximately 12.9 km south of the turbine array at its nearest point. The N26 is located approximately 16.5 km southeast of the Wind Farm Site. The nearest major route is the R314 regional road, situated less than 200 m from the nearest proposed turbine.

Under the Mayo County Development Plan (CDP) 2022-2028, the Wind Farm Site is located across two landscape character units: Area D: North Coast Plateaux (northern extent) and Area G: North Mayo Drumlins (southern extent). Character units in the wider area include Area E (North Mayo Mountain Moorland), Area F (North Mayo Inland Bog Basin), and Area C (North West Coastal Bog). The proposed wind farm is situated across Policy Area 1 (Mountain Coastal Zone), which has "High" sensitivity to wind farm development, and Policy Area 4 (Drumlins and Inland Lowland), which has "High/Medium" sensitivity.

For most commercial wind energy developments, the greatest potential for landscape impacts is the change in character due to the introduction of tall structures with moving components. In this instance, wind energy development is already an existing feature c. 5.5 km southeast (Killala) and in the wider southwest quadrant (Bellacorrick basin). The effect is therefore an intensification of an established land use rather than the introduction of a new, unfamiliar feature.The proposed wind farm is well assimilated within the Central Study Area due to the broad scale of landform and land use patterns. The turbines are well offset from some of the most sensitive coastal landscape

features. Ancillary features including an Onsite GIS Substation (approximately 15 m high), a BESS compound (approximately 6,360 m2) and a Met Mast (80 m high) will result in a localized increase in built development.

Summary of Visual Impacts

Up to 26 viewpoints were selected to represent local community receptors within the study area.

- Significance Range: Visual effects for local community views ranged from "Substantial-moderate" to "Slight-imperceptible".
- Substantial-moderate Impacts: Five viewpoints were classified as having a "Substantial-moderate" significance of effect: VP8, VP11, VP16, VP21, and VP36 (The Gazebo at Lacken).
- Moderate Impacts: Eight viewpoints representing the local community were classified with a "Moderate" residual significance of effect: VP9, VP14, VP15, VP19, VP22, VP24, VP26, and VP27.

While turbines will present at a considerable scale at some near receptors, they do not generate a notable sense of overbearing nor appear out of place in this robust setting. From susceptible coastal locations, turbines are typically viewed in the opposite direction to the main aspect of visual amenity (the sea). The irregular spacing and dispersed layout allow for visual permeability and prevent a sense of being contained within the wind farm. Overall, residual visual effects are assessed as Not Significant.

Cumulative Impacts

- Current Cumulative Scenario: Assesses the Proposed Development in respect of existing and consented developments. These are well offset from each other and viewed as separate developments. The magnitude of cumulative effect is deemed Low, as no other existing or consented developments are located within the central study area.
- Potential Future Cumulative Scenario: Includes proposed (in-planning) and pre-planning developments like Glenora and Keerglen. While this scenario would see a more prevalent presence of wind energy, the Proposed Development is contextually separated from these proposed farms by at least 7.6 km. The magnitude of cumulative effect for the future scenario is deemed High-medium.

Reference 2026 : Prospects for the Development of Onshore Wind Energy in Light of the Implementation of the European Landscape Convention: The Example of Poland. Krzysztof Badora and Radosław Wrobel. Sustainability 2026, 18, 11 https://doi.org/10.3390/su18010011

1. Introduction

The development of wind energy is determined by many factors, of varying importance in different regions of the world In addition to technological and economic factors related to, among others, the availability of areas with suitable wind conditions and cost–benefit analysis, key factors limiting the location and intensity of wind farm development are environmental protection conditions, closely linked to social acceptance of this form of energy Among them, an important element is the impact of wind farms on the landscape This impact includes changes in the structural elements of the landscape and its functioning, as well as changes in viewing conditions. The latter impact is identified as the most common due to the large visibility ranges of wind farms.

Areas with high visual landscape values sensitive to wind energy development are located particularly in the south of the country in mountainous regions and in the north along the Baltic Sea coast and lake districts [49] (Figure 1), characterized by diverse terrain, extensive forest cover, and the presence of coastlines and lakes.

Ultimately, the most important instrument for implementing landscape protection and shaping in accordance with the principles of the convention became the requirement to prepare landscape audits in individual regions of the country—voivodeships.

The most important role of landscape audits became to identify so-called priority landscapes and prepare recommendations and conclusions for them, which should be included in spatial planning.

In practice, the priority landscapes identified in the audits encompass the most valuable fragments of Poland's landscapes and include recommendations and conclusions, among others, limiting the development of investments that may negatively impact the structure, functioning, and visual values of the landscape. Among the investments with the greatest impact on the landscape are onshore wind farms.

From a technical and economic perspective, the potential impact of protecting priority landscapes on limiting the availability of land for wind energy development in zones with the most favorable wind conditions is of fundamental importance (Figure 4). Research results indicate that only some priority landscapes may limit wind energy development in zones with the most favorable and advantageous wind conditions.

4. Discussion

The implementation of the European Landscape Convention varies across European countries [46,65,66]. The implementation model adopted in Poland primarily involves designating priority landscapes, which are subject to protective measures, and leaving landscapes other than priority landscapes. Moreover, the protection of landscapes of national parks, nature reserves, and landscape parks is provided [51]. From the perspective of wind energy development, the adopted model is unfavorable. In priority landscapes, it creates very strong constraints on the development of wind farms, while in other areas without a rational landscape development policy, it can lead to significant changes, which are perceived as a significant impact of wind energy on people's lives [34–36]. This method of implementing ELC creates potential barriers to achieving the strategic goals of energy transformation and the country's energy security [58,59] and also poses a risk of intensifying social conflicts. The lack of social acceptance of wind energy development creates development constraints and reduces its profitability.

The ELC refers to three landscape-related components: protection, management, and planning [50,71]. The implementation of the convention in Poland primarily covers the protection segment, while for the development of wind energy and for local communities, the management and planning components are more important and are integrated with development plans and strategies, including the energy sector. Limiting the broad importance of landscape in the implementation of the ELC does not reflect the complexity of this issue [72,73]. The European Commission also points out the need to integrate wind energy development with rational landscape shaping and protection within the implementation of the ELC.

From the perspective of wind energy–landscape interactions, the problem with ELC implementation is the application of regional and local levels of action without ensuring national coordination and integration of 16 regional landscape protection and development policies. While a regional approach to ELC implementation is appropriate [74], the use of cohesion instruments is essential. Integration of landscape audits with other policies and development strategies has also not been considered. Implementing the convention requires interdisciplinary and transdisciplinary research [75], not limited only to landscape but also taking into account aspects of landscape management, including wind energy development.

Reference 2023 : Australian Draft Wind Energy Guideline. Department of Planning and Environment dpie.nsw.gov.au. Technical Supplement for Landscape and Visual Impact Assessment. November 2023

Setback

Wind turbines close to sensitive receivers including dwellings, historic homesteads, tourist accommodation, places of worship, town centres and central business districts, can be visually dominating despite the scenic quality or importance of the view. For example, a single 250 m turbine will generally have a dominant appearance if located within 2 km of a sensitive receiver and is completely visible.

Figure 2 prescribes a setback for turbines that are likely to have a dominant appearance. This setback applies from sensitive receivers and scales depending on the height of the turbines being proposed.

The setback is equivalent to 7 degrees of a person's vertical field of view.

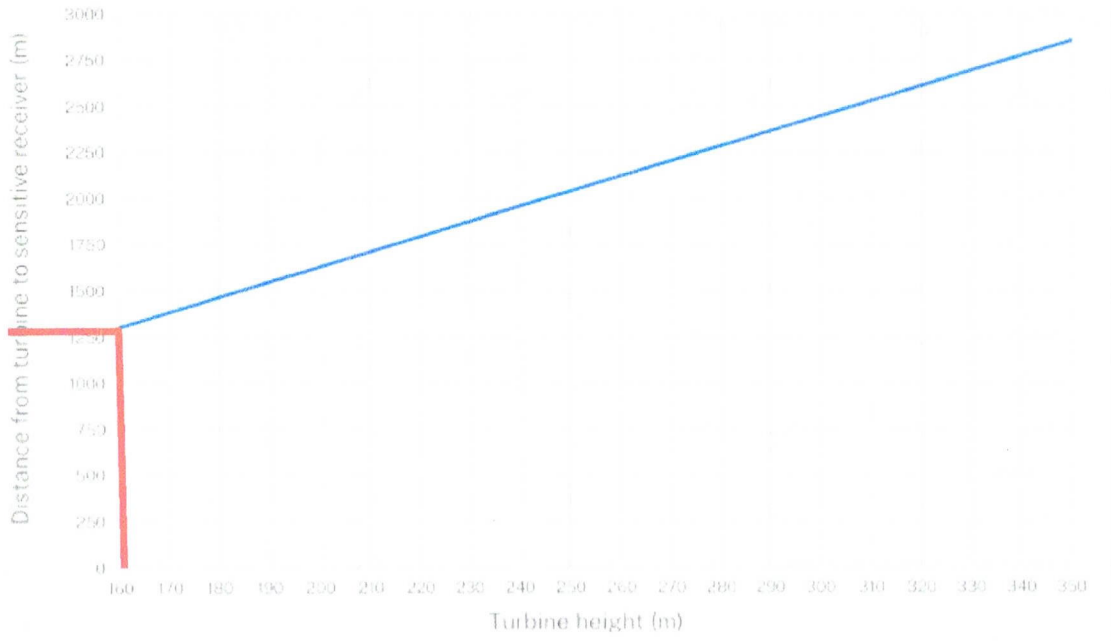


Figure 2. Setback from sensitive receivers

Response from MLavelle: For a sensitive receptor & 135m turbine height, the setback distance should be 1.25km.

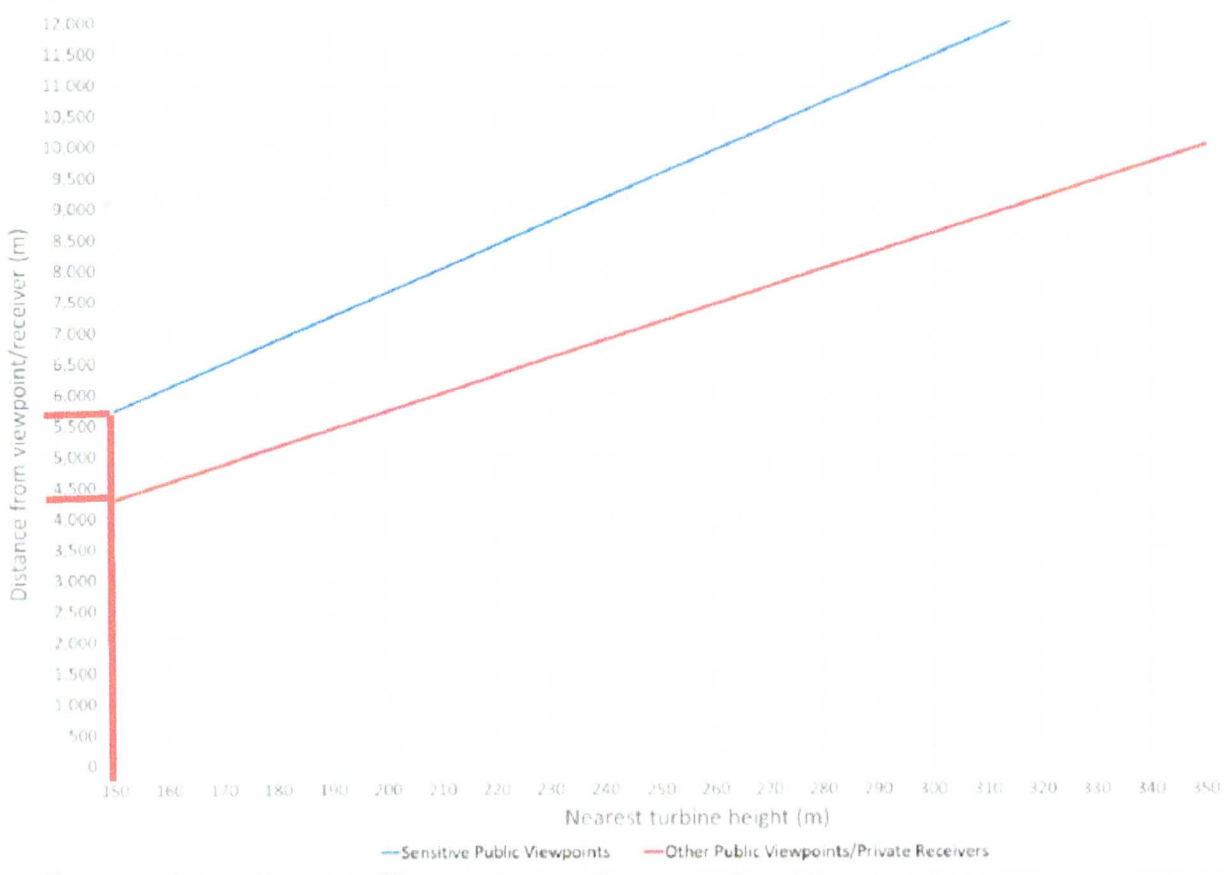


Figure 7. Extent of the scoping study area

Response from MLavelle: For a sensitive public viewpoint & 150m turbine height, the setback distance should be 5.6km. For other viewpoints, the setback should be 4.4km.

The first step of the scoping stage is for the applicant to identify a visual study area. The extent of the study area can be determined using the maximum height of the proposed wind turbines and the distances set out in Figure 7. The study area differs between public viewpoints and private receivers to recognise different values the community places on these locations and the reasons for their use.

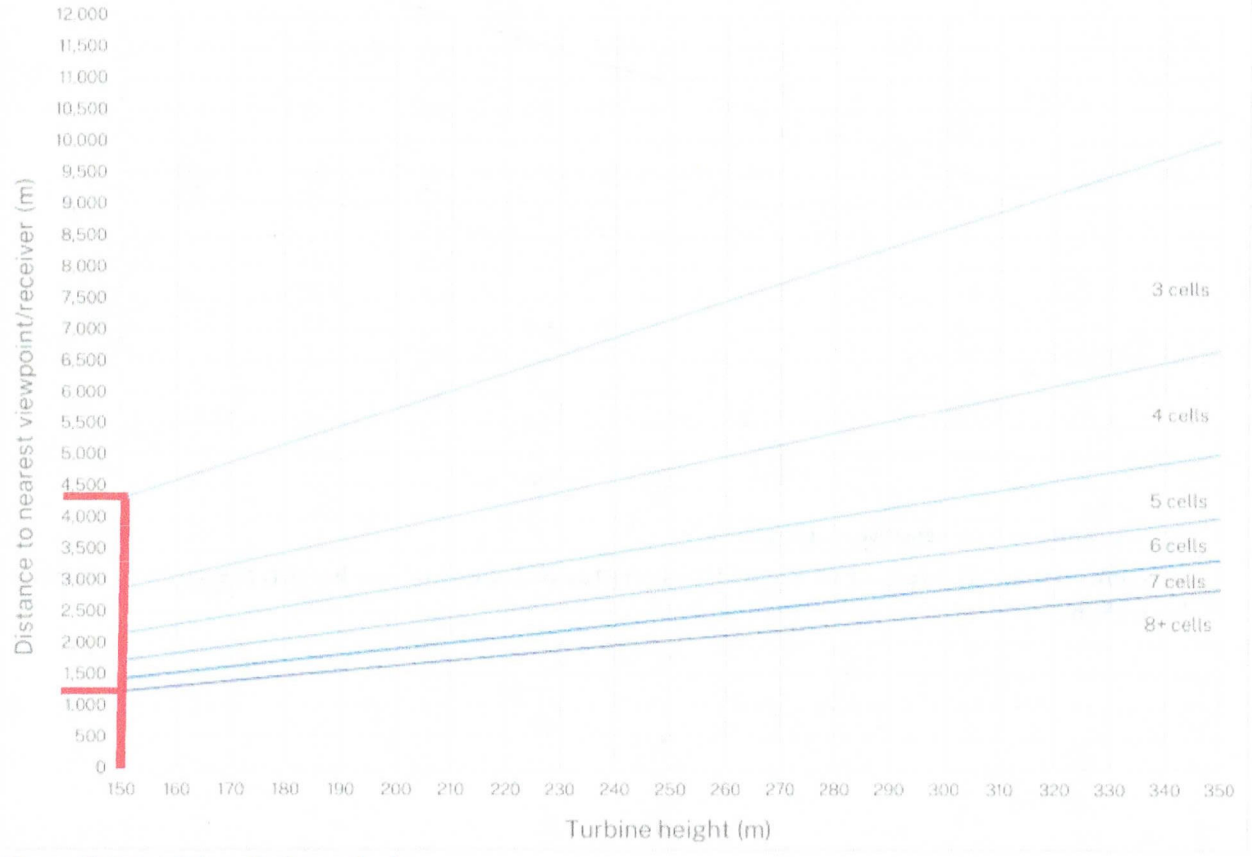


Figure 10. Potential vertical magnitude

Response from MLavelle: For a windfarm with more than 8 turbines, the setback should be 1.25km. However, the Tirawley proposed layout is a number of clusters of 3-4 turbines & this setback should be changed to 4.4km

Reference 2025 : Large-Scale Wind Energy Farm Development And Its Impacts On The Landscape: A Review Of The Greek Case. Evangelos Pavlis. Journal of Landscape Ecology (2025), Vol: 18 / No. 3 DOI: 10.2478/jlecol-2025-0019

The key concerns of landscape activists include:

a. The large scale of the investments (large size, concentration, and extent) in relation to the scale and carrying capacity of the landscape,

b. Negative impacts on avifauna, fossil records, Natura 2000 areas, and sensitive ecosystems;

c. Potential degradation of slow and sustainable tourism, including ecotourism, agritourism, and cultural tourism;

d. Adverse effects on the sustainable management of natural and cultural resources, such as agriculture and livestock farming;

e. Detrimental consequences for both natural and cultural heritage;

f. The significant profits garnered by wind energy companies through exploitation of the 'commons', potentially deepening socio-economic inequalities;

g. Disruption of prospects for localized sustainable development;

h. Inadequate provision of information and the lack of meaningful public consultation and engagement from the outset;

i. Depreciation of land values in affected areas;

j. Generation of surplus electricity primarily intended for export rather than local use;

k. The relatively small number of job opportunities created in the wind energy sector;

l. General lack of public involvement and democratic deliberation;

m. Insufficient compensatory benefits for local communities.

Site-Specific and Generic Barriers of Wind Energy Farms (WEFs) to the geological-geomorphological-climatic dimension of the landscape

Landscape dimension	Barrier Type	Description	Examples
	Site-Specific Barriers	Context-dependent and unique challenges that vary by location, tied to specific landscapes or environmental conditions	
Geological-geomorphological-climatic dimensions of the landscape	Geological and Geomorphological Constraints	Soil stability and bearing capacity issues requiring assessments. Potential risks of groundwater contamination due to deep excavations and construction activities.	Karst formations, geothermal fields, mountainous terrain, leakage of construction materials into aquifers.
	Microclimatic Impact	Wind farms may alter temperature, humidity, and rainfall patterns.	Increased nighttime temperatures, soil moisture loss.
	Vegetation and Soil Degradation	Land cover changes due to road networks, turbine foundations, and excavation, leading to soil erosion and degradation.	Desertification risk in arid areas, increased runoff affecting agricultural land.
	Infrastructure Challenges	Need for additional structures for slope stabilization and water drainage	Landslide prevention, reinforced road networks.
	Generic Barriers	Common challenges across various locations	
	Soil stability and bearing capacity concerns	Large-scale wind energy projects require assessment of soil stability, with challenges in areas with	Wind farms in mountainous areas may face issues with soil stability, requiring reinforcement measures such

		complex geological formations or steep slopes.	as slope stabilization to prevent landslides.
	Soil degradation and erosion	The construction process, including road building and excavation, can lead to erosion and soil degradation, especially in areas with fragile soil cover.	Roads built for turbine access in island regions prone to erosion could exacerbate soil loss, leading to further environmental degradation.
	Impact on local microclimate	Wind farms can alter the microclimate by mixing warm and cold air, potentially changing temperature and humidity.	Installation of wind turbines in agricultural areas could alter local microclimates, affecting crops that depend on specific temperature and humidity levels.
	Alteration of vegetation and soil cover	Large-scale WEF projects can disturb local vegetation and soil, leading to land degradation and a change in local ecosystems.	Construction of roads and turbines may disrupt local vegetation, leading to increased soil erosion and loss of biodiversity.
	Changes to rainfall patterns	WEFs may affect local rainfall patterns by altering the atmospheric flow, which could influence agriculture and local ecosystems.	Wind farms may alter precipitation patterns, leading to drier conditions in agricultural zones that depend on regular rainfall.
	Risk of desertification in high-risk areas	Areas at risk of desertification could experience exacerbated soil degradation and loss of vegetation due to large-scale wind energy developments.	Wind farms built in desertification-prone areas, such as the Aegean islands, could worsen soil erosion and accelerate the desertification process.

Scientific research indicates that the development and operation of large-scale WEFs can significantly affect avian and bat populations. Impacts may occur during migration, nesting, and breeding periods, especially for species with large wingspans or low reproductive rates (Hayes, 2013; Lehnert *et al.*, 2014; Carrete *et al.*, 2012; Dahl *et al.*, 2012; Tesfahunegny *et al.*, 2020; Furness *et al.*, 2013). In some cases, WEFs have been shown to disrupt migratory routes and alter daily flight behaviors of birds (Lucas *et al.*, 2021).

Beyond species-specific effects, WEF developments may also undermine broader ecological functions tied to traditional agricultural landscapes. In several targeted investment areas, land management practices such as terracing, hedgerows, and natural corridors have shaped distinct rural landscapes that act as vital biodiversity refuges (Rackham & Moody, 1996/2004). These features not only sustain ecological health but also contribute to the cultural and visual character of the countryside.

Table 2: Site-Specific and Generic Barriers of Wind Energy Farms (WEFs) to the ecological dimension of the landscape.

	Lack of Decommissioning and Restoration Plans	No clear policies on site rehabilitation after WEFs reach the end of their operational life.	Unclear strategies for biodiversity restoration, abandoned infrastructure impacting ecosystems.
	Generic Barriers	Common challenges across various locations.	
	Biodiversity Loss and Habitat Disruption	WEFs alter ecological relationships, affecting predator-prey dynamics and food chains.	Decline of key species affecting overall biodiversity balance.
	Long-Term Environmental Uncertainty	Insufficient research on the long-term ecological effects of WEFs.	Potential unforeseen consequences on flora, fauna, and soil stability.
	Conflicts with Conservation Policies	Wind energy projects may contradict national and international conservation frameworks.	Incompatibility with protected area regulations, legal challenges in ecologically sensitive zones.

Landscape dimension	Barrier Type	Description	Examples
	Site-Specific Barriers	Context-dependent and unique challenges that vary by location, tied to specific landscapes or environmental conditions.	
Ecological dimension of the landscape	Biodiversity Loss and Habitat Disruption	WEF installations impact species that are rare, vulnerable, endangered, or globally significant, altering ecosystems and disrupting habitats.	Disturbance in NATURA 2000 areas, destruction of breeding/nesting sites.
	Bird and Bat Mortality	Turbines pose a direct threat to flying species, particularly those with larger wingspans and lower reproduction rates.	Collision risks for migratory birds, displacement of bat populations.
	Disruption of Migration and Movement Patterns	Wind farms alter the migratory routes and daily movement of certain species.	Interference with birds' seasonal migration, changes in feeding and nesting behaviors.
	Loss of Agricultural Biodiversity	Traditional landscapes with ecological management elements (terraces, hedgerows, corridors) are degraded, reducing biodiversity.	Removal of crucial refuges for flora and fauna, loss of pollinators.

The visual-aesthetic dimension of the landscape

The visual dimension of the landscape is central to how humans decode space and make sense of their surroundings. Through perception—shaped by cognitive and neurological processes—the landscape becomes not merely a physical setting but an image, a spectacle, or a representation. This image, whether material, imaginary, or symbolic, is constructed within the human mind. Visibility and representation require a certain "distance" between the observer and the observed, enabling the landscape to reflect ideological, cultural, and ethical aspects of the human gaze. In this way, the observer is situated within a world that is simultaneously material and symbolic, subjective and objective (Terkenli, 2005).

The introduction of wind turbines into a landscape can significantly affect how it is perceived and valued. For instance, local acceptance of wind energy development is often influenced by visual exposure to turbines. Long-term exposure tends to reinforce perceptions of visual intrusion or dominance (Świdyńska *et al.*, 2024).

Key factors shaping the visual-aesthetic dimension include the landscape's character, features, and scale. The character of a landscape results from the unique combination of its elements, giving rise to a distinct 'sense of place' that differentiates one area from another (Swanwick, 2002). Landscape features—such as elevations, hedgerows, stone enclosures, pathways, and traditional buildings—embody both ecological and cultural significance. However, many of

these features, especially stone structures, are at risk of disappearing due to the decline of traditional building knowledge and practices (Kizos & Koulouri, 2006; Rackham & Moody, 1996/2004).

Scale is a critical concept in understanding the landscape. It provides a framework for interpreting the environment from the local to the regional level and challenges the notion of a "one size fits all" model in spatial planning. Both horizontal coverage and vertical height of structures must be assessed in relation to the inherent characteristics of the landscape. For example, in a setting characterized by modest dwellings, pine forests, low stone walls, and gentle relief, wind turbines exceeding 100 meters in height would appear incongruous and disproportionate, disrupting the visual harmony and coherence of the place (Scottish Natural Heritage, 2009).

The aesthetic value of the landscape transcends its functional use, emerging from sensory and emotional experiences such as beauty, tranquility, harmony, sacredness, and historical resonance. These qualities enrich human life and well-being by enabling deep, contemplative engagement with place. At the same time, aesthetic experience is not entirely subjective—it also involves intersubjective criteria shared across communities and cultures (Adorno, 1970/2000; Terkenli, 1996). As Kirchhoff (2014) points out, energy infrastructures can conflict with widely held aesthetic ideals, underscoring the need for spatial planning that respects and reflects collective visual values.

The integration—or lack thereof—of large-scale WEFs into the visual landscape is influenced by a number of factors: the form, shape, color, line, and texture of the turbines, their size, density, and spatial extent, and the broader context of mass energy production for export. These installations may dominate the landscape, altering its identity and provoking questions about power dynamics, land use, and local control (Mitchell, 2008). Moreover, such interventions are not limited to visual disruption; they may also have cascading ecological consequences, further affecting landscape quality.

In Greece, these concerns are particularly pressing in protected areas and Landscapes of Special Natural Beauty, a designation established under Law 1650/1986. In such contexts, the visual-aesthetic dimension of the landscape is not only an environmental and cultural asset but also a legal and ethical consideration in planning decisions.

Table 3: Site-Specific and Generic Barriers of Wind Energy Farms (WEFs) to the visual-aesthetic dimension of the landscape

Landscape dimension	Barrier Type	Description	Examples
	Site-Specific Barriers	Context-dependent and unique challenges that vary by location, tied to specific landscapes or environmental conditions.	
Visual-Aesthetic Dimension of the Landscape	Disruption of Landscape Character	WEF installations alter the visual coherence, identity, and sense of place of a landscape.	Large-scale wind turbines in traditional rural settings or cultural landscapes.
	Scale Incompatibility	The height and density of wind turbines contrast with existing landscape features, leading to visual disharmony.	Wind turbines exceeding 100m in areas with small-scale farmsteads, forests, or rolling hills.
	Impact on Designated Scenic and Protected Areas	WEFs in protected landscapes (e.g., Landscapes of Special Natural Beauty, NATURA 2000 sites) reduce their aesthetic and cultural value.	Wind farms in areas with historical or ecological significance, affecting heritage views.
	Loss of Aesthetic Enjoyment and Serenity	The presence of industrial structures in natural or cultural landscapes diminishes aesthetic experiences.	Wind farms in locations valued for tranquility, sacredness, or scenic beauty.
	Generic Barriers	Common challenges across various locations.	
	Visual Dominance and Skyline Intrusion	Large WEF installations disrupt the natural or cultural skyline, overpowering existing landscape elements.	High-density wind farms in open countryside, coastal areas, or mountain ridges.
	Subjective and Inter-Subjective Aesthetic Perceptions	Public perception of wind farms varies based on cultural, ideological, and personal aesthetic values.	Opposition to wind farms due to perceived industrialization of nature.
	Lack of Spatial Planning for Landscape Integration	Inadequate planning for WEF placement results in poor visual integration and spatial dissonance.	Misalignment between wind energy expansion and landscape aesthetics.
	Transformation of Traditional and Symbolic Landscapes	WEFs alter landscapes with historical, symbolic, or artistic significance.	Wind farms impacting the visual integrity of culturally important landscapes.

The socio-economic dimension of the landscape

The socio-economic dimension of the landscape refers to the processes through which landscapes are produced, reproduced, and consumed. These processes are shaped by socio-economic relations of production, which determine the form, structure, and function of landscapes within specific historical and technological contexts. Often marked by contradictions, these relationships influence whether natural and cultural resources are managed sustainably and collectively, or whether they are subject to exploitation and the appropriation of surplus value. A comprehensive understanding of the landscape thus demands insight into these underlying dynamics (Mitchell, 2008; Terkenli, 2006; Cosgrove, 1984).

In this context, large-scale, fast-tracked wind energy projects illustrate the growing influence of the Aeolian industry in both shaping and consuming rural landscapes. These oversized industrial installations do not merely generate energy—they also function as symbols of market dominance, reflecting the power imbalance between corporate interests and local communities. Such developments contribute to the transformation of rural economies from production-based systems into large-scale energy production hubs signifies a shift in power relations, sovereignty, and control, directly influencing the production and consumption of landscapes.

Such investments are expected to impact the productive sectors of local economies, traditionally based on agriculture and livestock farming, leading to potential alterations in the form, functions, and management of ecosystems. Wind energy facilities are known to affect agricultural and pastoral activities, potentially displacing livestock units and threatening the viability of local food systems such as beekeeping. These disruptions extend beyond economic

implications to impact social relations and the organization of rural life. As most WEFs are installed on public land, concerns have emerged about speculative appropriation, often supported by subsidies but offering limited benefit to local or regional development. Chatzimichalis (2014) emphasizes this dual process of green grabbing by highlighting the 'appropriation of public land by subsidized speculative investments with limited contribution to local/regional development' (2014:115) and the 'indirect appropriation of food resources through the conversion of arable land into industrial use' (2014:118). Siamanta (2019) examines the phenomenon of green grabbing as a process that reinforces socio-economic inequalities, adversely affecting local shepherds and farmers, small-scale and domestic electricity consumers, and contributing to ecological distribution conflicts. In post-crisis Greece, wind energy facilities are promoted as a socio-ecological fix to both economic recession and climate change, yet they often prioritize market interests over local livelihoods, equity, and inclusive development. Spanos & Petropoulou (2024) argue that, in Greece as well as in other contexts, investments in green energy are frequently motivated less by genuine commitments to mitigating climate change and more by the pursuit of capital accumulation through processes of land dispossession—dynamics that, in certain instances, constitute forms of green grabbing. They contend that enterprises engaged in such activities are often entangled in environmental conflicts, particularly where violations of environmental legislation are evident.

The result is the production of homogenized industrial landscapes, tailored to serve the needs of the wind energy industry but often in tension with other sectors—most notably, tourism. The tourism industry plays a significant role in landscape branding and management, relying on cultural narratives, symbolism, and scenic integrity through myths, images, stories, and ideologies. In island and mountainous regions, ecotourism—such as birdwatching and nature-based tourism—has become a key support system for small-scale rural economies. Yet, these activities are vulnerable to the environmental and visual impacts of WEFs, especially in areas of high biodiversity. The expansion of alternative tourism that depends on intact natural and cultural landscapes may be constrained or altogether obstructed by industrial development (Kipperberg *et al.*, 2019).

Table 4: Site-Specific and Generic Barriers of Wind Energy Farms (WEFs) to the socio-economic dimension of the landscape

Landscape dimension	Barrier Type	Description	Examples
	Site-Specific Barriers	Context-dependent and unique challenges that vary by location, tied to specific landscapes or environmental conditions.	
Socio-economic dimension of the landscape	Transformation of Local Economies	WEF development shifts rural economies from agricultural and livestock-based production to industrial energy hubs, disrupting traditional livelihoods.	Relocation of livestock units, reduction of agricultural land, impact on beekeeping.
	Impact on Local Tourism and Ecotourism	WEFs affect tourism sectors reliant on intact landscapes, cultural heritage, and biodiversity.	Decline in birdwatching, wildlife tourism, and nature-based tourism.
	Land Appropriation and Resource Reallocation	WEF installations often take place on public land, limiting access and altering land-use patterns.	Conversion of arable land into industrial energy zones, restricting local agricultural activities.
	Weak Contribution to Local Employment	Few permanent job opportunities are created, mainly for unskilled labor, failing to boost the local workforce.	Employment limited to temporary construction jobs and low-skill positions (e.g., guards, cleaners).
	Negative Effects on Rural Mobilities and Repopulation Efforts	The creation of industrialized landscapes discourages rural mobilities and efforts for rural residence, recreation or entrepreneurship.	Urban dwellers reconsider relocating to rural areas due to landscape transformation.
	Generic Barriers	Common challenges across various locations.	
	Market-Driven Development and Unequal Power Relations	The wind industry prioritizes profit over local socio-economic needs, leading to uneven regional development.	Energy supply decisions dictated by corporate interests rather than local needs.
	Absence of Consultation and Social Dialogue	Limited stakeholder engagement and top-down decision-making processes exclude local communities from planning.	Minimal participation of local actors in decision-making regarding WEF placements.
	Green grabbing	Green grabbing is the appropriation of land and resources in the name of environmental goals (climate change), often at the expense of local communities.	Privatization of public lands often leased at low cost to private investors with minimal local employment creation, rising energy costs for small users and unjust development
	Commodification and Homogenization of Landscapes	WEFs turn landscapes into standardized industrial zones, diminishing their uniqueness and multifunctionality.	Loss of diverse rural land uses, turning landscapes into sites of energy production.
	Conflicts Between Renewable Energy and Alternative Land Uses	WEF expansion competes with existing land-use strategies, such as agriculture, cultural heritage conservation, and tourism.	Reduction in agricultural productivity, fragmentation of cultural landscapes.
	Long-Term Social and Economic Uncertainty	The long-term impacts of WEF projects on local socio-economic structures remain unclear, especially post-decommissioning.	Lack of planning for landscape restoration after turbine lifespan ends.

Additionally, rural Greece has recently witnessed the emergence of a cultural economy tied to post-crisis urban-to-rural mobilities. Motivated by economic hardship and changing lifestyle preferences, urban households are relocating

to provincial areas, driving new forms of residence, recreation, and entrepreneurship (Gkartzios & Scott, 2015; Kasimis & Zografakis, 2014; Kasimis & Papadopoulos, 2013). However, the proliferation of large-scale wind parks poses a threat to this trend by diminishing the aesthetic and cultural qualities that attract new settlers and investment, thus impeding potential rural revitalization.

The promised employment benefits of wind energy projects often fall short. Energy companies typically offer limited local job opportunities, mostly low-skill positions (e.g., guards, maintenance workers), with few prospects for long-term or meaningful employment. Claims of substantial contributions to local labor markets are frequently overstated. Overall, there is a noticeable lack of meaningful dialogue among market actors, state authorities, and local communities. Decision-making is often centralized and opaque, privileging industrial profitability over social and ecological sustainability. As Mitchell (2008) argues, landscapes are increasingly reconfigured to serve the imperatives of capitalist production and energy demand, with little regard for their socio-cultural or ecological roles. The introduction of oversized energy infrastructures—as new dominant symbols—risks undermining the integrity and identity of rural landscapes, with long-term consequences for local economies, governance, and quality of life.

The historical-archaeological-national dimension of the landscape

Landscapes are not solely defined by their contemporary functions; they are layered spaces—palimpsests—that carry the imprints of past civilizations, historical events, and cultural practices (Bender, 1993; Crang, 1998; Muir, 1999; Rackham & Moody, 2012). As such, they operate as living archives, offering insight into the temporal continuity of place and bearing witness to the evolution of human societies. Through their forms, structures, and embedded symbols, landscapes become mosaics of cultural heritage, revealing how social groups have inscribed their identities, memories, and values upon the land over time.

This historical depth imbues landscapes with symbolic and national significance. They serve as sites where collective memory, myth, and geography intersect, cultivating a shared sense of belonging (Mumcu *et al.*, 2017; Soovali *et al.*, 2003; Häyrynen, 1998; Schama, 1995). Landscapes thus play an essential role in the formation and negotiation of national identity, which is not static but continually redefined through shifting geographical, functional, and symbolic contexts (Terkenli, 2001). As Massey (1995:187) asserts, "if the past transforms the present, helping to construct it, then the present also constructs the past"—emphasizing the dynamic reciprocity between memory and contemporary meaning.

Indeed, as Meinig (1979:164) notes, "every mature nation has its symbolic landscapes [...] which constitute part of the collective series of ideas, memories, and emotions that bind people together". Terkenli (2010:45) further highlights the landscape's centrality to nation-building, underscoring that 'the landscape is one of the most significant components of the ideological basis for constructing nations'. Through state narratives, monuments, and protected sites, the landscape is often mobilized to support national imaginaries and reinforce territorial legitimacy.

Table 5: Site-Specific and Generic Barriers of Wind Energy Farms (WEFs) to the historical-archaeological-national dimension of the landscape

Landscape dimension	Barrier Type	Description	Examples
	Site-Specific Barriers	Context-dependent and unique challenges that vary by location, tied to specific landscapes or environmental conditions.	
Historical-archaeological-national dimension of the landscape	Impact on Archaeological Sites	Wind energy projects may disturb or damage unexplored or vulnerable archaeological sites through construction activities such as road openings and foundation excavations.	Destruction or alteration of ancient ruins, burial sites, or other heritage sites during WEF construction.
	Loss of Landscape as Palimpsest	The installation of WEFs may erase or disrupt the historical layering of a landscape, undermining its symbolic and historical value.	Destruction of historical layers that connect the present to past cultural and historical memories.
	Threat to National Identity and Cultural Symbolism	Landscapes embody national history and identity; the ideological foundation of nationhood is deeply rooted in the landscape itself; the introduction of industrial WEFs may alter these landscapes in a way that weakens or transforms the national connection people have to them.	Disruption of symbolic landscapes tied to national identity or historical events, such as monuments or battlefields.
	Reduction in Sense of Belonging	If people can no longer recognize their identity in their landscapes, it can lead to disconnection from heritage and culture.	Communities feeling alienated from landscapes that once reflected their historical or cultural narratives.
	Generic Barriers	Common challenges across various locations.	
	Destruction of Cultural Memory	Large-scale industrial installations may overshadow or obscure cultural landscapes, erasing the connection between people and their historical environment.	Widespread installations in areas of cultural or national importance, reducing the visibility of cultural landmarks.
	Fragmentation of Historical Narratives	WEFs may fragment or distort the continuity of historical and archaeological stories embedded in the landscape.	Disturbance of landscapes that are integral to national myths, legends, or historical events.
	National Identity Conflict	Conflicting interests between preserving a national heritage and developing modern energy infrastructure may lead to ideological divisions.	Tension between the development of renewable energy projects and the preservation of national heritage, particularly in culturally significant areas.
	Lack of Recognition of Cultural Value	National and cultural heritage may not be sufficiently prioritized in planning decisions related to WEF installations.	Oversight of historical or cultural importance when selecting sites for wind farms.

However, this palimpsestic quality of the landscape is increasingly threatened by large-scale industrial interventions, particularly those associated with wind energy development. Infrastructure works—such as extensive road construction, excavation, and the installation of turbines—pose significant risks to unexplored or undocumented archaeological sites. These interventions may result in the irreversible damage or loss of historical layers, thus severing critical links to the past and disrupting the continuity of cultural memory embedded in the land.

When such transformations obscure or erase the traces through which people recognize themselves and their histories in the landscape, a rupture in identity can occur. Landscapes function as mirrors of collective cultural expression and societal choice (Meinig, 1979). If these mirrors no longer reflect the people who inhabit them, a sense of dislocation and alienation may emerge. In such cases, communities may be compelled to redefine their identities, not through inherited cultural landscapes, but through new geographies shaped by market imperatives.

These evolving dynamics underscore the power relations inherent in landscape production. The imposition of market-driven priorities—often at the expense of historical, cultural, and archaeological values—illustrates the growing dominance of capital in reshaping not only the physical but also the symbolic dimensions of the landscape (Mitchell, 1994; 2008). This raises critical concerns about the extent to which current development practices respect, preserve, and integrate the deep temporal and cultural layers that constitute landscape identity.

The experiential dimension of the landscape

The experience of landscape transcends visual perception, encompassing a broad array of sensory engagements—including touch, smell, taste, and sound—that contribute to a holistic understanding of place (Wylie, 2017; Bourassa, 1991). While efforts to preserve visual aesthetics and architectural heritage often dominate landscape protection agendas, there is growing recognition of the multisensory character of landscapes and the critical role of non-visual stimuli in shaping spatial experience and identity.

Sound, for instance, plays a pivotal role in defining the atmosphere and emotional resonance of a place. The widespread installation of industrial WEFs has been shown to significantly increase noise pollution, particularly through low-frequency sounds that may contribute to sleep disturbances and broader psychological impacts among nearby residents (Ellenbogen *et al.*, 2024; Tabassum-Abbasi *et al.*, 2014; Bakker *et al.*, 2012). Similarly, landscapes possess distinctive olfactory signatures, or "olfactory maps," which include both pleasant and unpleasant odors—ranging from the aroma of blooming vegetation and local cuisine to smells from sewage systems, pig farms, or olive oil production facilities.

The tactile dimension of landscape emerges through physical interaction with material surfaces—such as the textures of cobblestones, marble slabs, rough pavements, or earthen paths—which evoke particular spatial and emotional responses. Likewise, a "taste map" reflects the culinary identity of a region, where local ingredients, traditional foodways, and preparation techniques connect gastronomy to landscape experience and regional heritage (Stefanou & Stefanou, 2005). These layered sensory experiences reinforce the embodied and affective dimensions of landscape, anchoring memory, identity, and belonging.

Noise pollution, especially from continuous turbine operation, can contribute to the degradation of both environmental and sensory quality, posing potential risks to physical and psychological health. These effects are particularly pronounced during the construction phases of wind energy projects, when noise levels escalate. Addressing this issue requires specialized acoustic assessments that measure not only the frequency and intensity of turbine noise but also its impacts on human well-being and landscape perception. Recent research also highlights how turbine-related sound affects wildlife habitats, particularly those of predator species, with scientists employing advanced computational methods to assess and mitigate ecological impacts (Nazir *et al.*, 2020).

Moreover, the psychological dimensions of noise exposure—such as the "nocebo effect", where individuals report adverse health symptoms based on negative expectations rather than direct physical causes—must also be taken into account (Simos *et al.*, 2019). These responses, classified under the broader category of idiopathic environmental intolerance, underscore the need for inclusive approaches that combine empirical evidence with a deeper understanding of community perceptions and lived experiences regarding wind turbine noise.

Large-scale wind energy developments also have the potential to disrupt outdoor recreation, and rural tourism, which are increasingly important to the socio-economic revitalization of rural areas. Rural tourism is an evolving concept shaped by time and place, yet grounded in enduring core values—like environmental protection—that align with UNWTO and UN SDGs (Rosalina, 2021). Agritourism has emerged as a "smart chance" for sustaining mountain rural environments by diversifying farm income, sustaining agrifood systems, valorizing the role of producers, preserving and renewing local traditions, and combating depopulation (Ciolac *et al*, 2020; Ivona & Privitera, 2022; Partalidou & De Matteis, 2024). Nature based tourism involves visits to relatively undisturbed natural areas, focusing on scenery,

wildlife, and natural reserves, encompassing education, recreation (Lee, 2013) and adventure elements, and a series of nature based solutions (Padma *et al.*, 2019).

Since the 1990s, rural areas have been reshaped by de-agriculturalization, socio-economic integration, and increased pluriactivity, forming a 'new rurality' (Kasimis & Papadopoulos, 2013). In recent years, the Greek countryside has witnessed a surge in outdoor and mountain activities, such as hiking, rock climbing, mountain biking, jeep safaris, and hunting, alongside traditional agricultural labor and rural practices (Belias, 2019; Karagianni *et al.*, 2019). Simultaneously, there is increasing recognition of the ecological, economic, and cultural value of rural and agricultural landscapes. For instance, traditional practices like masticulture, raisin production, and olive cultivation are now seen as vital heritage landscapes (Gkoltsiou *et al.*, 2021). These developments underscore a growing 'back to the land' / 'back to the countryside' movement that blends modern approaches with traditional practices (Kasimis & Papadopoulos, 2013; Figueiredo *et al.*, 2020), while also aiming to enhance quality of life and promote place-based economies grounded in local culture, the environment, rural landscapes, and territorial assets (Pavlis, 2017; 2024). Wind energy infrastructures, however, may obstruct access to these landscapes, fragment existing trail networks, and diminish the aesthetic and recreational value of natural areas. This can severely compromise rural development strategies focused on experiential tourism, cultural heritage valorization, and landscape-based innovation. As such, a comprehensive and participatory spatial planning framework is needed—one that integrates environmental, social, cultural, and economic considerations to ensure that renewable energy transitions do not undermine the experiential integrity and developmental potential of rural landscapes.

Table 6: Site-Specific and Generic Barriers of Wind Energy Farms (WEFs) to the experiential dimension of the landscape

Landscape dimension	Barrier Type	Description	Examples
	Site-Specific Barriers	Context-dependent and unique challenges that vary by location, tied to specific landscapes or environmental conditions.	
Experiential dimension of the landscape	Noise Pollution from Turbines	Continuous exposure to turbine noise during operation or construction stages can degrade the landscape's experiential quality, leading to health issues such as sleep disturbance, stress, and psychological burdens.	Turbine noise affecting nearby residents and wildlife, with heightened impacts during construction.
	Turbine Noise Impact on Predator Habitats	Noise pollution can disturb predator habitats, leading to disruptions in local ecosystems and wildlife behavior.	Decreased presence of local wildlife due to turbine noise affecting animal senses and habitats.
	Disruption of Hiking Trails and Recreational Spaces	The installation of WEFs can alter or block established hiking trails, reducing opportunities for outdoor activities like agrotourism and ecotourism.	Hiking trails disrupted by WEF installations in rural or mountainous areas, reducing accessibility for outdoor enthusiasts.
	Aesthetic and Sensory Degradation	The visual and auditory presence of large-scale WEFs may diminish the scenic and sensory experience of natural landscapes.	Obtrusive turbines affecting the tranquility of rural areas known for their natural beauty and recreational appeal.
	Health Concerns Due to Noise (Nocebo Effect)	Psychological impacts such as "nocebo effect" (health complaints due to perceived environmental intolerance) may be exacerbated by turbine noise, affecting local residents' quality of life.	Complaints about headaches, stress, and sleep disturbances from local residents living near turbine installations.
	Impact on Local Tourism Activities	Tourism activities that rely on natural, quiet, and aesthetically pleasing environments (e.g., hiking,	Decline in ecotourism and agrotourism activities due to the presence of turbines

		rock climbing, mountain biking) may be hindered by the presence of large-scale wind farms.	disrupting natural aesthetics and peace.
	Generic Barriers	Common challenges across various locations.	
	Cultural and Experiential Disconnect	Local communities may feel a disconnect from the landscape if its sensory experience is altered, affecting their sense of place and cultural ties to the environment.	Loss of sensory experiences such as smells, sounds, and tactile elements of the landscape due to industrialization.
	Negative Impact on Rural Recreation and Education	Educational and recreational activities that depend on the natural state of landscapes (e.g., research, environmental education, or nature-based recreational activities) may be negatively affected by the industrialization of landscapes.	Difficulty in developing or maintaining ecomuseums, cultural/educational trails, and nature-based recreational activities due to the presence of wind farms.

DISCUSSION

The integration of large-scale WEFs into the landscape is not merely a technical challenge— it is fundamentally a socio-cultural issue that requires alignment with the sense of place and societal values (di Cosmo, 2023). Landscapes are inherently social and cultural constructs, and their transformation through energy infrastructure raises profound questions about identity, equity, and sustainability. The development of such projects risks privatizing commons, reshaping rural territories, and jeopardizing both natural and cultural resources. A particularly noteworthy aspect, especially when considering that it was not accomplished even by the broader, large-scale processes of change (Van der Sluis, 2013).

This is not solely a matter of visual aesthetics or symbolic representation. Rather, it involves a set of complex, site-specific, and more generalized barriers (as detailed in Tables 1–6) that can significantly shape public acceptance. Social dimensions of renewable energy transitions—often underappreciated—may, in fact, be as critical as technical ones (Pasqualetti, 2011). Key factors such as attachment to landscape, preservation of cultural heritage, safeguarding of local livelihoods, and meaningful community engagement are central to how wind energy projects are perceived and received.

To date, public consultation processes regarding the installation of wind farms—and more broadly on issues of public interest—remain inadequate. Conducted primarily through the opengov.gr platform, participation is limited to a small segment of the population, as the majority of citizens are neither sufficiently informed about the existence of this mechanism nor encouraged to engage with it. Furthermore, the time frame during which consultations are open is often insufficient for stakeholders to become adequately informed and to develop considered positions. In terms of information accessibility, crucial project data is not always fully available, and there is a lack of public presentations that objectively outline both the potential benefits and adverse impacts of such developments. Information dissemination is frequently undertaken by self-organized and self-mobilized citizen groups, often in the absence of institutional involvement. Moreover, there is a lack of transparency concerning how consultation feedback submitted via opengov.gr is processed and the extent to which it informs decision-making or project implementation. These shortcomings raise significant concerns that merit the attention of the Council of Europe.

In the absence of inclusive dialogue and participatory planning, the imposition of large-scale WEFs risks reinforcing local resistance, escalating social tensions, and undermining the very goals of a just and sustainable energy transition. Opposition to these projects often reflects deeper connections to the land, encompassing a wide array of environmental, socio-economic, and cultural concerns. These include issues such as geological instability, erosion, soil degradation, changes to microclimates, biodiversity loss, habitat fragmentation, disruption of cultural heritage, visual impacts, and potential conflicts with rural economies reliant on tourism and agriculture. Moreover, broader themes of social justice and the long-term viability of energy infrastructure further fuel resistance.

Such reactions are not merely conservative responses to change. Instead, they speak to the role of landscapes as lived spaces, cultural repositories, and economic resources. Addressing these concerns calls for a more integrated and nuanced approach—one that considers not only the technical feasibility of wind energy but also the intricate socio-environmental dynamics that shape each landscape.

Ultimately, the siting of wind farms must follow integrated spatial planning principles and involve early and meaningful public consultation, in line with Directive 85/337/EEC and the Aarhus Convention. Clear guidelines for

appropriate placement are outlined in Table 7, providing a framework to ensure that energy transitions do not come at the cost of landscape degradation or social alienation.

Table 7: Guidelines for the Suitable Placement of Wind Energy Farms (WEFs)

Category	Criteria
Suitable Areas for WEFs	
Non-sensitive landscapes	Areas of lower scenic quality (e.g. industrial zones) with less visual, ecological, cultural, social and economic impact.
Non-protected zones	Areas outside nature reserves, national parks, and UNESCO sites to avoid biodiversity conflicts.
Offshore locations	Offshore regions, where feasible, to minimize land-based environmental, socio-economic, cultural and visual impacts.
Minimize impact on population	Ensure distance from densely populated areas to reduce noise, visual, and social effects. Employ advanced mapping and planning techniques to identify optimal locations.
Unsuitable Areas for WEFs	
High-quality landscapes	Scenic and culturally significant landscapes (e.g., coastal areas, high mountains).
Protected nature & landscape areas	Nature reserves, cultural heritage sites, and biodiversity hotspots to prevent environmental harm.
Areas with strong local attachment	Regions where communities have deep cultural, social, or economic ties to the existing landscape.
Recommended Size of Installations	
Smaller-scale installations	Fewer turbines per site for better public acceptance and landscape compatibility.
Limited turbine height	Ideal height range of 20-40 meters to balance efficiency with visual, geological, morphological, ecological, etc. integration.
Site-specific design	Adapting installation size and layout based on landscape characteristics and socio-cultural impact.

14 SHADOW FLICKER & EMI

Chapter 15 of the EIAR contains a shadow flicker analysis. Shadow flicker is the effect of light levels in a sunlit room noticeably varying as a result of the shadow of a turbine blade passing a window, causing a nuisance. Industry standard software was used to model the potential for shadow flicker to occur, based on the proposed turbine locations and dimensions and the locations of residential properties.

The Study Area is defined as 10 times the maximum potential rotor diameter (10 x 117 m = 1,170 m). It is common practice to use a distance of ten rotor diameters as a maximum limit within which significant shadow flicker effects can occur, this is based on WEDGs 2006 which state: 'At distances greater than 10 rotor diameters from a turbine, the potential for shadow flicker is very low'

Response from MLavelle: The turbines, if granted, should be conditioned to be switched off for 1hr after dawn & before dusk each day.

Cumulative shadow flicker effects could arise if dwellings are at risk from potential shadow flicker effects as a result of more than one wind farm. While separate wind farms are not likely to cause effects simultaneously, they could increase the cumulative total hours where a receptor is affected. In this instance, there are no proposed or operational wind farms within a 2 km range of the Wind Turbines that may cause cumulative effects.

The assessment has identified the potential for shadow flicker to affect 108 no. out of 119 no. receptors within the shadow flicker Study Area. It is proposed that a shadow control system be installed to eliminate the potential for shadow flicker from the Proposed Development above the recommendations of the 2006 Guidelines. This assessment has identified that by installing a blade shadow control system on the proposed turbines, there will be no significant direct or indirect effects. Given that only effects of significant effect or greater are considered "significant" in terms of the EIA Directive the potential effects of the Proposed Development as a result of shadow flicker, when mitigated, are considered to be not significant. The Proposed Development has been assessed as having the potential to result in neutral, imperceptible, long-term effects overall with regards to shadow flicker. There are no predicted cumulative effects.

15 CULTURAL HERITAGE

Chapter 14 of the EIAR presents a baseline study of and impact assessment on, the cultural heritage of the Proposed Development and an associated defined Study Area. The assessment was based on a series of site inspections and a programme of desktop research which were carried out to identify and record any archaeological, architectural and cultural heritage receptors that may be affected by the Proposed Development. The significance of effect on a receptor is considered by establishing its value/sensitivity, and how (and to what extent) it may be impacted based on the proposed design of the Proposed Development.

There are no designated cultural heritage receptors located within the footprint of the Proposed Development. There is one undesignated cultural heritage receptor located within the footprint of the Proposed Development that is likely to be directly impacted during the construction stage. This comprises the derelict remains of a nineteenth century vernacular structure in Leacarrowntemple townland which is within the route of a Site Access Track to AT16. The direct construction phase effect on this undesignated structure is considered to be of Moderate significance. A written, drawn and built heritage survey of this structure will be carried out prior to removal (preservation by record) which will result in a residual Slight significance of effect.

There are a number of designated cultural heritage receptors located within the 100m corridor centred on the GCR which extends along areas previously disturbed by the construction of existing roads. One of these, Palmerstown Bridge (RPS ref. 017), is located within the route corridor while the other examples are located within private properties located adjacent to the route (four ringforts, a holy well and five architectural heritage structures). Palmerstown Bridge and its associated watercourse will not require any interventions as part of the Proposed Development with the GCR construction involving directional hydrologic drilling underneath the riverbed and entering/existing beyond the riverbank on both sides. The construction of the GCR will result in no direct effects on known cultural heritage receptors and indirect setting effects on receptors within its environs will be Not Significant in significance.

The TDR will require improvements and temporary accommodation requirements along existing local road networks. There are no recorded cultural heritage constraints at any of the locations of these works. A megalithic structure (MA014-050----) is located within a greenfield area 70 m to the northwest of a road widening area in Annagh Beg townland and a Neutral effect on this archaeological site is predicted. The construction the TDR will not result in any direct or indirect effects on known cultural heritage receptors.

There are a number of archaeological monuments and designated architectural structures located in lands surrounding the Wind Farm Site which retain sensitive landscape setting characteristics. These include Carn House (RPS 187), Carn archaeological complex (MA014-061001- to MA014-061005-), Castlelackan folly (Lackan Gazebo) (RPS 016), cairn sites MA014-002005- and MA014-002006-, Rathlackan archaeological complex and amenity area including court tomb MA007-016006-, wedge tomb at Rathfranpark (National Monument 633), stone circle at Rathfran (National Monument 389) and Rathfran Abbey (National Monument 269). Overall, these are considered high value receptors that are likely to have predicted negative long-term (reversible) indirect effect of medium-high magnitude on setting, and this will result in a range of Moderate-Significant indirect significance of effects during the operational phase. Given the nature of the Turbine structures, there are no mitigation measures that can address these indirect effects on heritage landscape setting, but it is noted that these effects will be reversible at the decommissioning phase.

In advance of the main construction stage, a programme of licenced archaeological testing shall be carried out at certain locations within the design footprint, in agreement with the National Monuments Service. Ground works during the construction phase will also be subject to archaeological monitoring by a suitably qualified archaeologist under licence by the National Monuments Service. This will also include systematic advance programme of archaeological field-walking surveys within Proposed Development areas in forestry plantations following tree felling.

In the event that any sub-surface archaeological features are identified during archaeological monitoring they will be securely cordoned off, cleaned and recorded in situ. The National Monuments Service will then be notified and

consulted to determine further appropriate mitigation measures, which may include preservation in situ (by avoidance) or preservation by record (archaeological excavation).

Reference 2026 : Different Kinds of Physical Cultural Heritage: Asian Development Bank. Handbook On Cultural Heritage In Impact Assessment May 2026

The scale and importance of physical cultural heritage vary greatly, ranging from simple burials, shrines, or tree groves of local importance to monumental historic sites that are recognized and valued globally. The categories are not hard and fast, as a specific cultural heritage site may include more than one type. For example, a built heritage site may also include archaeological remains and human burials.

Archaeological Sites and Materials

Archaeological sites are the buried and surface remains of past human settlement and activity. Pottery shards, chipped and ground stone artifacts, metal implements, and other durable materials are the most common archaeological remains, and these may be found among collapsed or preserved structures, in caves, at open-air sites, buried beneath mounds, and elsewhere. Archaeological sites, like other cultural heritage types, can also be part of larger configurations of cultural heritage known as cultural landscapes.

Burials and Human Remains

Burials and Human Remains include human burials, burial grounds, memorials, and other physical representations of past human life.

These are among the most universally sensitive types of cultural heritage, and the specific sensitivities are exceptionally diverse. They may be marked or unmarked and vary significantly in form depending on factors such as the cultural affiliation or social status of the deceased. Any human burial of any period should be considered cultural heritage.

Grave sites, when already marked and fenced, are easy to identify and avoid. Local authorities can also help with cemetery identification. For unmarked burials, community consultation may be the only way to map and avoid them.

Built Heritage

Built Heritage refers to individual structures or groups of architectural works in urban or rural settings that exemplify a past time period, an important architectural style, or a historic event or person of interest. Built heritage is among the most common and visible forms of heritage, notable for the way it shapes the identity and feel of a surrounding community, large or small. Groups of related historic structures or buildings may be classified as historic districts, affording legal protection to areas and structures within their boundaries.

Natural Features with Cultural Significance

Natural Features with Cultural Significance are natural features and landscapes that constitute cultural heritage. Such features include hills, mountains, streams, rivers, waterfalls, caves, rocks, plants, trees or tree-groves, and other landscape elements. The significance of this kind of cultural heritage may often be localized in small community groups, not being readily recognizable to those outside the community. Their value is often religious or spiritual. This type of cultural heritage reflects the intimate relationship that traditional communities have with their environments.

Natural features with cultural significance are among the most difficult types of cultural heritage to recognize. What makes a forest, stream, mountain, or ritual site special? The reason may be part of a group's oral history, their stories transmitted from generation to generation. Most often, such features are not legally protected or documented. They must be identified by face-to-face community engagement.

Movable Cultural Heritage

Movable Cultural Heritage includes historic or rare books and manuscripts, paintings, drawings, sculptures, figurines, and carvings; modern or historic religious items; historic costumes, jewellery, and textiles; fragments of monuments or historic buildings; archaeological material; and natural history collections such as fossils, shells, flora, or minerals. These objects may reside in formal or informal museums, libraries, reliquaries, or in religious-ceremonial facilities, and they may be publicly or privately owned.

Movable cultural heritage may be kept in a household or secluded shrine, a place of worship, or another location. It is often undocumented and unsecured physically. Local community engagement or consultation with local religious, cultural, or civic organizations are the primary ways of identifying this type of cultural heritage.

What is Intangible Cultural Heritage?

All types of heritage have an intangible aspect, being the knowledge or belief system that makes the heritage important to its users and the broader community or society. Religion, myth, history, and science are some examples of these value systems. These belief systems are intangible but inherent in all kinds of tangible cultural heritage, from scientifically important archaeological sites to locally important and sometimes secret ritual sites. Focusing on the knowledge and practices of traditional and often small-scale communities, UNESCO's 2003 Convention for the Safeguarding of the Intangible Cultural Heritage expanded global perceptions of cultural heritage. The convention highlights threats to "intangible cultural heritage" and the need to safeguard it. Especially relevant for any safeguarding discussion is the potential threat that project activities could pose to the social processes and environmental resources used by local communities to sustain and transmit traditional knowledge and practice to each new generation. However, it is also important to recognize that adopting new, non-traditional lifeways may be the preference of a community. The choice between cultural assimilation and the maintenance of tradition should rightly be left to individual communities. Where there are systemic threats to valued traditional practices, governments, and nongovernment organizations (NGOs), some projects will conduct inventories of intangible cultural heritage and assess risks and threats to the various intangible elements as a part of safeguarding programs. Such inventories, if they exist for a project area, may be a valuable resource for the project.

Assessment practitioners should pay close attention to existing information on the potential intangible cultural heritage of the affected communities in their project. Information sources may include recent intangible inventories, traditional ethnographic research, and interviews with community members. This information may be the only way to identify important cultural sites, such as forests, mountains, or waterbodies that a project could impact. These sites, places, and structures of community importance may be an irreplaceable part of what is sometimes referred to as place-based intangible cultural heritage.

Intangible cultural heritage resources can be investigated at the outset by reviewing ethnographies, local histories, and related materials. Where UNESCO and other organizations have created intangible cultural heritage inventories, these will be valuable desktop resources. If a desktop assessment indicates potential project interactions with local knowledge and tradition, then local community engagement is the next step in the assessment process.

Untangling Intangibles

The terminology connected to tangible and intangible cultural heritage can be confusing. These definitions may help to reduce the confusion:

Tangible Cultural Heritage – Also called physical cultural heritage or physical cultural resources, these terms refer to sites, structures, and places of cultural significance. Any physical cultural heritage, however, will also possess associated cultural beliefs and concepts. A ritual site used by a traditional community becomes important because of the associated religious beliefs and practices of the community. Likewise, the
importance of an archaeological site rests on the principles of history and archaeology, which are intangible.

Intangible Cultural Heritage – Defined by UNESCO as the traditional practices, expressions, knowledge, and skills that the communities recognize as cultural heritage. Heritage professionals will sometimes use "intangible cultural heritage" as a kind of shorthand for tangible sites, structures, and places that owe their importance more to traditional beliefs about them than to any remarkable physical characteristics. The term "place-based intangible cultural heritage" can be used to clarify the sometimes-confusing use of the term "intangible" to refer to things that clearly are tangible.

Cultural Ecosystem Services – This concept refers to ecological elements such as plant and animal species or special habitats that may be integral to local practice and knowledge, and without which these cultural elements may not survive with subsequent generations. Recognition and safeguarding of the ecosystem may require the collaboration of cultural and biodiversity members of an impact assessment team.

Living Heritage – A term often used as a less technical way of referring to intangible cultural heritage.

The word "living" is used here to denote some traditional object or knowledge still in active use by a community. Ancient archaeological objects, by contrast, are often appreciated for the fact that they provide evidence of a tradition that only exists in the past, a heritage that is "no longer living."

Safeguarding of Intangible Cultural Heritage – This is a phrase used by heritage specialists.
Safeguarding is a preferred alternative to "protection" or "conservation," which imply the goal of keeping something in a static state, as it has always been. To safeguard intangible cultural heritage is not simply to retain or preserve a belief or practice as it is, but rather to protect a community's ability to pass that belief or knowledge to future generations in whatever form the community may choose.
Every kind of cultural heritage has its intangible component: the oral traditions, values, or ideas that make it important to people and communities. Talking with heritage users about these intangible factors may be critical to identifying and understanding specific instances of tangible cultural heritage, such as sacred landscape features or festival sites, and how they are used.

Legal Protections for Different Types of Cultural Heritage

Certain legal protections are in place for cultural heritage in every country—as are treaty protections when a country ratifies them—but these protections are not consistent across all six categories. Legal protection also varies significantly from country to country. Country-level protection is nearly always provided to important archaeological sites and historic monuments (built heritage). More broadly, UNESCO treaties encompass all the categories but have not been signed by all national governments. Furthermore, country-based legal protection may be available across multiple local or regional jurisdictions. Countries, subnational areas, and sometimes even local communities have lists of known and protected cultural heritage sites, structures, and places. Many legal frameworks also provide generic protection to unlisted and undiscovered sites. The impact assessment process, as required by host countries and international financial institutions (IFIs), typically respects all applicable legal protections and treaty obligations, with the additional dimension of community-based heritage as defined through local consultation. The purpose of the assessment is not usually to invest in or enhance cultural heritage, but rather to protect it from the unintended negative effects of a project.

What is the Reason for Legal Protection?

Cultural heritage, in its tangible and intangible aspects, is unique and irreplaceable, a product of processes that unfold over long historic and even geological time periods. When damaged, lost, or forgotten, cultural heritage is very difficult, if not impossible, to recreate.
From UNESCO World Heritage Sites at one end of the scale to the more modest but far more numerous examples of locally important heritage at the other, all countries and communities possess and value cultural heritage. These sites, structures, and places, along with the knowledge and values they embody, are integral to the fabric of any society or community. They form a knowledge base for all and remind residents and visitors of what is important and distinctive about a place and its people. Above all, cultural heritage is a source of community identity, cohesion, and pride. It can also be a significant resource for social and economic development.

Key Stakeholders

Official Stakeholders	Knowledgeable Individuals
• Representatives of the one or more agencies responsible for cultural heritage: (i) cultural ministry, (ii) antiquities ministry, (iii) national host country archaeological survey, (iv) sports and tourism ministry, (v) institutes of archaeological or ethnological studies, (vi) national host country trust for heritage conservation, (vii) national museums (viii) universities, (ix) representatives of religious organizations. • Elected representatives of regional, local, and village councils. • Leaders (chairmen, directors) of local cooperatives. • Community-based organizations, local nongovernmental organizations (NGOs), and local women's groups.	• Community elders • Academics • Experts • Interest groups within and outside the country • Descendant groups affiliated with burial grounds • School teachers • Librarians • Tourist guides • Farmers • Herders • Affected people who may no longer live in the community • Religious leaders

Safeguarding Intangible Cultural Heritage

Large projects will include risks to traditional practices as they may affect the intergenerational transmission of native languages and other traditional skills and knowledge. In these situations, projects may need to assess local cultural patterns to determine risk levels and establish appropriate measures to safeguard the transmission of intangible cultural heritage. The term "safeguarding" is preferred for intangible cultural heritage. Preservation applies to archaeological sites or historic buildings, aiming to keep these remains as close to their original condition as possible. Safeguarding, on the other hand, implies, enabling the desired continuity of tradition while allowing for modification and adaptation to changing circumstances, including the selective and voluntary assimilation of outside, and potentially modernizing influences.

Some measures for safeguarding intangible aspects of cultural heritage include:

- Avoid activities that interfere with traditional learning and education.
- Manage impacts to biological resources and habitats that are a part of local traditional practice.
- Plan project implementation to ensure continued access to sites and resources that support traditional practices.

When such a safeguarding program is needed, it will build on the findings of the cultural heritage team but may also involve resettlement, social, and other specialist teams to design long-term community-based programs and careful monitoring.

There are few, if any, adequate means of restoring a community's loss of traditional knowledge and practice once it has occurred. International development specialists believe that significant investment in safeguard programs is advisable.

16 MATERIAL ASSETS AND OTHER ISSUES

Chapter 13 of the EIAR considers a number of other issues associated with the Proposed Development, including potential effects on Land Use – Agriculture and Forestry, Telecommunications, Electricity Networks, Air Navigation, Quarries and Utilities (gas, water, wastes).

16.1 Land Use - Agriculture

The Wind Farm Site is comprised of blanket bog, coniferous forestry, transitional woodland scrub and agricultural pastures. Land cover at the Wind Farm Site is mapped by Corine (2018) as inland wetland peat bogs, with some smaller areas of coniferous forestry, semi natural areas and agricultural pastures (www.epa.ie).

The total permeant land take of the Wind Farm Site, including the Site Access Tracks, Turbine Hardstands, Turbine Foundations, Permanent Operations Compound, Met Mast Hardstands, sub-station, BESS and public roads within the Wind Farm Site is approximately 9.21 ha. The Wind Farm Site has an area of 108.06 ha therefore the total land take is 8.52% of the Wind Farm Site. The immediate surrounding agricultural grasslands will remain in agricultural use.

The construction, operational and decommissioning phase of the Proposed Development will result in a change of approximately 15.68 hectares of agricultural land use in area, to facilitate new Site Access Tracks, Onsite Substation, BESS, civil works and Turbine Hardstands.

There will be 7 no. turbines located on or partly on agricultural lands. This will result in the change of use from agricultural use to windfarm use. This will have a long-term, slight, negative effect on agricultural land use due to the removal of grazing lands for the duration of the Proposed Development during construction and operation phases.

Response from MLavelle: This is untrue. The microclimate fall in temperature from wake will decrease crop yields for 55diameters downwind & effect residence house temperatures. This decrease means that householders will have to use energy to heat their houses & further impact carbon savings.

16.2 Land Use - Forestry

The proposed site area contains approximately 172 hectares of forestry, all of which is under private ownership and is being managed on a commercial basis. The proposed windfarm infrastructure layout affects forestry at 9 of the 16 planned turbine locations. Additionally, the Met Mast location and parts of the proposed Site Access Tracks overlap with forested areas. To facilitate the construction of the proposed wind farm at Tirawley, approximately 31.86 ha of existing forestry is due for infrastructure felling. A summary of the forestry affected is provided in **Table 16.1**

Table 16.1: Summary of Removal of Forestry to facilitate the Proposed Development

Infrastructure	Area of forestry lost (ha)	Species present
AT01	-	-
AT02 (incl. Site Access Tracks)	2.91	SS, JL, BI
AT03 (incl. Site Access Tracks)	5.15	SS, JL
AT04 (incl. Site Access Tracks)	4.21	SS, JL
AT05	-	-
AT06	1.58	SS, JL
AT07	-	-
AT08 (Site Access Tracks only)	0.28	SS, JL
AT09 (incl. Site Access Tracks)	3.44	SS, JL
AT10 (incl. Site Access Tracks)	2.93	SS, JL
AT11	1.79	SS, JL
AT12 (incl. Site Access Tracks)	3.08	SS, JL
AT13	-	-
AT14	-	-
AT15 (incl. Site Access Tracks)	3.46	SS, LP
AT16	-	-
Met Mast (incl. Site Access Tracks)	2.78	SS, JL, BI
Public road widening	0.25	Ash, ALD, SS, JL
Total	**31.86**	

The associated afforestation of alternative lands equivalent in area to those lands being permanently clear-felled is also subject to licensing ('afforestation licensing'). The Forest Service of the Department of Agriculture, Food & the Marine is Ireland's national forest authority and is responsible for all forest licensing. In light of the foregoing and for the purposes of this Proposed Development, the Developer has committed that the location of any replanting (alternative afforestation) associated with the Proposed Development will be greater than 10 km from the wind farm site and also outside any potential hydrological pathways of connectivity i.e., outside the catchment within which the Proposed Development is located. On this basis, it is reasonable to conclude that there will be no more than imperceptible, indirect, or in-combination effects associated with the replanting.

On this basis, it is reasonable to conclude that there will be no more than imperceptible, indirect or in-combination effects associated with the replanting.

Response from MLavelle: This is project splitting. The alternative afforestation lands should have been identified & included with this EIAR & Application.

16.3 Telecommunications

Operators of microwave communication links were contacted during the EIA process. Mitigation measures were adopted during the layout design to avoid impacting communication links. Disruption to television reception is considered unlikely following the switchover to digital broadcasting, as the signals are less susceptible to interference from turbines.

During the consultation with telecommunications operators was initiated during the scoping phase of this EIA to identify any potential microwave or telecommunication links that could be affected by the Proposed Development. Details of the Proposed Development were shared with link operators. Telecommunications operator 'Three' responded with concerns over wind turbine AT13 of the Proposed Development being located directly in the path of 1 of their existing transmission links.

Telecommunications operator 'ENET' responded with concerns over distances between the Proposed Development and their existing transmission links. Following mapping, concerns between the existing ENET transmission link and wind turbine AT04 were raised.

Other potential effects during the construction phase are likely to be as a result of tall cranes used for constructing the turbines. These cranes will be located close to the proposed turbine. There is potential for cranes at AT13 and AT14 to interfere with 1 link which passes through the area. There is a potential for cranes at AT04 to interfere with 1 link which passes through the area. However, any effect will be temporary in nature as it will only last when the mentioned turbines (AT04, AT13 & AT14) are being erected (approximately 2-3 days). The effect can be classed as moderate negative, but short-term in nature.

Following the feedback from the Three link operator, rerouting of the Three link from Knockboha to Ballina to Knockboha to Tawnaghmore was undertaken by Three. The rerouting allowed the link to pass at an acceptable setback distance from AT13. No effects are predicted on the Three link.

Following further investigation from the ENET operator the link from Shanettra to Beannchair was determined to be situated at a sufficient distance back from turbine AT04.

Therefore, no effects are predicted on the ENET link. Compliance with the EMC Directive 2014/30/EU will mean that the electromagnetic emissions from devices used will not cause interference to other equipment.

The effect on telecommunications during construction/decommissioning is likely to have a temporary slight negative effect.

The proposed turbines will have a long-term moderate negative effect on telecommunications during the operational phase. Implementation of the measures, will ensure that any residual effects will be not-significant negative and long-term in duration.

The effect on telecommunications during the construction and decommissioning phase of the Proposed Development due to electromagnetic emissions from the Proposed Development is likely to have an imperceptible effect.

There are 14 no. proposed, permitted or operational wind farms within 20 km of the Proposed Development (**EIAR Appendix 1.2**). In line with the Draft Wind Energy Guidelines 2019, each Developer is responsible for engaging with all relevant telecommunications operators to ensure their proposals will not interfere with television or radio signals by acting as a physical barrier. As such, the cumulative effect on telecommunications during the operational phase will remain not-significant, negative and long-term in duration.

The implementation of mitigation measures will ensure no interference with communication links. Therefore, no significant effects are predicted on telecommunications or radio reception as a result of the Proposed Development.

16.4 Electricity Networks

The preferred GCR will be an UGC from the Onsite Substation to the Tawnaghmore 110 kV Substation. Refer to **Figure NTS-7** for the proposed GCR. The overall length of this connection is 13.55 km. Of this, 12.43 km is located along the public road corridor, and 1.12 km is within the Killala Business Park grounds.

Connection will be sought from the grid system operator by application to EirGrid. The Onsite Substation will connect via 110 kV UGC to the Tawnaghmore 110 kV substation. At the existing Tawnaghmore 110 kV substation, the cable will connect into existing infrastructure within the confines of the substation and its compound. EirGrid is currently uprating the 110 kV overhead lines leaving the Tawnaghmore 110 kV substation to increase network capacity and support renewable energy integration in North Connacht. An upgrade of the existing transformer of the Tawnaghmore substation is likely to be required. Such upgrades will have a slight, positive short-term effect in terms of upgrading of critical infrastructure.

No significant negative effects on the electricity networks are anticipated. There will be a long-term slight positive residual effect on transmission infrastructure in the area (due to the installation of new infrastructure). There is no effect on the distribution network, as it is not proposed to utilise any elements of the distribution network. In addition, the energy produced will be from carbon neutral technology which will offset carbon from fuel energy production locally which will be a slight positive local effect.

16.5 Air Navigation

Operating wind farms have the potential to cause a variety of effects on aviation. Rotating wind turbine blades may impact on radar operations, although it is not likely at Tirawley. The physical height of turbines can cause obstruction to aviation and the overall performance of communications, navigation and surveillance equipment. All structures over 150 m in height are required to have lighting to warn aviation traffic.

The distance of the Proposed Development from all aircraft facilities in Ireland was undertaken. Crossmolina Airstrip is located c. 11.69 km south-west of the Wind Farm Site. Ballina Airfield is located c. 18.5 km to the south-east of the Wind Farm Site. Sligo Airport is located c. 43.2 km to the east of the Wind Farm Site. The closest international commercial airport is Ireland West Knock Airport is located c. 47.3 km to the south-east of the Wind Farm Site. The Wind Farm Site is outside of all "no-go" areas.

No significant effects are predicted in terms of air navigation. In adherence to IAA Safety Regulations and International Civil Aviation Organisation, ICAO Annex 15, aeronautical obstacle warning light schemes will be installed as requested by IAA. Co-ordinates of ground and tip height elevations at each wind turbine location as constructed will be provided to the IAA. IAA will be notified of the provision of the intention to commence crane operations within a minimum of 30 days prior to erection.

The potential effects of the Proposed Development on air navigation are considered not significant.

16.6 Utilities (gas, water, waste)

Gas

There are no gas mains located within the Proposed Development Redline. There is therefore no potential for effect. Gas Networks Ireland website Dial Before you Dig1 was consulted, which indicated that there are no existing gas services along the GCR

There will no effect on the gas network pipelines during the construction phase, no effect during the operational phase and no effect during the decommissioning phase.

Water

In relation to water services within the Proposed Developments Redline, it has been assumed that there is the potential to encounter local water services within the Proposed Development.

The following water service features were identified along the GCR:

- Air control valves
- Fitting
- Hydrant
- Mains Line
- Network Meter
- System Valve

Potential effects arising from the Proposed Development relating to existing water services have been assessed and are detailed in **Chapter 9: Hydrology and Hydrogeology** and referred to in **Chapter 5: Population and Human Health** with accompanying mitigation measures.

Waste

It is likely that waste will be generated onsite during the construction and decommissioning phases of the Proposed Development. All rubbish and waste/excess materials will be removed from Site to an appropriate licenced facility from where it will be reused/recycled, where possible, or disposed of accordingly.

A desk study of available information from the EPA did not identify any waste facilities, illegal waste activities, chemical monitoring points or industrial EPA licensed facilities within a 2 km radius of the Site. The nearest waste facility to the Proposed Development is a site at the Rathroeen Civic Amenity Site (W0067-02).

Mitigation measures will be implemented during each phase of the Proposed Development. Therefore, the residual effects of waste produced as a result of the construction, operational and decommissioning phases of the Development are considered to be not significant.

16.7 Quarries

Crushed stone required for construction of the Site Access Tracks, Turbine Hardstand, Turbine Foundation upfill, Onsite Substation, BESS compound, TDR works and Grid Connection works will be imported as outlined in **Chapter 17: Traffic and Transport**. The stone, estimated to be a volume of 35,592 m3 will come from a licenced quarry in the locality such as:

- Killala Rock Quarry, Killala
- Mullafarry Quarry, Killala
- Lacken Stone, Rathlacken
- Barrets Quarry, Banger Erris
- Molloy Concrete Limited, Ballina
- Harrington Concrete & Quarries, Turlough, Co. Mayo

No significant negative effects on local quarries are anticipated. There will be a slight, permanent, negative residual effect on natural resources in the area from the construction phase. There will be no effect during either the operational or decommissioning phases

This impact effect is considered to be imperceptible in the long-term

17 ACCESS, TRAFFIC AND TRANSPORT [Note: No Road Safety Audit. No Sight Distance Triangles or Forward Sight distances at 14 entrances. No details on passing bays. As specified in SID Direction]

Chapter 17 Traffic and Transport of the EIAR assesses the potential effects of traffic associated with the Proposed Development on the public road network and sensitive receptors. The assessment describes the existing public road and junction network, identifies the potential for significant effects in isolation and in combination with other developments, and outlines mitigation measures to avoid or reduce potential effects.

Assessment Scope

The assessment considers traffic generated during the following phases:

- Construction of the Proposed Development.
- Construction of the proposed Grid Connection.
- Transportation of turbine components along the Turbine Delivery Route (TDR).
- Enabling works at junctions and pinch points to facilitate the delivery of abnormal loads.
- Operation and maintenance of the Proposed Development during its 35-year life.
- Decommissioning of the Proposed Development.

Methodology and Documentation

Access to the Wind Farm Site will be provided via a total of 14 entrances, consisting of **5 new and 9 existing locations**. These entrances are located off local public roads that branch off the R314. A detailed description of these entrances is provided in **EIAR Table 17.12**.

Turbine components will be shipped to Killybegs Harbour, Galway Port, or Foynes Port and transported via abnormal load vehicles. A Swept Path Analysis was undertaken for the Vestas V117 turbine, which features a blade length of 57.2 m, to identify required road alterations at 19 "pinch point" locations.

Predicted Traffic Volumes and Significance

The total number of HGV loads for the 21-month construction period is estimated at 11,022. This includes:

- 3,153 loads for Access Track work and Turbine Hardstands.
- 4,957 loads associated with civil and electrical works (BESS, Substation).
- 2,622 loads associated with Grid Connection works.
- 290 abnormal loads for turbine components.

EIAR Chapter 17

• Construct 5 no. new permanent site entrances as described in the EIAR **Chapter 17: Traffic and Transport** and **Figure 2.1**.

- Figure 2.1 - Site Entrance Map.pdf [PDF]
- Figure 2.10 - Road Construction Details (Sheet 1 of 2).pdf [PDF]
- Figure 2.11 - Road Construction Details (Sheet 2 of 2).pdf [PDF]
- Figure 2.12 - Met Mast Location Map.pdf [PDF]
- Figure 2.13 - Proposed 80M Meteorological Mast 1 Details.pdf [PDF]
- Figure 2.14 - Proposed Onsite 110kV Electrical Substation and BESS Location Map.pdf [PDF]
- Figure 2.15 - Proposed Onsite 110kV Electrical Substation Details (Sheet 1 of 2).pdf [PDF]
- Figure 2.16 - Proposed Onsite 110kV Electrical Substation Details (Sheet 2 of 2).pdf [PDF]
- Figure 2.17 - Electrical Compound - Substation Elevations (Sheet 1 of 2).pdf [PDF]
- Figure 2.18 - Electrical Compound - Substation Elevations (Sheet 2 of 2).pdf [PDF]
- Figure 2.19 - Wind Farm Collector Cable Trench Details.pdf [PDF]
- Figure 2.2 - Proposed Grid Connection Route.pdf [PDF]
- Figure 2.20 - Standard 110kV Roadway Trench Terfoil Design (160mm Duct).pdf [PDF]
- Figure 2.21 - Temporary Construction Compound Location Map.pdf [PDF]
- Figure 2.22 - Proposed Operations Building Location Map.pdf [PDF]
- Figure 2.23 - Vestas V117 (4.3 MW) IEC IIA Schematic.pdf [PDF]
- Figure 2.3 - Residential Dwellings within 2km of the Proposed Wind Farm Site.pdf [PDF]
- Figure 2.4 - Cumulative Wind Farms.pdf [PDF]
- Figure 2.5 - Site Layout Map.pdf [PDF]
- Figure 2.6 - Typical Hardstand Details.pdf [PDF]
- Figure 2.7 - Turbine Delivery Route Option 1 (Killybegs Harbour to Site).pdf [PDF]
- Figure 2.8 - Turbine Delivery Route Option 2 Galway Port to Site.pdf [PDF]
- Figure 2.9 - Turbine Delivery Route Option 3 (Foynes Port to Site).pdf [PDF]

Summary of Effects

- Construction Phase: Assessed as having a negative, low, direct, short-term, high probability effect. With mitigation, residual effects are assessed as low, negative, and short-term.
- Operational Phase: Traffic effects are considered imperceptible, involving approximately 1–2 maintenance visits per week.
- Decommissioning Phase: Effects are considered slight, negative, direct, and short-term.
- Cumulative Effects: Assessed as slight to moderate, negative, and short-term with a low probability of occurrence.

Response from MLavelle: The generation of traffic flows at junctions without traffic counts is just guesswork. It has no value. The applicants & Agents had sufficient time to conduct a 14-day automatic traffic count at each of the 5 proposed new site entrances & 9 existing entrances. No reliance can be made on the traffic guesswork submitted.

A 2 hour traffic count is totally unsatisfactory & is in breach of TII Guidelines. If this application is under the SID process, it has to be compliant with TII Guidelines/Standards.

17.3.4 Existing Traffic Volumes

The R314 is the main route between Ballina and the Proposed Development Site. This is a regional road and as would be expected, there is no specific traffic data from Traffic Infrastructure Ireland (TII) for this road or local public roads in the vicinity as TII's counters are located only on National roads. Thus, this was necessary to carry out traffic counts. Jennings O'Donovan & Partners carried out classified traffic counts at one location on the R314 at Palmerstown Bridge. This location was chosen as it is close to the Wind Farm Site and where all the local public roads utilised by the Wind Farm Site converge. This location was used to determine baseline traffic volumes and junction capacity on the public road network which will be directly affected by construction traffic during the wind farm construction period. The classified traffic counts were carried out during the morning and evening peak hour traffic periods to record maximum traffic levels on the road network.

Response from MLavelle: Automatic Traffic counters are a well established method to measure traffic volumes. 14-daycounts should have been provided for this application for each of the 14 site entrances.

17.3.4.1 Transport Infrastructure Ireland DATA

In order to determine trends on the public road network, data was taken from the nearest available TII Data Station along the N59 between Sligo and Ballina Traffic Station TMU N59 040.0 S (**Table 17.14**), below is a summary. TII conduct traffic counts continuously2 on the N59 at Rathglass, north-east of Corballa (Station Id: TMU N59 040.0 S). The Average Annual Daily Traffic (AADT) volume on the road was recorded to be 4,042 vehicles in 2019 (2020 and 2021 values are less due to Covid Restrictions) as outlined in **Table 17.14**. From this table, in 2019, the number of HGVs was 125 with light vehicles making up the remaining 3,916 of the totals of up to 4,692 in 2025. For 2025, while the AADT was slightly higher in 2025 than in 2019 (4,692 vehicles), the number of HGV was similar at 145.

Response from MLavelle: Traffic counts east of Ballina on the Sligo Road are irrelevant.

17.3.4.2 Traffic Counts at R314 / Unnamed Rd Junction

A short period traffic count was carried out at the R314/ Unnamed rd. junction on Friday 30th June 2023. The count was carried out between the hours of **08:00 and 09:00 during the morning period and 16:30 and 17:30 for the afternoon period.** The location of the traffic count is shown on **Plate 17.2**. The layout of the junction is shown on **Plate 17.3** and **Plate 17.4**.

17.3.4.3 Existing Traffic Flows on the R314 and the Unnamed Local Road

The Annual Average Daily Traffic (AADT) values for each of the R314 and the local public road were calculated using TII Publication PE-PAG-02039 "Expansion Factors for Short Period Traffic Counts". This document provides a mechanism to convert short-term traffic count data to AADT. The study area is located within the West region. From Appendix A of PE-PAG-02039, the proportion of the 24-hour traffic occurring during the period 08:00 to 09:00 is 0.077 and 16:30 to 17:30 is 0.095.

Response from MLavelle: This is totally unacceptable especially in this purported Strategic Infrastructure Development Application.

The TII automatic counter is EAST of Ballina & far removed from the Development Site. Taking a 1hr morning & evening traffic count on the Regional Road is irresponsible, especially when TII recommend 14-days (below) & on a Friday, which isn't allowed. The ignoring of traffic counts on the Local Roads is further incompetence. The omission of junction Sight Distance Triangles, Forward Sight Distance requirements is further breach of requirements. It should be noted that no Road Safety Audit is included as required by ACP pre-Planning approval & only a few locations are included for the Sweptpath requirement for oversail & overhang without any landowner agreements.

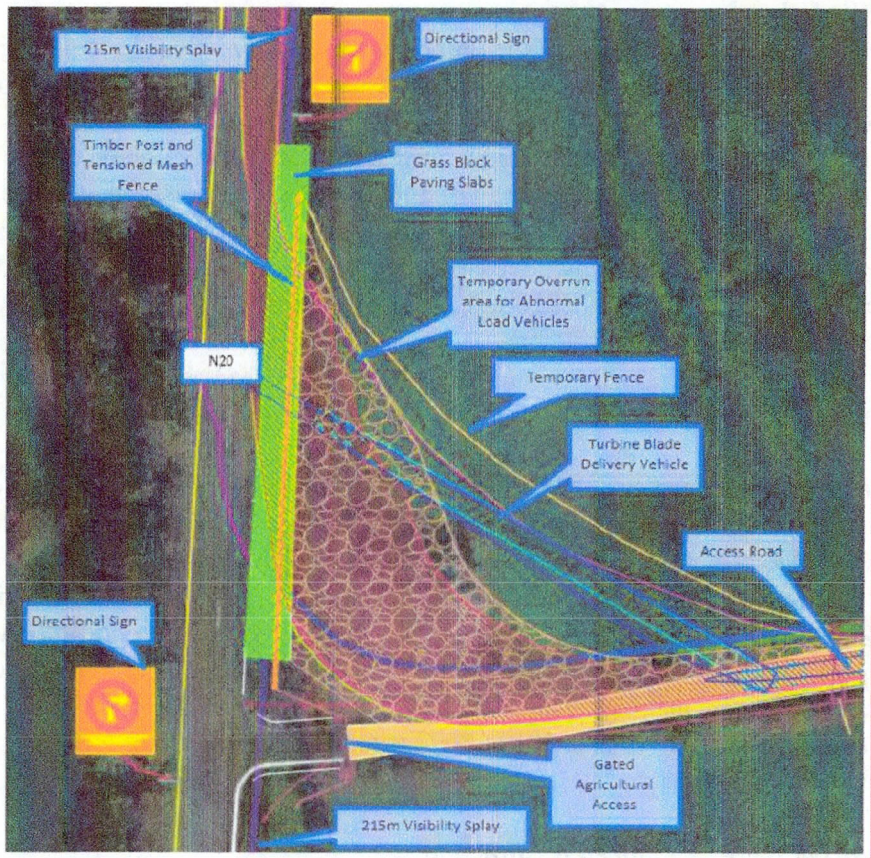


Plate 3 – Typical Site Entrance Upgrades

Where is this Typical Site Entrance located?



Plate 4 – Typical Site Entrance Upgrades

Where is this Typical Site Entrance Upgrade located?

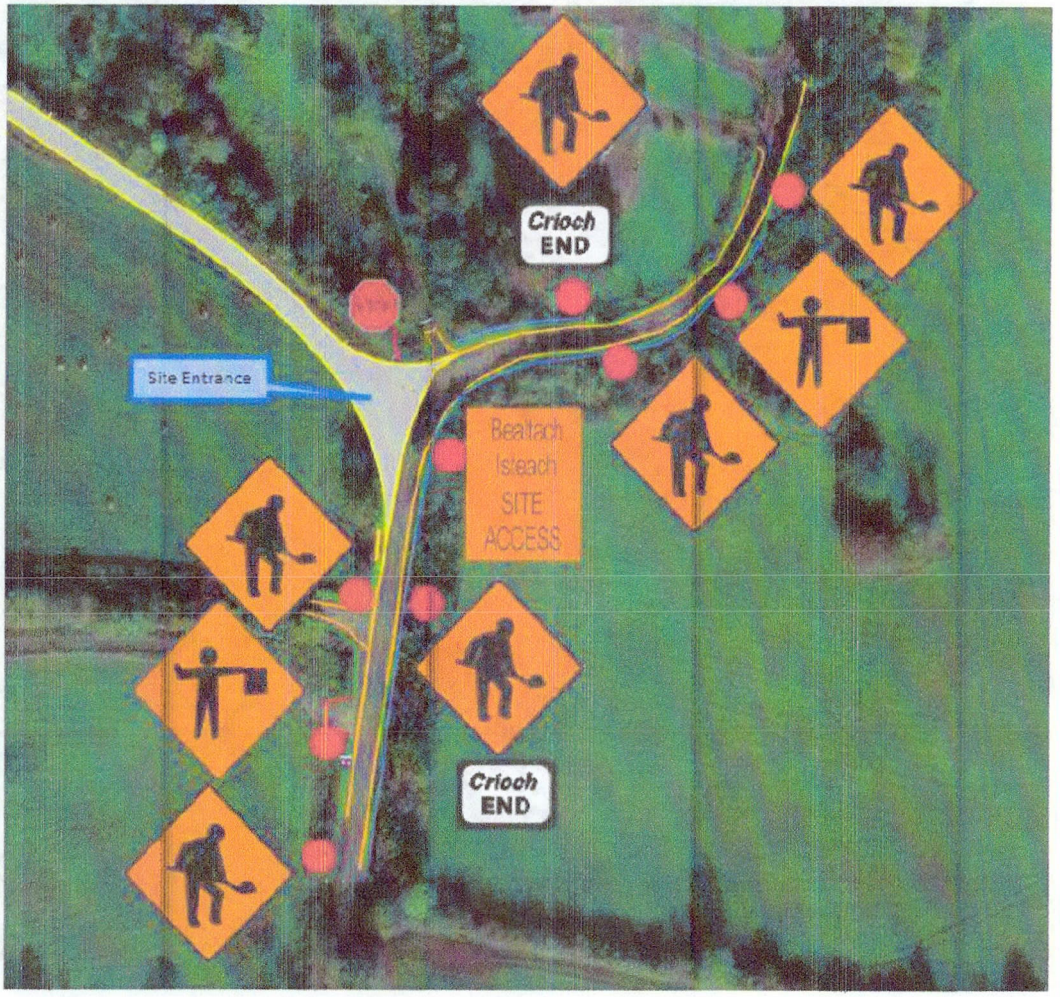


Plate 5 – Typical Site Entrance Signage

Where is this Typical Site Entrance Signage located?
Response from MLavelle: This type of submission must be rejected.

Sweptpath Drawings from Ballina to Site

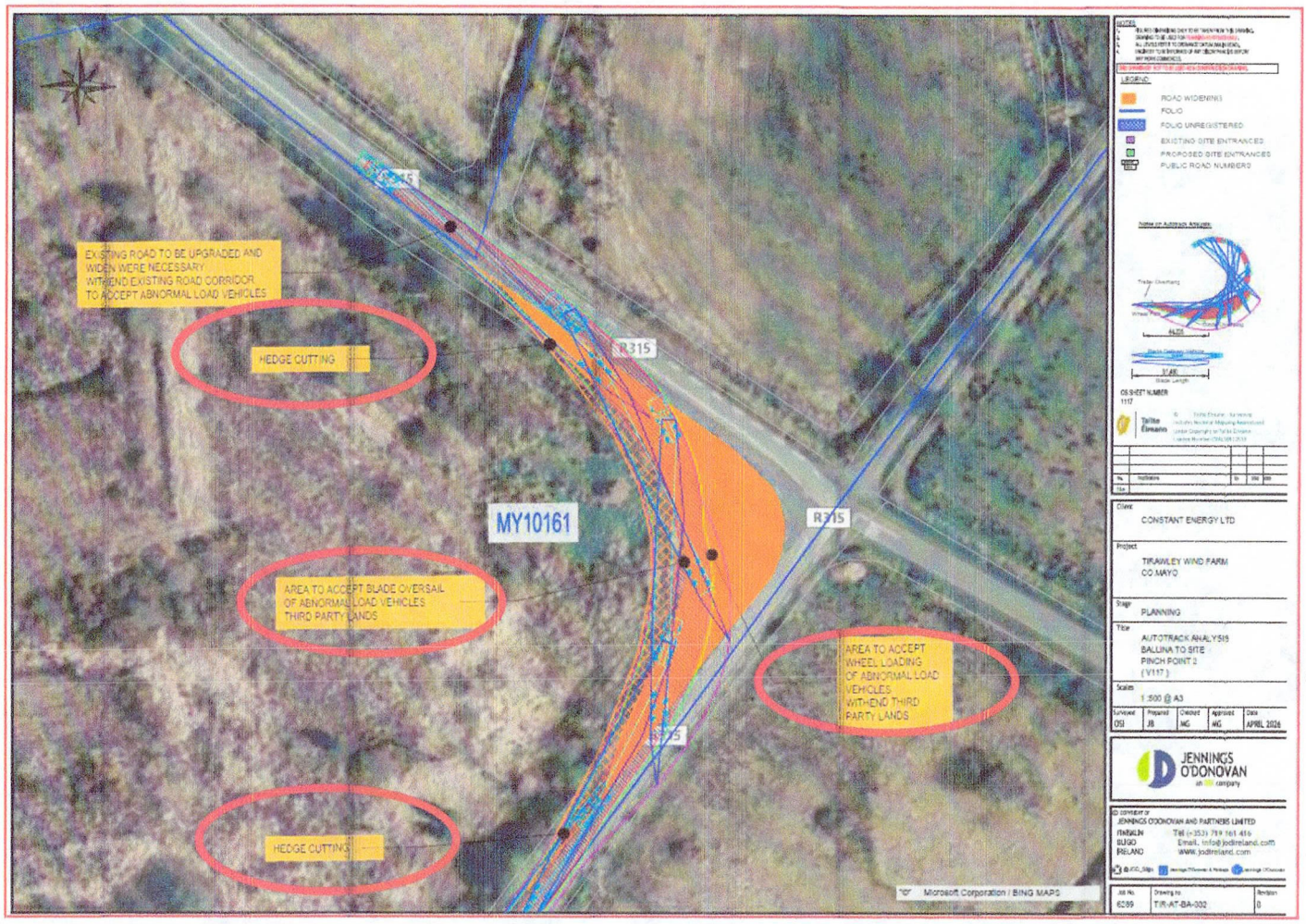


Response from MLavelle: No landowner agreements (as required by ACP in SID PrePlanning decision) for blade oversail or hedge cutting. No Townland names provided which was a further requirement of SID decision. Without Townland names, many people cannot locate the sweptpath image. Additionally, many people cannot read maps & without Townland identifiers, the images have zero value.

SweptpathAutotruck analyses are a desktop exercise. There would be little difficulty presenting such outputs from Port to site for two-way traffic & turning motions.

The route from Galway Port passes through Claregalway & Milltown, where river bridges exist. Were they assessed for structural capacity?

What Crane weight is used to assemble the turbines? Other presentations mention 750tonnes. Have bridges been assessed for such weights?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AREA TO ACCEPT WHEEL LOADING OF ABNORMAL LOAD VEHICLES WITHIN THIRD PARTY LANDS
HEDGE CUTTING
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LEGEND:
ROAD WIDENING
FOLIO
FOLIO UNREGISTERED
EXISTING SITE ENTRANCES
PROPOSED SITE ENTRANCES
PUBLIC ROAD NUMBERS
CONSTANT ENERGY LTD
TIRAWLEY WIND FARM
CO.MAYO
PLANNING
AUTOTRACK ANALYSIS
BALLINA TO SITE
PINCH POINT 2
(V117)
1:500 @ A3
APRIL 2026
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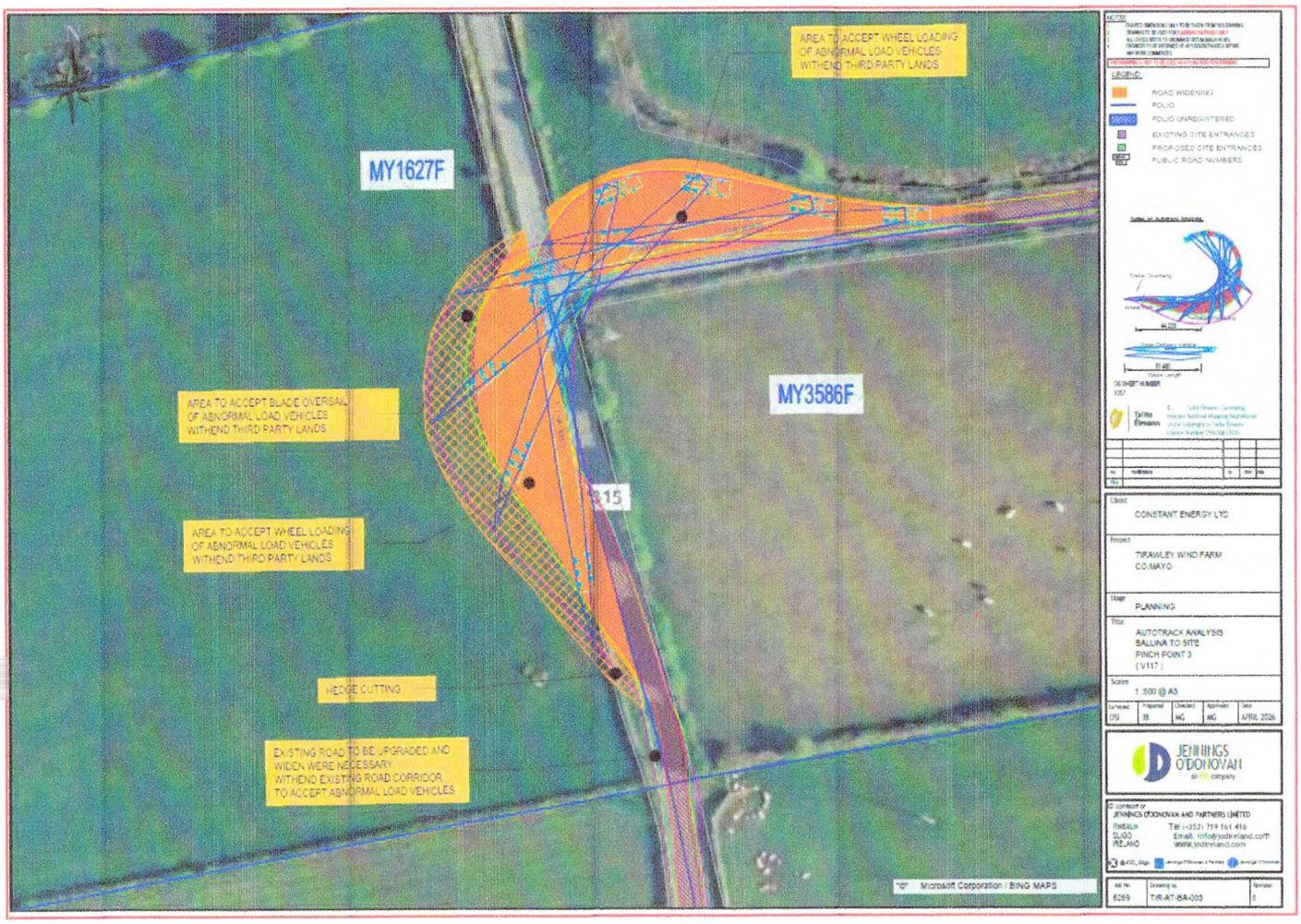
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HEDGE CUTTING
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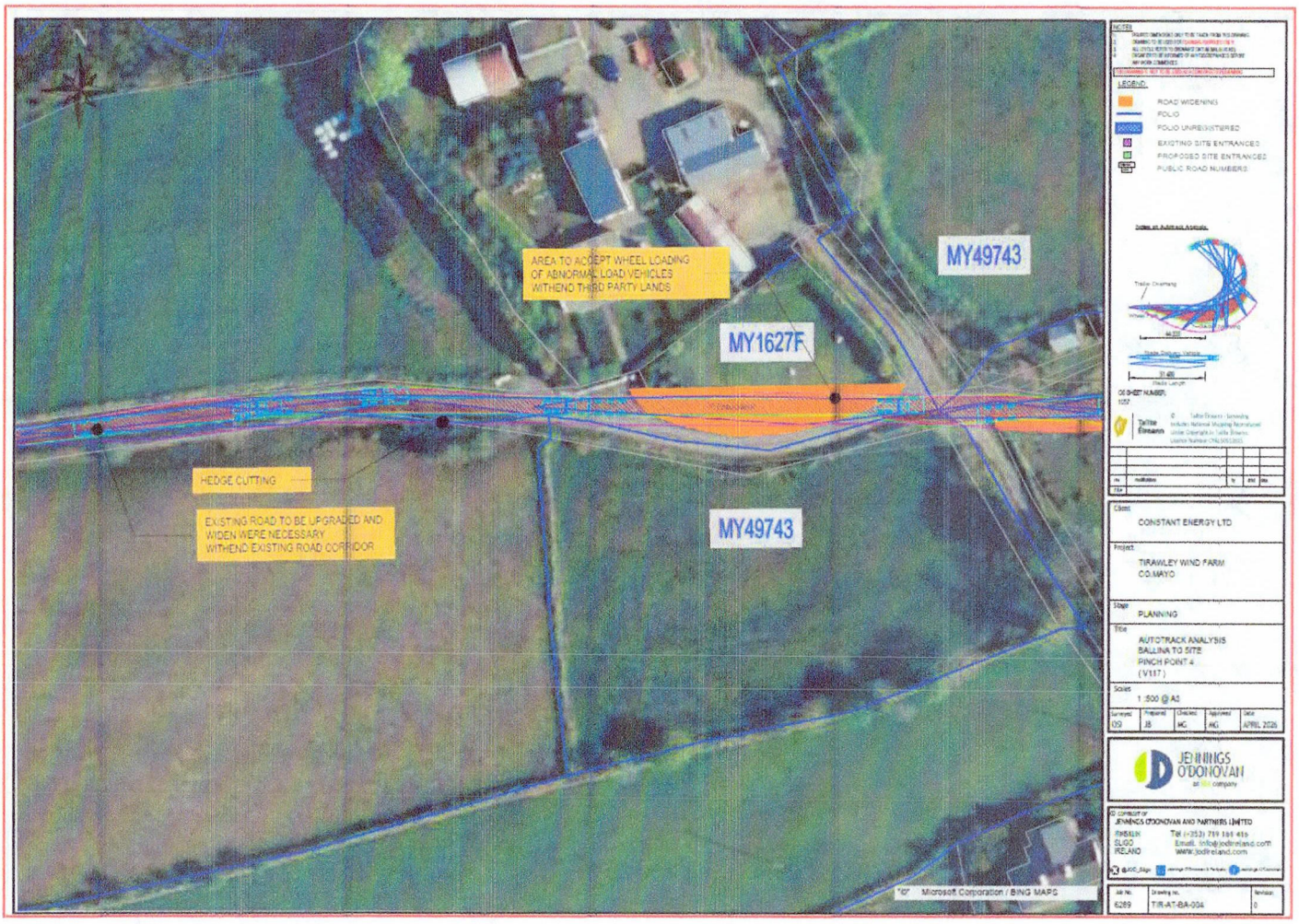
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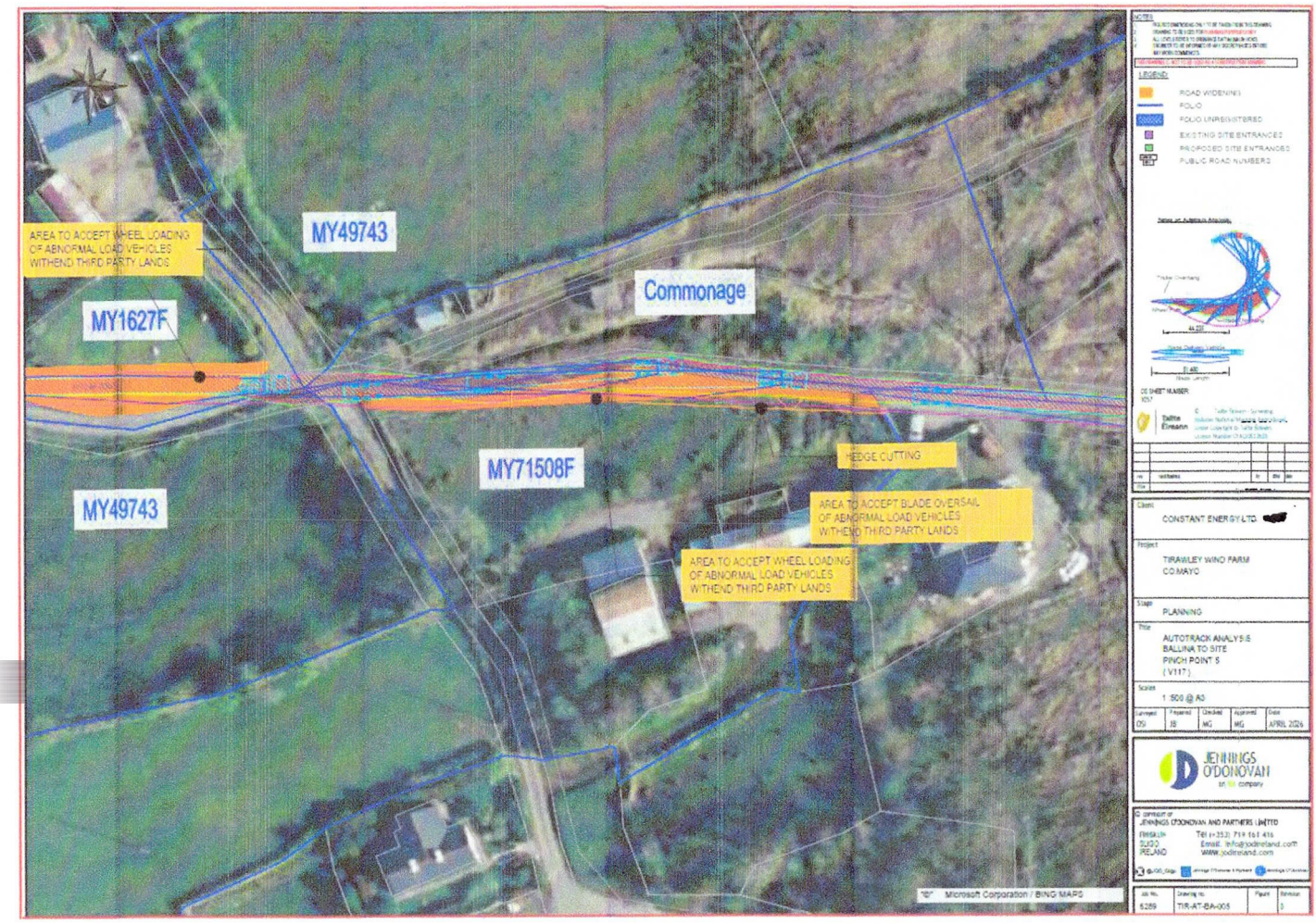
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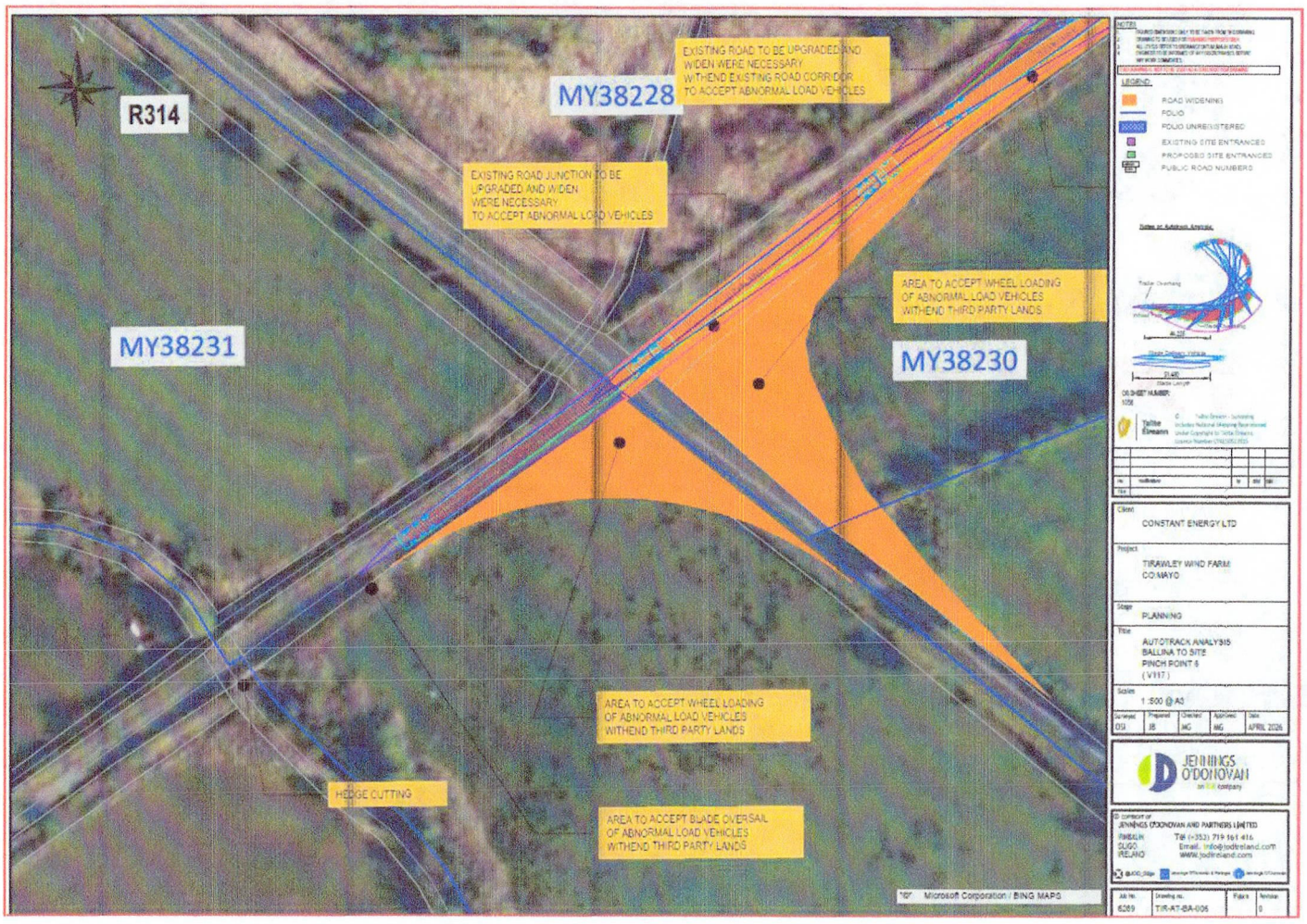
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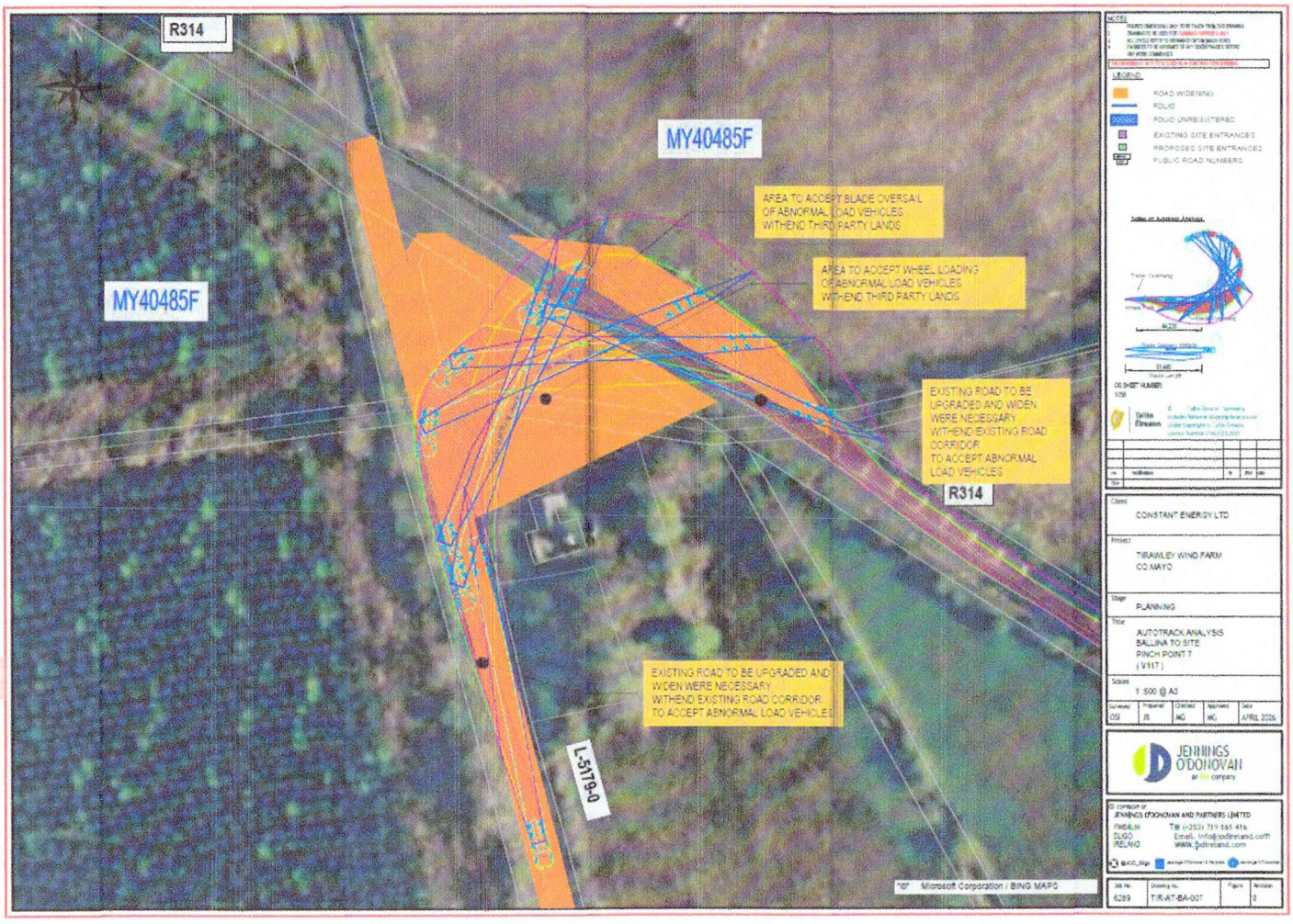
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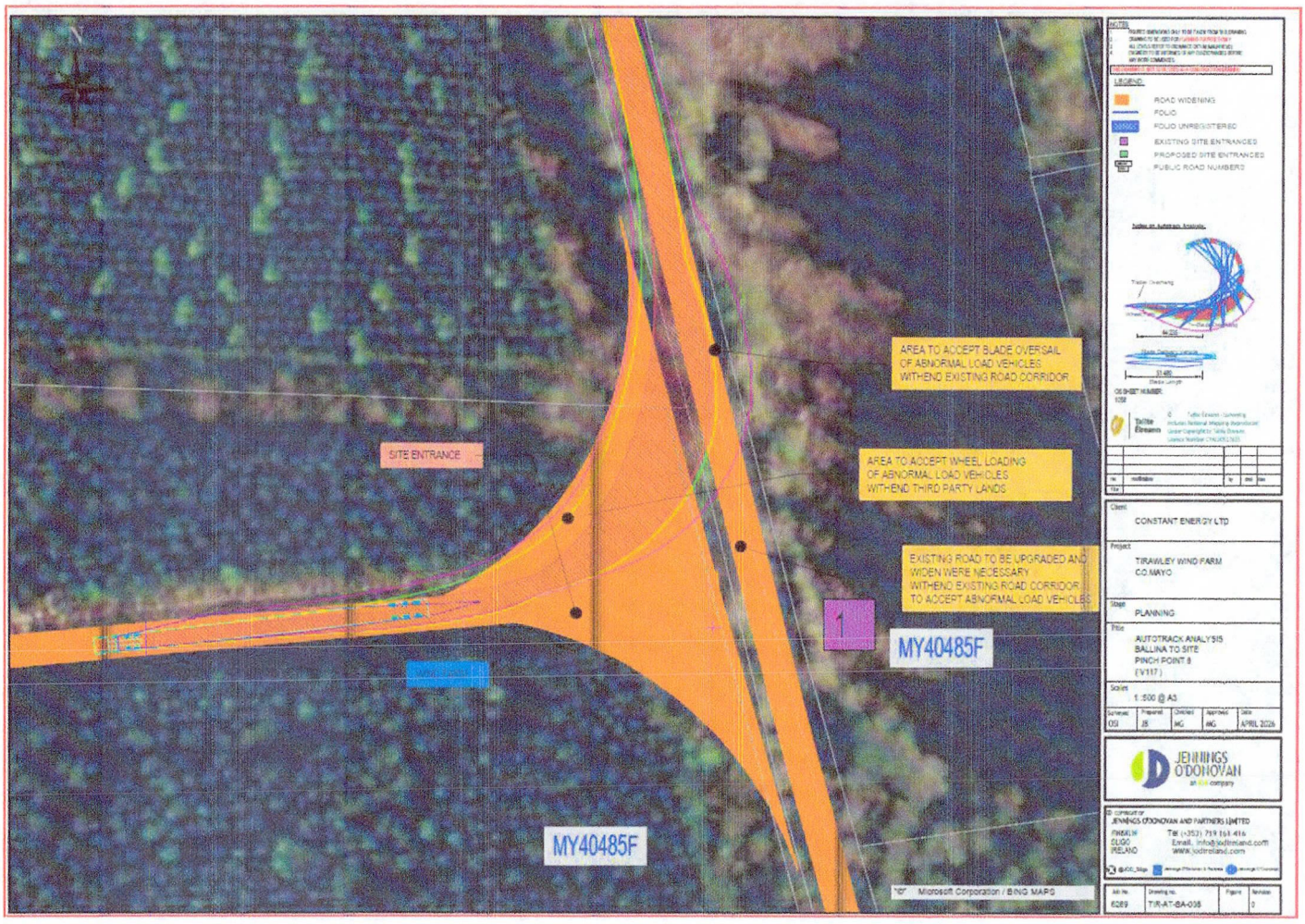
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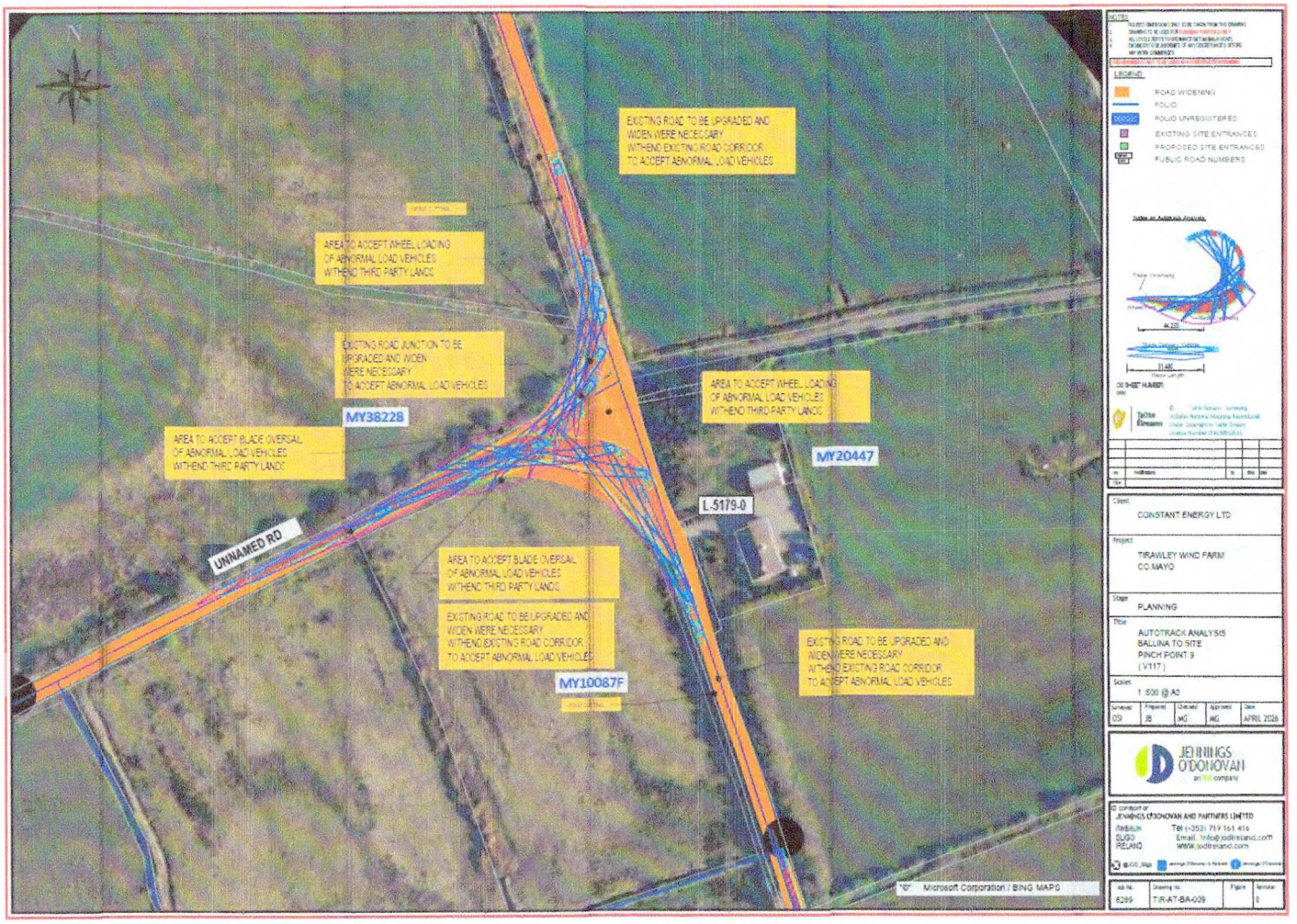
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Client: CONSTANT ENERGY LTD
Project: TIRAWLEY WIND FARM CO MAYO
Stage: PLANNING
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Scales: 1 :500 @ A3
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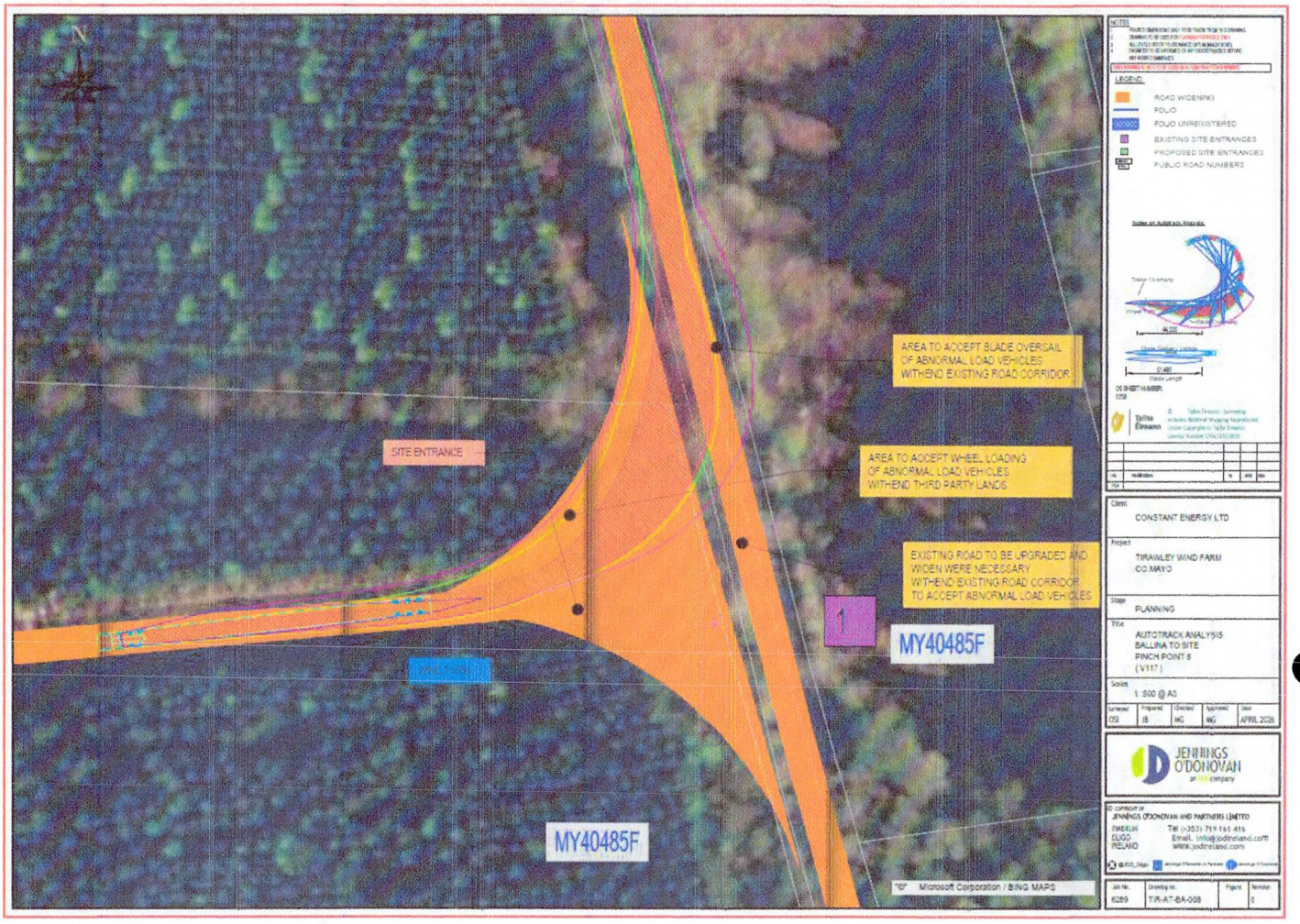
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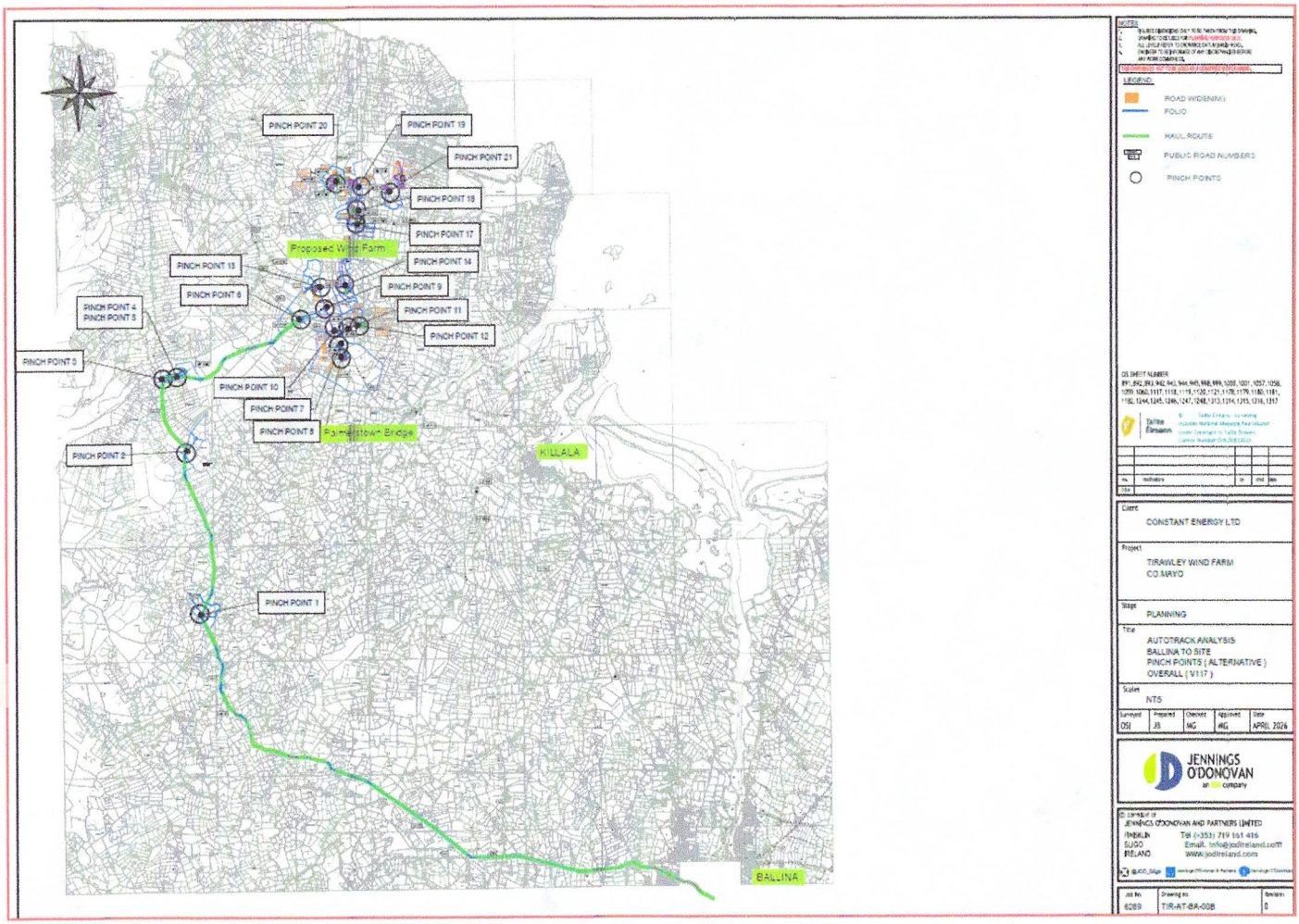
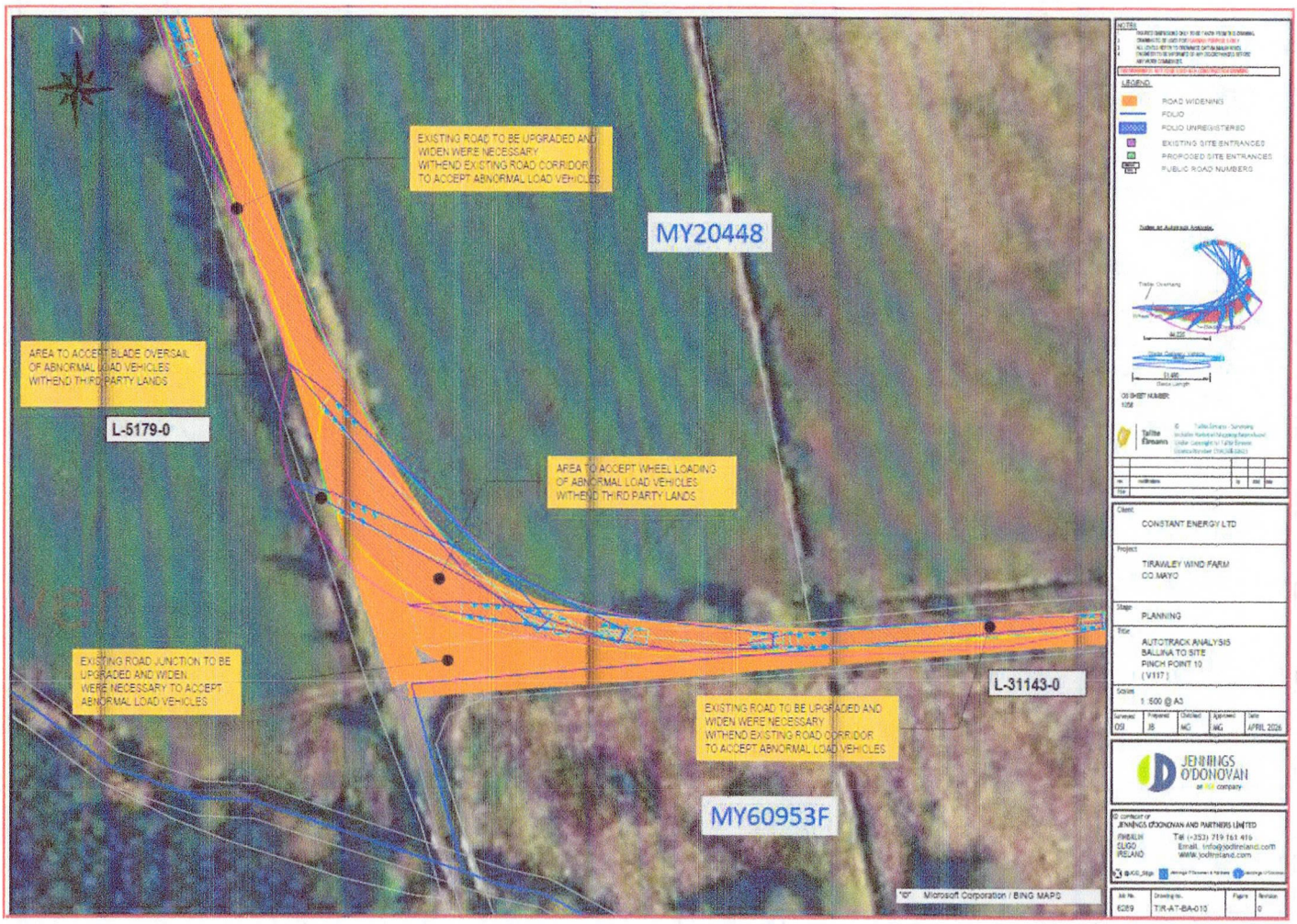


Response from MLavelle: Is this map supposed to provide information to the public?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Stage
PLANNING
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BALLINA TO SITE
PINCH POINT 10
(V117)
Scales
1 :500 @ A3
Surveyed OSI
Prepared JB
Checked MG
Approved MG
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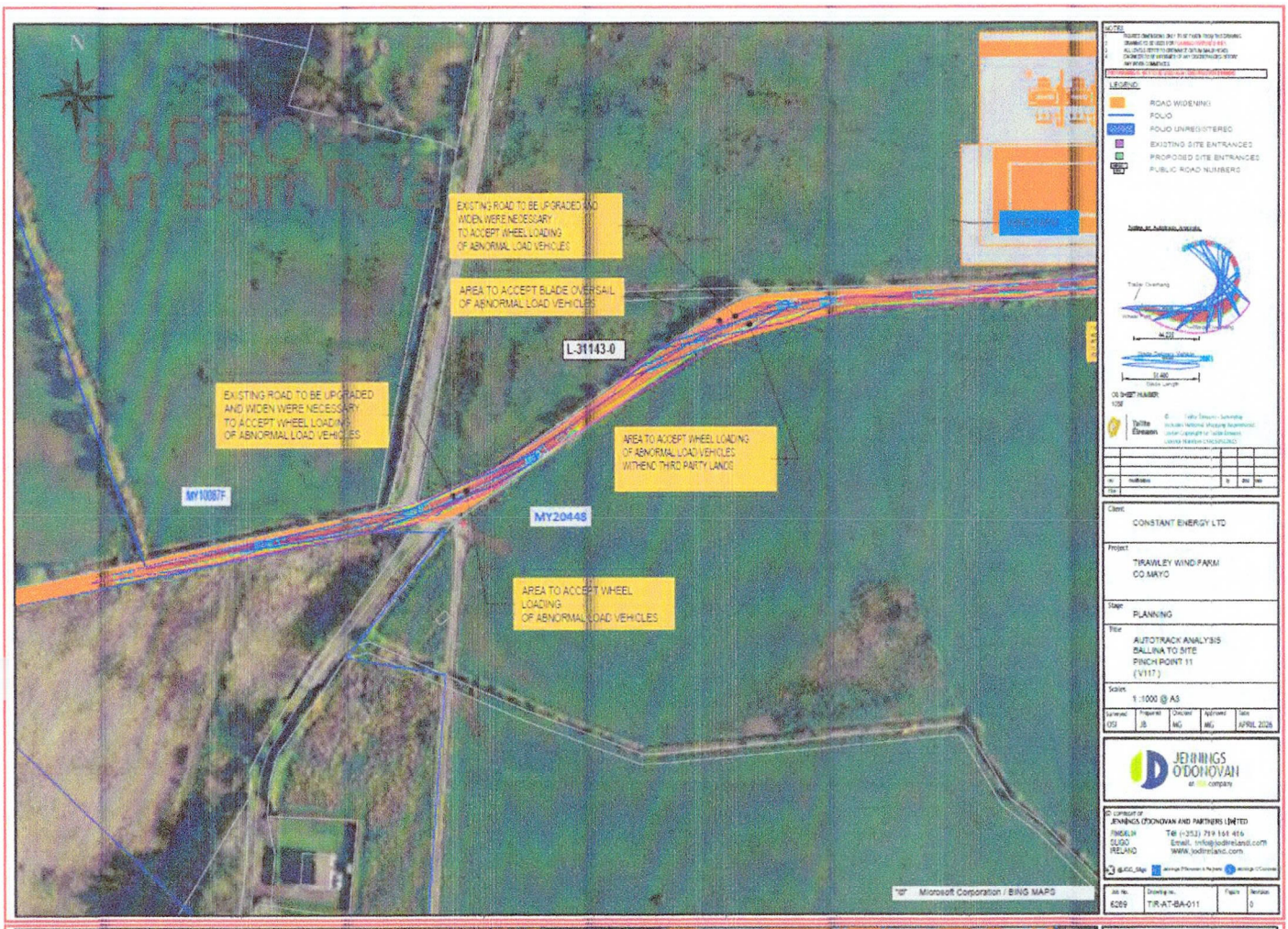
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PUBLIC ROAD NUMBERS
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AREA TO ACCEPT WHEEL LOADING OF ABNORMAL LOAD VEHICLES
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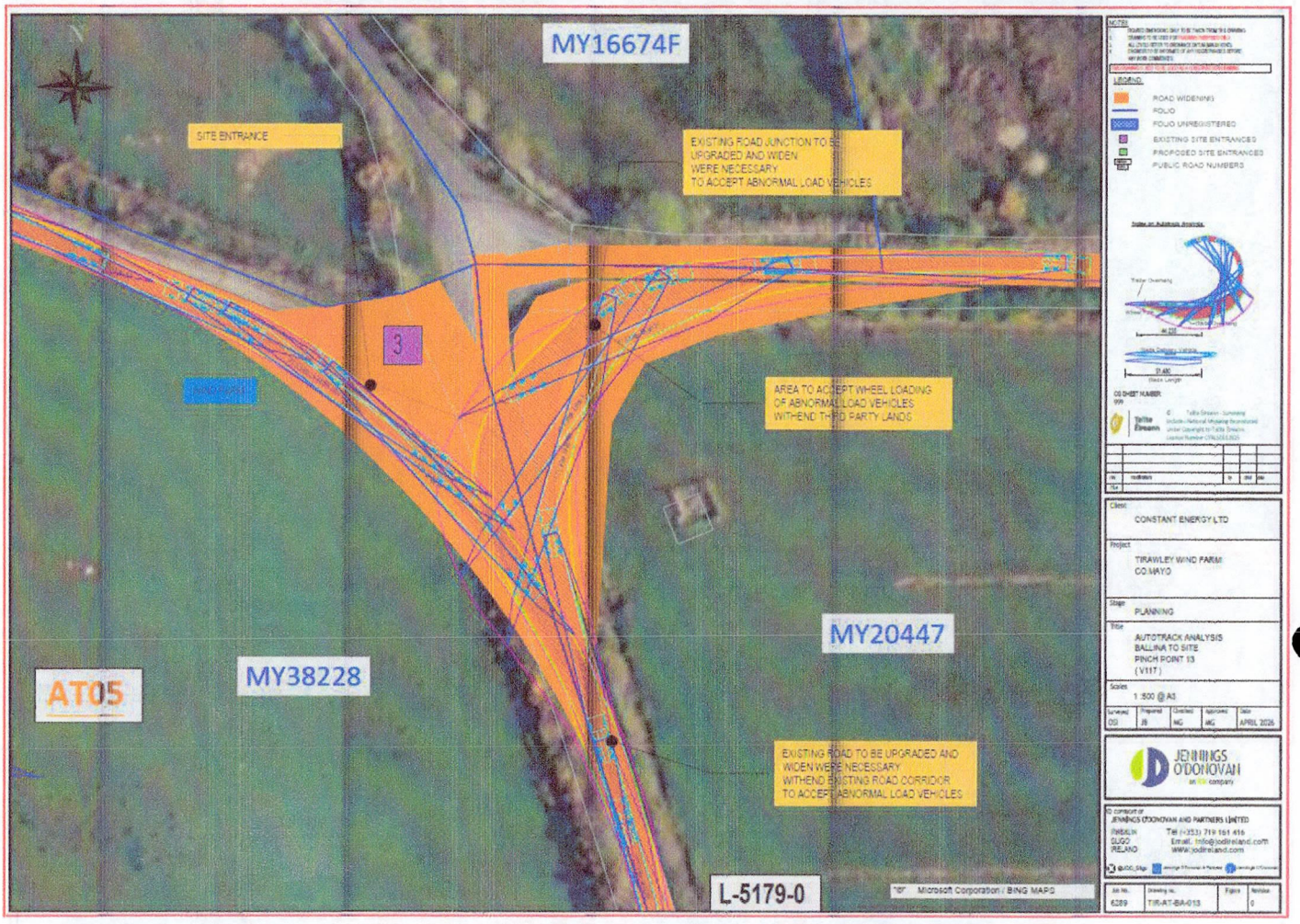
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EXISTING ROAD TO BE UPGRADED AND WIDEN WERE NECESSARY WITHEND EXISTING ROAD CORRIDOR TO ACCEPT ABNORMAL LOAD VEHICLES
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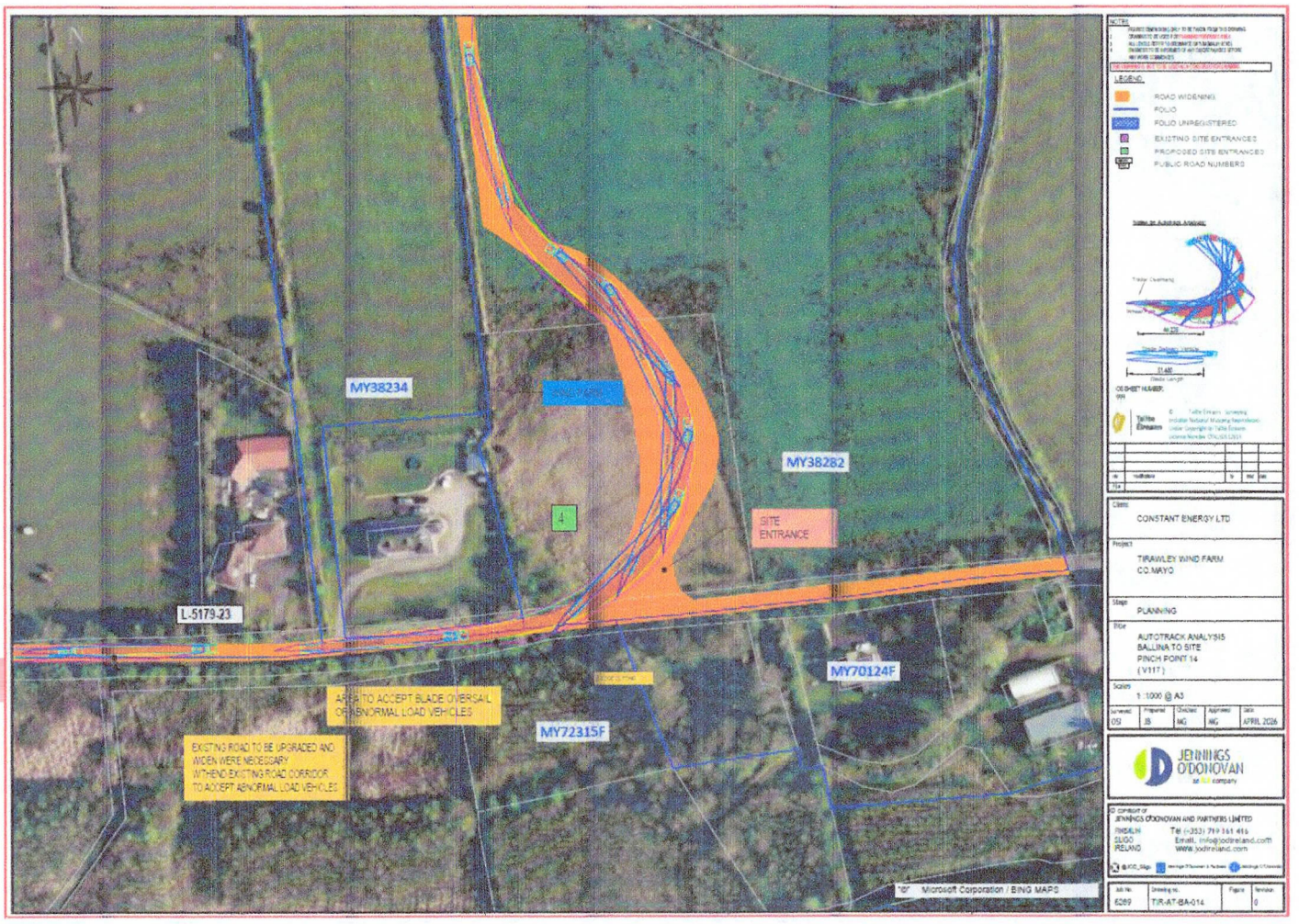
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AT09
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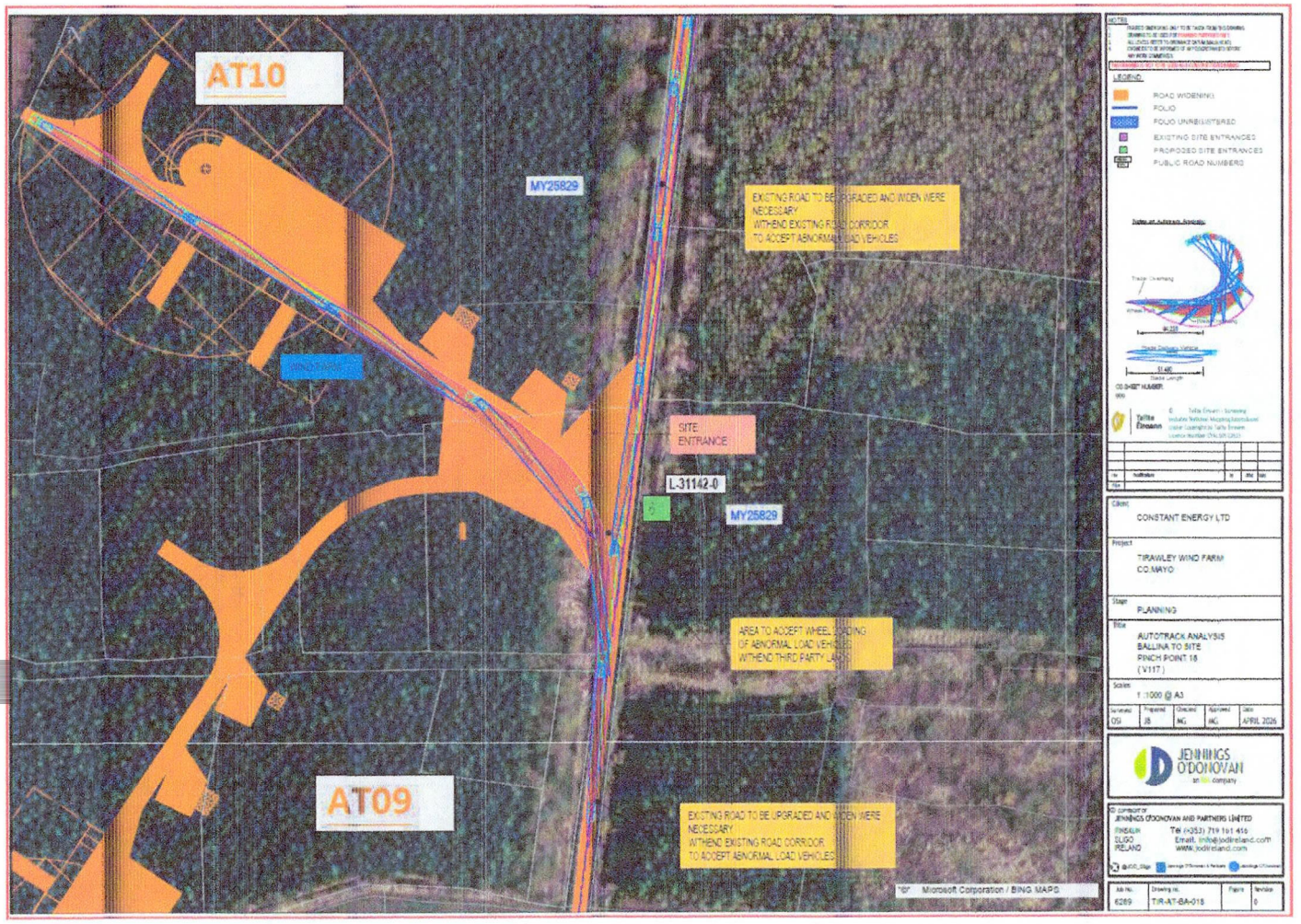
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Approved: MG
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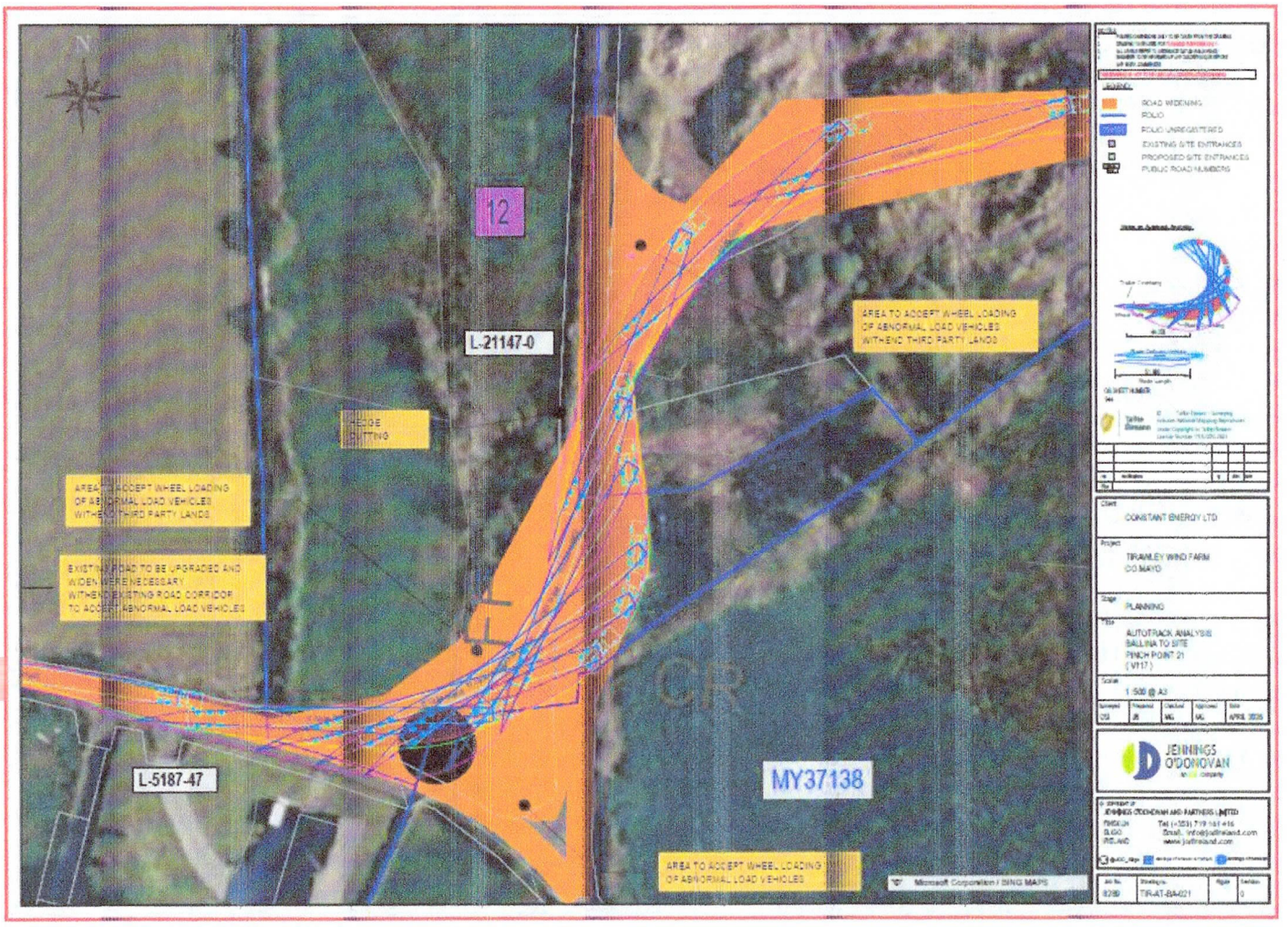
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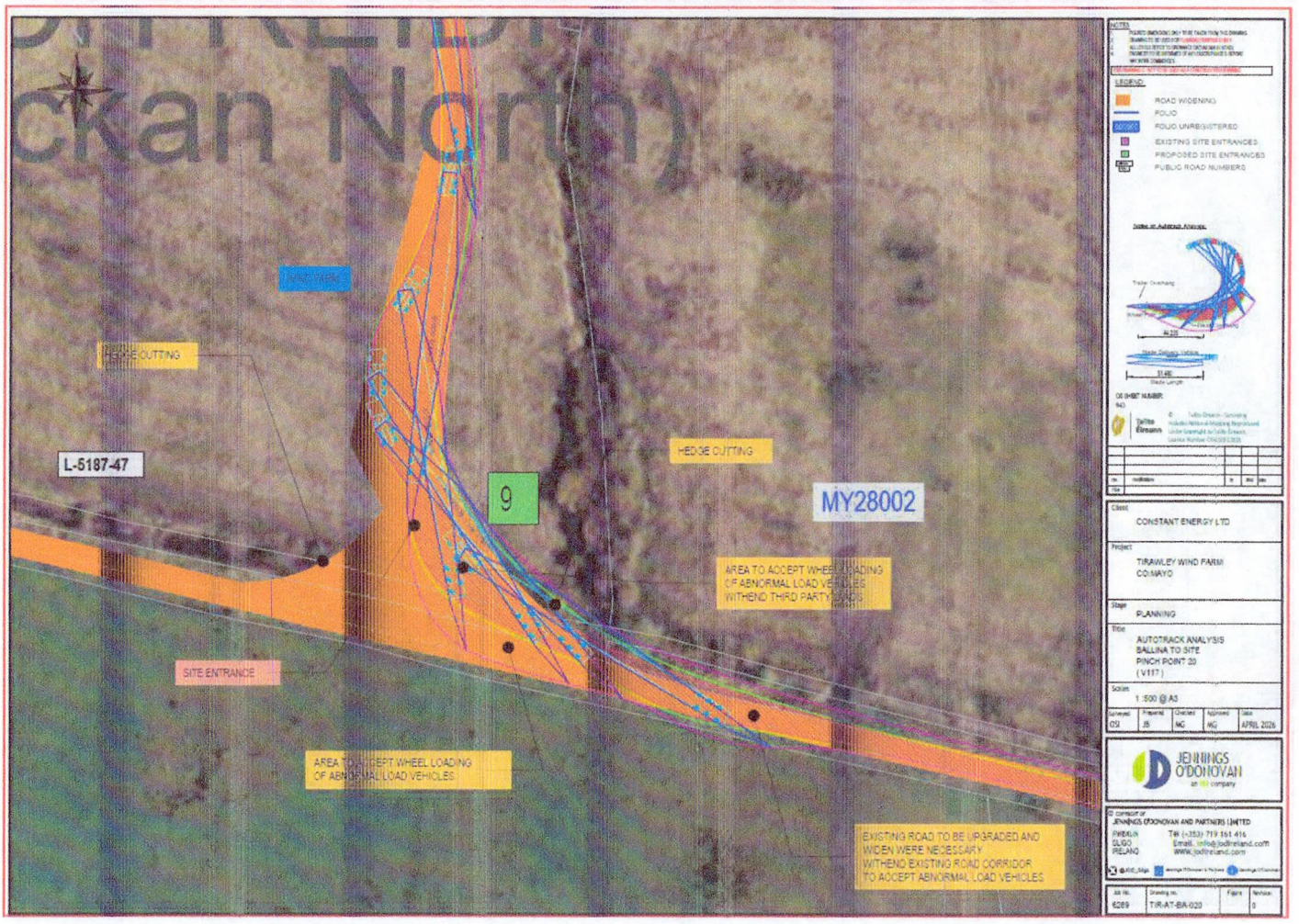
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4.1 Traffic Volume Data - Link Counts

A link count survey which is commonly referred to as an Automatic Traffic Count (ATC) records each vehicle passing a fixed location by direction and according to a specified vehicle classification and speed. The classification of vehicles can vary but in general the classification should allow for the aggregation of vehicle data into the seven classifications recorded by the TII Traffic Monitoring Units:

1. Motorbikes
2. Cars
3. Light Goods Vehicles (LGV)
4. Bus
5. Other Goods Vehicles 1 (OGV1)
6. Other Goods Vehicles 2 (OGV2)
7. Caravans

An ATC can be temporarily installed for a specified period or permanently installed as per the network of TII TMUs which allow for the long term monitoring of traffic growth. Either type of ATC can provide useful supplementary information to a turning count or roadside interview data (which are usually undertaken on one day only) as they can indicate whether that survey day was typical or not.

ATCs may also be used to count the number of pedal cyclists but there are known problems with accuracy under this approach. For example, pneumatic tube counters deployed over multiple lanes of carriageway may not generate a big enough pulse to reach the counter. This problem is partly overcome by the use of a second (more sensitive) tube. Inductive loops are the most common method of counting traffic over a long period. However, the accurate detection of cycle flows under this approach is difficult. As well as pneumatic tubes, camera detection methods can also be used for ATCs and later analysed through Artificial Intelligence (A.I.) powered engines for tracking and classification of vehicles.

It is normal practice for ATCs to be conducted for at least two full weeks. ATCs carried out for two weeks or longer will capture day to day variability. Furthermore, it is essential to place ATCs in favourable positions along links so as to avoid or minimise the likelihood of queues forming over the counters as this leads to less accurate counts. In general, link counts should be undertaken on links that are liable to experience changes in traffic flow related to a scheme proposal.

At the most basic level, ATCs may be required for the development of simple junction models, microsimulation models as well as assignment and variable demand models. ATCs can be used to monitor traffic flows and to provide information about the relationship between survey day traffic and longer term flow levels. ATCs can also be used to provide information about local 12 hour, 16 hour, 18 hour and 24-hour flow ratios, and daily and seasonal traffic variations, all of which are required to estimate average daily traffic flows from shorter period data. In addition, good quality counts are required for both validation and calibration of link traffic flows in transport models.

17.5.16 Road Safety Audit

A Road Safety Audit is required for all National Road Schemes. TII Publication GE-STY-01024, Dec. 2017 sets out two categories of scheme:

- Road Scheme – A scheme which results in new road construction or permanent change to the existing road or roadside layout.
- Development Scheme – A Scheme which results in a change to the road or roadside layout that is indicated and/or executed for commercial or private development.

The construction phase effects identified in this chapter will be short-term associated with deliveries of materials to Site. **No new junctions are being provided** as part of the Proposed Development and there will not be any permanent change that will have a material effect on the safety and free flow of traffic.

Response from MLavelle: In this sentence they state "NO NEW JUNCTIONS ARE BEING PROVIDED" And then (above) they state 5 new & 9 existing entrances.

18 INTERACTIONS OF THE FOREGOING

Any potential impact on one element of the environment as a result of the Proposed Development may also impact on another. **Chapter 18** of the EIAR provides a summary of the interactions and interrelationships between environmental aspects of the Proposed Development. This includes significant effects from each EIAR chapter and also summarises the mitigation measures proposed to reduce either the likelihood or magnitude of these effects to an acceptable level.

Table 18.1 below outlines the different environmental aspects which have potential to interact because of the Proposed Development. Interactions have been clearly identified in the early stages of the Proposed Development and where the potential exists for interaction between environmental impacts, the EIAR specialists have taken the interactions into account when making their assessment. Potential interactions (both positive and negative) have been considered for the construction, operational and decommissioning phases of each of the different environmental aspects of the Proposed Development.

All environmental factors are interrelated to some extent. Having studied the interaction of potential impacts during the construction, operational and decommissioning phases of the Proposed Development, it has been determined that no amplification effect is anticipated. The Proposed Development will have some positive impacts on an international, national, regional and local level. It is important to note that the landscape and visual impacts are almost entirely reversible upon decommissioning of the Development.

Table 18.1: Summary matrix of Interactions of Negative Impacts during Construction and Operational Phases (Source: Adapted from EIAR Guidelines, 2022)[2]

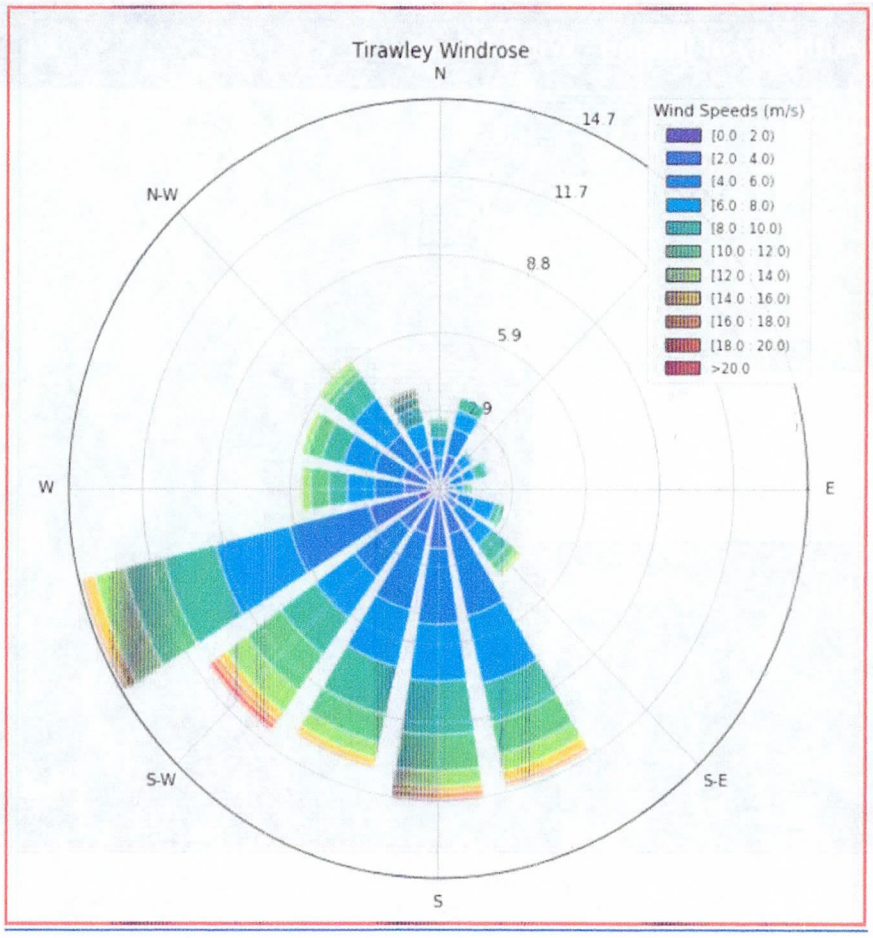
	Population & Human Health		Biodiversity		Soils & Geology		Hydrology and Hydrogeology		Noise		Landscape & Visual		Material Assets		Cultural Heritage		Traffic & Transportation		Air and Climate	
	Const & Decom	Oper	Const & Decom	Oper	Const & Decom	Oper	Const & Decom	Oper	Const & Decom	Oper	Const & Decom	Oper	Const & Decom	Oper	Const & Decom	Oper	Const & Decom	Oper	Const & Decom	Oper
Population & Human Health																				
Biodiversity																				
Soils & Geology																				
Hydrology and Hydrogeology																				
Noise																				
Landscape & Visual																				
Material Assets																				
Archaeology and Cultural Heritage																				
Traffic & Transportation																				
Air and Climate																				

Note: Const & Decom = Construction & Initial Decommissioning phase; Oper = Operational phase

Interaction or inter-relationship

No interaction or inter-relationship


Sustainable Energy Authority of Ireland - Wind Atlas
100m
Zoom to
Wind Speed Range (m/s)
9.1 - 9.2
seai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[8.0 : 10.0)
[10.0 : 12.0)
[12.0 : 14.0)
[14.0 : 16.0)
[16.0 : 18.0)
[18.0 : 20.0)
>20.0

Note the MANUFACTURER`S POWER OUTPUT (below) for 9.1m/s is c2.1Mw and not 4.2Mw. These 16 turbines have a power output of 33Mw & NOT 68Mw. This development is not over the 50Mw SID threshold.

ACP is incorrect in determining that Brochure Capacity is Output. Note how applicant omitted the power curve data, which would/should have determined that this application is NOT SID.

Note Air Density at Sea level is 1.225kg/m^3 and this is used in tables below as 1.25kg/m^3 .

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Document no.: 0067-7063 V03
2017-11-29

Performance Specification

V117-4.0/4.2 MW 50/60 Hz

Strong Wind



Original Instruction: T05 0067-7063 VER 03

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Original Instruction - T05 0067-7063 VER 03

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See general reservations, notes and disclaimers (including, Section 5, p. 10) to this Performance Specification.

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Original Instruction: T05 0067-7063 VER 03

1 General Description

The Vestas V117-4.0/4.2 MW wind turbine is a pitch regulated upwind turbine with active yaw and a three-blade rotor. The Vestas V117-4.0/4.2 MW turbine has a rotor diameter of 117 m and a rated power of 4.0 MW.

Vestas offers an optional Power Optimized (PO) mode at 4.2 MW for the V117-4.0 MW variant.

2 Type Approvals and Available Hub Heights

The standard turbine is type certified according to the certification standards and available hub heights listed below:

Certification	Wind Class	Hub Height
Tower type		Standard
IEC61400-22	IEC IB	91.5 m
	IEC IIA	91.5 m

Table 2-1: Type approval data and available hub heights

The hub height can be increased by up to 3 m by use of raised foundation. Use of raised foundation is subject to site-specific evaluation and is not available for all soil conditions.

3 Operational Envelope and Performance Guidelines

Actual climate and site conditions have many variables and should be considered in evaluating actual turbine performance. The design and operating parameters set forth in this section do not constitute warranties, guarantees, or representations as to turbine performance at actual sites.

3.1 Climate and Site Conditions

The standard turbine is designed for the wind climate conditions listed below. Values refer to hub height.

Wind Climate	IEC IB	IEC IB S	IEC IIA
Power Rating	4.0MW	4.2MW	4.0/4.2MW
Extr Wind Speed (10 min average), V_{50}	50.0 m/s	50.0 m/s	42.5 m/s
Survival Wind Speed (3 s gust), V_{e50}	70.0 m/s	70.0 m/s	59.5 m/s
Turbulence Intensity, I_{V50}	11%	11%	11%

Table 3-1: Extreme design parameters – IEC

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Wind Climate	IEC IB	IEC IB S	IEC IIA
Power Rating	4.0MW	4.2MW	4.0/4.2MW
Wind Speed (10 min average), V_{ave}	10.0 m/s	9.5 m/s	8.5 m/s
Weibull Scale Factor, C	11.3 m/s	10.7 m/s	9.6 m/s
Weibull Shape Factor, k	2.0	2.0	2.0
I_{ref} acc. to IEC 61400-1	0.14	0.14	0.16
Turbulence Intensity acc. to IEC 61400-1, Including Wind Farm Turbulence (@15 m/s) I_{90}(90% quantile)	15.7%	15.7%	18.0%
Wind Shear exponent, α	0.20	0.20	0.20
Inflow Angle (vertical)	8°	8°	8°

Table 3-2: Average design parameters – IEC

3.1.1 Complex Terrain

Classification of complex terrain according to IEC 61400-1:2005 Chapter 11.2. For sites classified as complex, appropriate measures are to be included in site assessment. Positioning of each turbine must be verified via Vestas Site Check.

3.1.2 Altitude

The turbine is designed for use at altitudes up to 1000 m above sea level as standard and optional up to 2000 m above sea level.

3.1.3 Wind Power Plant Layout

Turbine spacing is to be evaluated site-specifically. Spacing below two rotor diameters (2D) may require sector-wise curtailment.

NOTE As evaluation of climate and site conditions is complex, consult Vestas for every project. If conditions exceed the above parameters, Vestas must be consulted.

3.2 Operational Envelope – Wind

Values refer to hub height and are determined by the sensors and control system of the turbine.

Wind Climate	IEC IB	IEC IB S	IEC IIA
Power Rating	4.0MW	4.2MW	4.0/4.2MW
Cut-In, V_{in}	3 m/s	3 m/s	3 m/s
Cut-Out (10 min exponential avg.), V_{out}	25.0 m/s	25.0 m/s	25.0 m/s
Re-Cut In (10 min exponential avg.)	23.0 m/s	23.0 m/s	23.0 m/s

Table 3-3: Operational envelope – wind – IEC

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3.3 Operational Envelope – Wind (HWO)

Optionally, the turbine can be offered with the High Wind Operation (HWO) control feature. The HWO control feature allows the turbine to operate up to the extended cut-out wind speeds listed in Table 3-4, p. 7, with a controlled derating of power and speed. The power curves associated with optional HWO control are found in Sections 7, 9, **Error! Reference source not found.**, **Error! Reference source not found.** and **Error! Reference source not found.**. Values refer to hub height and are determined by the sensors and control system of the turbine.

Wind climate	IEC IB	IEC IB S	IEC IIA
Power Rating	**4.0MW**	**4.2MW**	**4.0/4.2MW**
Cut-In, V_{in}	3 m/s	3 m/s	3 m/s
Cut-Out (10 min exponential avg.), V_{out}	30.0 m/s	30.0 m/s	30.0 m/s
Re-Cut In (10 min exponential avg.)	28.0 m/s	28.0 m/s	28.0 m/s

Table 3-4: Operational envelope – wind – IEC (High Wind Operation)

3.4 Operational Envelope – Conditions for Power Curve and Ct Values (at Hub Height)

Consult Section 6 and later sections for power curves and C_t values.

Conditions for Power Curve and C_t Values (at Hub Height)	
Wind Shear, α	0.00-0.30 (10 minute average)
Turbulence Intensity, I	6-12% (10 minute average)
Blades	Clean
Rain	No
Ice/Snow on Blades	No
Leading Edge	No damage
Terrain	IEC 61400-12-1
Inflow Angle (Vertical)	0 ±2°
Grid Voltage	Nominal Voltage ±2.5%
Grid Frequency	Nominal Frequency ±0.5 Hz
Grid Active Power (at LV-side of turbine transformer)	As per tabulated values in Section 6 and later sections
Grid Reactive Power (at LV-side of turbine transformer)	Power Factor 1.0

Table 3-5: Conditions for power curve and Ct values

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3.5 Sound Modes

The sound modes listed below are available for the turbine.

Sound modes			
Mode No.	Maximum Sound Level	Serrated trailing edges	Available hub heights
0/PO1	106.0 dBA	Yes (standard)	91.5 m
0-0S/ PO1-0S	108.5 dBA	No (option)	91.5 m

Table 3-6: Available sound performance

NOTE The turbine is as standard equipped with serrated trailing edges on the blades. Optionally, Mode 0-0S and PO1-0S can be offered without serrated trailing edges mounted on the blades.

In addition, Sound Optimized (SO) modes as listed below are available as options for the turbine.

Sound Optimized (SO) modes			
Mode No.	Maximum Sound Level	Serrated trailing edges	Available hub heights
SO1	105.0 dBA	Yes	91.5 m
SO2	103.0 dBA	Yes	91.5 m
SO3	101.0 dBA	Yes	91.5 m

Table 3-7: Available Sound Optimized modes

NOTE Sound Optimized (SO) modes are only available with serrated trailing edges on the blades. For further details on sound performance, please contact Vestas Wind Systems A/S.

3.6 Load Modes

The Load Optimized (LO) modes listed below are available for the turbine.

Load Optimized (LO) modes				
Mode No.	Power	Maximum Sound Level	Serrated trailing edges	Available hub heights
LO1	3.8 MW	106.0 dBA	Yes	91.5 m
LO2	3.6 MW	106.0 dBA	Yes	91.5 m

Table 3-8: Available Load Optimized modes

NOTE Load Optimized (LO) modes are only available with serrated trailing edges mounted on the blades.

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4 Drawings

4.1 Structural Design – Illustration of Outer Dimensions

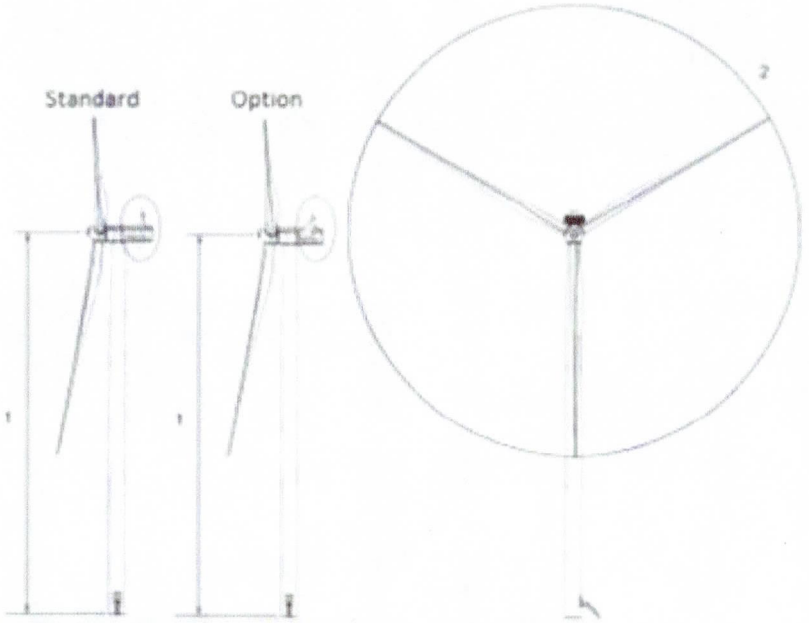

Figure 4-1: Illustration of outer dimensions – structure

1 Hub height:
91.5 m

2 Diameter:
117 m

NOTE The turbine to the right is shown with side panels on the cooler top (Option).

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5 General Reservations, Notes and Disclaimers

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- The performance specifications described in this document apply to the current version of the V117-4.0/4.2 MW wind turbine. Updated versions of the V117-4.0/4.2 MW wind turbine, which may be manufactured in the future, may differ from these performance specifications. In the event that Vestas supplies an updated version of the V117-4.0/4.2 MW wind, Vestas will provide an updated performance specification applicable to the updated version.
- All listed start/stop parameters (e.g. wind speeds) are equipped with hysteresis control. This can, in certain borderline situations, result in turbine stops even though the ambient conditions are within the listed operation parameters.
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Original Instruction: T05 0067-7063 VER 03

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6 Power Curves, Ct Values and Sound Curves, Mode 0/0-0S

6.1 Power Curves, Mode 0/0-0S

Air density [kg/m³]														
Wind speed [m/s]	1.225	0.95	0.975	1.0	1.025	1.05	1.075	1.1	1.125	1.15	1.175	1.2	1.25	1.275
3.0	12	4	5	5	6	7	7	8	9	9	10	11	13	14
3.5	65	38	41	43	46	48	50	53	55	58	60	63	68	70
4.0	140	96	100	104	108	112	116	120	124	128	132	136	144	148
4.5	230	168	172	178	184	190	195	201	207	213	218	224	236	242
5.0	336	248	256	264	272	280	288	296	304	312	320	328	344	351
5.5	460	344	355	365	376	386	397	407	418	429	439	450	471	481
6.0	610	460	474	487	501	515	528	542	556	569	583	597	624	638
6.5	788	597	615	632	649	667	684	701	719	736	753	770	805	822
7.0	996	756	780	802	823	845	866	888	910	931	953	974	1017	1038
7.5	1236	944	971	997	1024	1050	1077	1103	1130	1157	1183	1210	1262	1289
8.0	1507	1155	1187	1219	1251	1284	1316	1348	1380	1412	1443	1475	1539	1570
8.5	1814	1394	1432	1471	1509	1548	1586	1624	1662	1700	1738	1776	1851	1889
9.0	2155	1663	1708	1753	1799	1844	1888	1933	1978	2022	2067	2111	2199	2243
9.5	2521	1956	2008	2060	2112	2165	2216	2268	2319	2370	2420	2470	2570	2619
10.0	2892	2270	2328	2387	2445	2504	2560	2617	2673	2730	2784	2838	2945	2998
10.5	3245	2589	2652	2714	2777	2840	2899	2958	3018	3077	3133	3189	3298	3351
11.0	3555	2899	2964	3029	3094	3159	3218	3278	3337	3397	3449	3502	3601	3648
11.5	3800	3191	3257	3322	3387	3453	3507	3562	3617	3671	3714	3757	3833	3865
12.0	3940	3463	3523	3583	3643	3703	3745	3787	3829	3871	3894	3917	3952	3965
12.5	3987	3696	3743	3789	3836	3882	3903	3923	3944	3964	3972	3979	3990	3994
13.0	3998	3870	3894	3918	3942	3966	3972	3979	3986	3993	3994	3996	3999	3999
13.5	3999	3940	3950	3961	3971	3982	3985	3989	3992	3995	3996	3998	3999	3999
14.0	4000	3977	3981	3986	3990	3995	3996	3997	3998	3999	3999	4000	4000	4000
14.5	4000	3993	3994	3996	3997	3999	3999	3999	4000	4000	4000	4000	4000	4000
15.0	4000	3998	3999	3999	3999	4000	4000	4000	4000	4000	4000	4000	4000	4000
15.5	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
16.0	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
16.5	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
17.0	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
17.5	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
18.0	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
18.5	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
19.0	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
19.5	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
20.0	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
20.5	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
21.0	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
21.5	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
22.0	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
22.5	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
23.0	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
23.5	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
24.0	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
24.5	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
25.0	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000

Table 6-1: Power curve, Mode 0/0-0S

Original Instruction · T05 0067-7063 VER 03

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6.2 Ct Values, Mode 0/0-0S

	Air density kg/m³													
Wind speed [m/s]	1.225	0.950	0.975	1.0	1.025	1.05	1.075	1.1	1.125	1.15	1.175	1.2	1.25	1.275
3.0	0.880	0.885	0.885	0.885	0.884	0.884	0.883	0.883	0.882	0.881	0.881	0.880	0.879	0.879
3.5	0.870	0.875	0.875	0.874	0.874	0.873	0.873	0.872	0.872	0.871	0.871	0.870	0.870	0.869
4.0	0.838	0.842	0.842	0.841	0.841	0.841	0.840	0.840	0.839	0.839	0.839	0.838	0.837	0.837
4.5	0.813	0.814	0.814	0.813	0.813	0.812	0.812	0.812	0.812	0.813	0.813	0.813	0.813	0.812
5.0	0.812	0.811	0.811	0.811	0.812	0.812	0.812	0.812	0.812	0.812	0.812	0.812	0.812	0.812
5.5	0.812	0.814	0.814	0.814	0.814	0.814	0.814	0.813	0.813	0.813	0.813	0.812	0.812	0.811
6.0	0.807	0.811	0.811	0.811	0.810	0.810	0.810	0.809	0.809	0.809	0.808	0.808	0.807	0.807
6.5	0.804	0.808	0.807	0.807	0.806	0.806	0.806	0.805	0.805	0.805	0.804	0.804	0.803	0.803
7.0	0.801	0.806	0.805	0.805	0.805	0.804	0.804	0.803	0.803	0.802	0.802	0.801	0.800	0.799
7.5	0.794	0.801	0.800	0.800	0.799	0.798	0.798	0.797	0.797	0.796	0.795	0.795	0.793	0.793
8.0	0.787	0.796	0.795	0.794	0.794	0.793	0.792	0.791	0.790	0.790	0.789	0.788	0.786	0.786
8.5	0.786	0.796	0.795	0.794	0.793	0.792	0.791	0.791	0.790	0.789	0.788	0.787	0.785	0.784
9.0	0.783	0.795	0.794	0.793	0.792	0.791	0.790	0.789	0.788	0.786	0.785	0.784	0.782	0.780
9.5	0.770	0.792	0.790	0.789	0.787	0.786	0.784	0.782	0.780	0.778	0.775	0.773	0.767	0.764
10.0	0.739	0.780	0.777	0.774	0.770	0.767	0.763	0.760	0.756	0.752	0.748	0.743	0.734	0.729
10.5	0.687	0.747	0.742	0.737	0.732	0.727	0.721	0.715	0.710	0.704	0.698	0.692	0.681	0.675
11.0	0.626	0.697	0.691	0.685	0.679	0.672	0.666	0.659	0.653	0.646	0.639	0.633	0.618	0.611
11.5	0.564	0.644	0.637	0.631	0.624	0.618	0.610	0.603	0.595	0.588	0.580	0.572	0.555	0.548
12.0	0.496	0.595	0.587	0.579	0.572	0.564	0.556	0.546	0.537	0.528	0.517	0.507	0.486	0.475
12.5	0.430	0.546	0.536	0.527	0.517	0.508	0.497	0.485	0.474	0.463	0.452	0.441	0.419	0.409
13.0	0.372	0.495	0.483	0.471	0.459	0.447	0.436	0.425	0.413	0.402	0.392	0.382	0.363	0.355
13.5	0.327	0.439	0.427	0.415	0.404	0.392	0.382	0.372	0.362	0.352	0.344	0.335	0.320	0.312
14.0	0.289	0.387	0.377	0.366	0.355	0.345	0.336	0.327	0.319	0.310	0.303	0.296	0.282	0.276
14.5	0.257	0.343	0.333	0.324	0.314	0.305	0.297	0.290	0.283	0.275	0.269	0.263	0.251	0.246
15.0	0.228	0.303	0.295	0.286	0.278	0.270	0.264	0.257	0.251	0.244	0.239	0.234	0.224	0.219
15.5	0.206	0.271	0.264	0.256	0.249	0.242	0.237	0.231	0.225	0.220	0.215	0.210	0.202	0.197
16.0	0.186	0.243	0.237	0.231	0.225	0.218	0.213	0.208	0.203	0.198	0.194	0.190	0.182	0.179
16.5	0.169	0.220	0.215	0.209	0.203	0.198	0.193	0.189	0.185	0.180	0.176	0.173	0.166	0.162
17.0	0.154	0.200	0.195	0.190	0.185	0.180	0.176	0.172	0.168	0.164	0.161	0.157	0.151	0.148
17.5	0.141	0.182	0.178	0.173	0.169	0.164	0.161	0.157	0.154	0.150	0.147	0.144	0.138	0.136
18.0	0.130	0.167	0.163	0.159	0.155	0.151	0.148	0.144	0.141	0.138	0.135	0.132	0.127	0.125
18.5	0.119	0.153	0.150	0.146	0.142	0.139	0.136	0.133	0.130	0.127	0.124	0.122	0.117	0.115
19.0	0.110	0.141	0.137	0.134	0.131	0.127	0.125	0.122	0.119	0.116	0.114	0.112	0.108	0.106
19.5	0.102	0.130	0.127	0.124	0.121	0.118	0.115	0.113	0.110	0.108	0.106	0.104	0.100	0.098
20.0	0.094	0.120	0.118	0.115	0.112	0.109	0.107	0.105	0.102	0.100	0.098	0.096	0.093	0.091
20.5	0.088	0.112	0.109	0.107	0.104	0.101	0.099	0.097	0.095	0.093	0.091	0.090	0.086	0.085
21.0	0.082	0.104	0.102	0.099	0.097	0.095	0.093	0.091	0.089	0.087	0.085	0.084	0.080	0.079
21.5	0.077	0.098	0.096	0.093	0.091	0.089	0.087	0.085	0.084	0.082	0.080	0.079	0.076	0.074
22.0	0.072	0.091	0.089	0.087	0.085	0.083	0.082	0.080	0.078	0.077	0.075	0.074	0.071	0.070
22.5	0.068	0.086	0.084	0.082	0.080	0.078	0.076	0.075	0.073	0.072	0.070	0.069	0.067	0.065
23.0	0.063	0.080	0.078	0.076	0.075	0.073	0.071	0.070	0.068	0.067	0.066	0.065	0.062	0.061
23.5	0.060	0.075	0.073	0.072	0.070	0.068	0.067	0.066	0.064	0.063	0.062	0.061	0.059	0.058
24.0	0.056	0.071	0.069	0.068	0.066	0.064	0.063	0.062	0.061	0.059	0.058	0.057	0.055	0.054
24.5	0.053	0.067	0.065	0.064	0.062	0.061	0.060	0.058	0.057	0.056	0.055	0.054	0.052	0.051
25.0	0.050	0.063	0.061	0.060	0.059	0.057	0.056	0.055	0.054	0.053	0.052	0.051	0.049	0.049

Table 6-2: C_t values, Mode 0/0-0S

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6.3 Sound Curves, Mode 0/0-0S

Sound Power Level at Hub Height		
Conditions for Sound Power Level:	**Measurement standard IEC 61400-11 ed. 3** **Maximum turbulence at hub height: 30%** **Inflow angle (vertical): 0 ±2°** **Air density: 1.225 kg/m³**	
Wind speed at hub height [m/s]	**Sound Power Level at Hub Height [dBA]** **Mode 0 (Blades with serrated trailing edge)**	**Sound Power Level at Hub Height [dBA]** **Mode 0-0S (Blades without serrated trailing edge)**
3	92.2	94.5
4	92.8	95.4
5	94.0	97.1
6	97.0	100.2
7	100.0	103.1
8	102.8	105.6
9	105.1	107.7
10	106.0	108.5
11	106.0	108.5
12	106.0	108.5
13	106.0	108.5
14	106.0	108.5
15	106.0	108.5
16	106.0	108.5
17	106.0	108.5
18	106.0	108.5
19	106.0	108.5
20	106.0	108.5

Table 6-3: Sound curves, Mode 0/0-0S

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7 Power Curves, Ct Values and Sound Curves, Mode 0/0-0S (HWO)

7.1 Power Curves, Mode 0/0-0S (HWO)

	Air density [kg/m³]													
Wind speed [m/s]	1.225	0.950	0.975	1.000	1.025	1.050	1.075	1.100	1.125	1.150	1.175	1.200	1.250	1.275
3.0	12	4	5	5	6	7	7	8	9	9	10	11	13	14
3.5	65	38	41	43	46	48	50	53	55	58	60	63	68	70
4.0	140	96	100	104	108	112	116	120	124	128	132	136	144	148
4.5	230	166	172	178	184	190	195	201	207	213	218	224	236	242
5.0	336	248	256	264	272	280	288	296	304	312	320	328	344	351
5.5	460	344	355	365	376	386	397	407	418	429	439	450	471	481
6.0	610	460	474	487	501	515	528	542	556	569	583	597	624	638
6.5	788	597	615	632	649	667	684	701	719	736	753	770	805	822
7.0	996	758	780	802	823	845	866	888	910	931	953	974	1017	1038
7.5	1236	944	971	997	1024	1050	1077	1103	1130	1157	1183	1210	1262	1289
8.0	1507	1155	1187	1219	1251	1284	1316	1348	1380	1412	1443	1475	1539	1570
8.5	1814	1394	1432	1471	1509	1548	1586	1624	1662	1700	1738	1776	1851	1889
9.0	2155	1663	1708	1753	1799	1844	1888	1933	1978	2022	2067	2111	2199	2243
9.5	2531	1956	2008	2060	2112	2165	2216	2268	2319	2370	2420	2470	2570	2619
10.0	2892	2270	2328	2387	2445	2504	2560	2617	2673	2730	2784	2838	2945	2998
10.5	3245	2589	2652	2714	2777	2840	2899	2958	3018	3077	3133	3189	3298	3351
11.0	3555	2899	2964	3029	3094	3159	3218	3278	3337	3397	3449	3502	3601	3648
11.5	3800	3191	3257	3322	3387	3453	3507	3562	3617	3671	3714	3757	3833	3865
12.0	3940	3463	3523	3583	3643	3703	3745	3787	3829	3871	3894	3917	3952	3965
12.5	3987	3696	3743	3789	3836	3882	3903	3923	3944	3964	3972	3979	3990	3994
13.0	3998	3870	3894	3918	3942	3966	3972	3979	3986	3993	3994	3996	3999	3999
13.5	3999	3940	3950	3961	3971	3982	3985	3989	3992	3995	3996	3998	3999	3999
14.0	4000	3977	3981	3986	3990	3995	3996	3997	3998	3999	3999	4000	4000	4000
14.5	4000	3993	3994	3996	3997	3999	3999	3999	4000	4000	4000	4000	4000	4000
15.0	4000	3998	3999	3999	3999	4000	4000	4000	4000	4000	4000	4000	4000	4000
15.5	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
16.0	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
16.5	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
17.0	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
17.5	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
18.0	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
18.5	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
19.0	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
19.5	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
20.0	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
20.5	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
21.0	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
21.5	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
22.0	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
22.5	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
23.0	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
23.5	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
24.0	3999	3999	3999	3999	3999	3999	3999	3999	3999	3999	3999	3999	3999	3999
24.5	3989	3989	3989	3989	3989	3989	3989	3989	3989	3989	3989	3989	3989	3989
25.0	3961	3961	3961	3961	3961	3961	3961	3961	3961	3961	3961	3961	3961	3961
25.5	3904	3904	3904	3904	3904	3904	3904	3904	3904	3904	3904	3904	3904	3904
26.0	3823	3823	3823	3823	3823	3823	3823	3823	3823	3823	3823	3823	3823	3823
26.5	3715	3715	3715	3715	3715	3715	3715	3715	3715	3715	3715	3715	3715	3715
27.0	3590	3590	3590	3590	3590	3590	3590	3590	3590	3590	3590	3590	3590	3590
27.5	3422	3422	3422	3422	3422	3422	3422	3422	3422	3422	3422	3422	3422	3422
28.0	3220	3219	3219	3219	3219	3219	3219	3220	3220	3220	3220	3220	3220	3220
28.5	2987	2987	2987	2987	2987	2987	2987	2987	2987	2987	2987	2987	2987	2987
29.0	2733	2733	2733	2733	2733	2733	2733	2733	2733	2733	2733	2733	2733	2733
29.5	2484	2484	2484	2484	2484	2484	2484	2484	2484	2484	2484	2484	2484	2484
30.0	2305	2305	2305	2305	2305	2305	2305	2305	2305	2305	2305	2305	2305	2305

Table 7-1: Power curve, Mode 0/0-0S (HWO)

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7.2 Ct Values, Mode 0/0-0S (HWO)

	Air density kg/m³													
Wind speed [m/s]	1.225	0.950	0.975	1.000	1.025	1.050	1.075	1.100	1.125	1.150	1.175	1.200	1.250	1.275
3.0	0.880	0.885	0.885	0.885	0.884	0.884	0.883	0.883	0.882	0.881	0.881	0.880	0.879	0.879
3.5	0.870	0.875	0.875	0.874	0.874	0.873	0.873	0.872	0.872	0.871	0.871	0.870	0.870	0.869
4.0	0.838	0.842	0.842	0.841	0.841	0.841	0.840	0.840	0.839	0.839	0.839	0.838	0.837	0.837
4.5	0.813	0.814	0.814	0.813	0.813	0.812	0.812	0.812	0.812	0.813	0.813	0.813	0.813	0.812
5.0	0.812	0.811	0.811	0.811	0.812	0.812	0.812	0.812	0.812	0.812	0.812	0.812	0.812	0.812
5.5	0.812	0.814	0.814	0.814	0.814	0.814	0.814	0.813	0.813	0.813	0.813	0.812	0.812	0.811
6.0	0.807	0.811	0.811	0.811	0.810	0.810	0.810	0.809	0.809	0.809	0.808	0.808	0.807	0.807
6.5	0.804	0.808	0.807	0.807	0.806	0.806	0.806	0.805	0.805	0.805	0.804	0.804	0.803	0.803
7.0	0.801	0.806	0.805	0.805	0.805	0.804	0.804	0.803	0.803	0.802	0.802	0.801	0.800	0.799
7.5	0.794	0.801	0.800	0.800	0.799	0.798	0.798	0.797	0.797	0.796	0.795	0.795	0.793	0.793
8.0	0.787	0.796	0.795	0.794	0.794	0.793	0.792	0.791	0.790	0.790	0.789	0.788	0.786	0.786
8.5	0.786	0.796	0.795	0.794	0.793	0.792	0.791	0.791	0.790	0.789	0.788	0.787	0.785	0.784
9.0	0.783	0.795	0.794	0.793	0.792	0.791	0.790	0.789	0.788	0.786	0.785	0.784	0.782	0.780
9.5	0.770	0.792	0.790	0.789	0.787	0.786	0.784	0.782	0.780	0.778	0.775	0.773	0.767	0.764
10.0	0.739	0.780	0.777	0.774	0.770	0.767	0.763	0.760	0.756	0.752	0.748	0.743	0.734	0.729
10.5	0.687	0.747	0.742	0.737	0.732	0.727	0.721	0.715	0.710	0.704	0.698	0.692	0.681	0.675
11.0	0.626	0.697	0.691	0.685	0.679	0.672	0.666	0.659	0.653	0.646	0.639	0.633	0.618	0.611
11.5	0.564	0.644	0.637	0.631	0.624	0.618	0.610	0.603	0.595	0.588	0.580	0.572	0.555	0.546
12.0	0.496	0.595	0.587	0.579	0.572	0.564	0.555	0.546	0.537	0.528	0.517	0.507	0.486	0.475
12.5	0.430	0.546	0.536	0.527	0.517	0.508	0.497	0.485	0.474	0.463	0.452	0.441	0.419	0.409
13.0	0.372	0.495	0.483	0.471	0.459	0.447	0.436	0.425	0.413	0.402	0.392	0.382	0.363	0.355
13.5	0.327	0.439	0.427	0.415	0.404	0.392	0.382	0.372	0.362	0.352	0.344	0.335	0.320	0.312
14.0	0.289	0.387	0.377	0.366	0.355	0.345	0.336	0.327	0.319	0.310	0.303	0.296	0.282	0.276
14.5	0.257	0.343	0.333	0.324	0.314	0.305	0.297	0.290	0.283	0.275	0.269	0.263	0.251	0.246
15.0	0.228	0.303	0.295	0.286	0.278	0.270	0.264	0.257	0.251	0.244	0.239	0.234	0.224	0.219
15.5	0.206	0.271	0.264	0.256	0.249	0.242	0.237	0.231	0.225	0.220	0.215	0.210	0.202	0.197
16.0	0.186	0.243	0.237	0.231	0.225	0.218	0.213	0.208	0.203	0.198	0.194	0.190	0.182	0.179
16.5	0.169	0.220	0.215	0.209	0.203	0.198	0.193	0.189	0.185	0.180	0.176	0.173	0.166	0.162
17.0	0.154	0.200	0.195	0.190	0.185	0.180	0.176	0.172	0.168	0.164	0.161	0.157	0.151	0.148
17.5	0.141	0.182	0.178	0.173	0.169	0.164	0.161	0.157	0.154	0.150	0.147	0.144	0.138	0.136
18.0	0.130	0.167	0.163	0.159	0.155	0.151	0.148	0.144	0.141	0.138	0.135	0.132	0.127	0.125
18.5	0.119	0.153	0.150	0.146	0.142	0.139	0.136	0.133	0.130	0.127	0.124	0.122	0.117	0.115
19.0	0.110	0.141	0.137	0.134	0.131	0.127	0.125	0.122	0.119	0.116	0.114	0.112	0.108	0.106
19.5	0.102	0.130	0.127	0.124	0.121	0.118	0.115	0.113	0.110	0.108	0.106	0.104	0.100	0.098
20.0	0.094	0.120	0.118	0.115	0.112	0.109	0.107	0.105	0.102	0.100	0.098	0.096	0.093	0.091
20.5	0.088	0.112	0.109	0.107	0.104	0.101	0.099	0.097	0.095	0.093	0.091	0.090	0.086	0.085
21.0	0.082	0.104	0.102	0.099	0.097	0.095	0.093	0.091	0.089	0.087	0.085	0.084	0.080	0.079
21.5	0.077	0.098	0.096	0.093	0.091	0.089	0.087	0.085	0.084	0.082	0.080	0.079	0.076	0.074
22.0	0.072	0.091	0.089	0.087	0.085	0.083	0.082	0.080	0.078	0.077	0.075	0.074	0.071	0.070
22.5	0.068	0.086	0.084	0.082	0.080	0.078	0.076	0.075	0.073	0.072	0.070	0.069	0.067	0.065
23.0	0.063	0.080	0.078	0.076	0.075	0.073	0.071	0.070	0.068	0.067	0.066	0.065	0.062	0.061
23.5	0.060	0.075	0.073	0.072	0.070	0.068	0.067	0.066	0.064	0.063	0.062	0.061	0.059	0.058
24.0	0.056	0.071	0.069	0.068	0.066	0.064	0.063	0.062	0.061	0.059	0.058	0.057	0.055	0.054
24.5	0.053	0.066	0.065	0.064	0.062	0.061	0.059	0.058	0.057	0.056	0.055	0.054	0.052	0.051
25.0	0.050	0.062	0.061	0.060	0.058	0.057	0.056	0.055	0.054	0.052	0.052	0.051	0.049	0.048
25.5	0.047	0.058	0.057	0.056	0.055	0.053	0.052	0.051	0.050	0.049	0.048	0.048	0.046	0.045
26.0	0.043	0.054	0.053	0.052	0.051	0.049	0.049	0.048	0.047	0.046	0.045	0.044	0.043	0.042
26.5	0.040	0.050	0.049	0.048	0.047	0.046	0.045	0.044	0.043	0.042	0.041	0.041	0.039	0.039
27.0	0.037	0.046	0.045	0.044	0.043	0.042	0.041	0.040	0.040	0.039	0.038	0.037	0.036	0.036
27.5	0.033	0.042	0.041	0.040	0.039	0.038	0.037	0.037	0.036	0.035	0.035	0.034	0.033	0.032
28.0	0.030	0.037	0.037	0.036	0.035	0.034	0.034	0.033	0.032	0.032	0.031	0.031	0.030	0.029
28.5	0.027	0.033	0.033	0.032	0.031	0.031	0.030	0.029	0.029	0.028	0.028	0.027	0.026	0.026
29.0	0.024	0.029	0.029	0.028	0.027	0.027	0.026	0.026	0.025	0.025	0.025	0.024	0.023	0.023
29.5	0.021	0.026	0.025	0.025	0.024	0.024	0.023	0.023	0.022	0.022	0.022	0.021	0.021	0.020
30.0	0.019	0.023	0.022	0.022	0.022	0.021	0.021	0.020	0.020	0.020	0.019	0.019	0.019	0.018

Table 7-2: C_t values, Mode 0/0-0S (HWO)

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Original Instruction · T05 0067-7063 VER 03

T05 0067-7063 Ver 03 – Approved - Exported from DMS: 2018-02-19 by FRPIC

7.3 Sound Curves, Mode 0/0-0S (HWO)

Sound Power Level at Hub Height		
Conditions for Sound Power Level:	**Measurement standard IEC 61400-11 ed. 3** **Maximum turbulence at hub height: 30%** **Inflow angle (vertical): 0 ±2°** **Air density: 1.225 kg/m³**	
Wind speed at hub height [m/s]	**Sound Power Level at Hub Height [dBA]** **Mode 0 (HWO) (Blades with serrated trailing edge)**	**Sound Power Level at Hub Height [dBA]** **Mode 0-0S (HWO) (Blades without serrated trailing edge)**
3	92.2	94.5
4	92.8	95.4
5	94.0	97.1
6	97.0	100.2
7	100.0	103.1
8	102.8	105.6
9	105.1	107.7
10	106.0	108.5
11	106.0	108.5
12	106.0	108.5
13	106.0	108.5
14	106.0	108.5
15	106.0	108.5
16	106.0	108.5
17	106.0	108.5
18	106.0	108.5
19	106.0	108.5
20	106.0	108.5

Table 7-3: Sound curves, Mode 0/0-0S (HWO)

Original Instruction: T05 0067-7063 VER 03

T05 0067-7063 Ver 03 – Approved - Exported from DMS: 2018-02-19 by FRPIC

8 Power Curves, Ct Values and Sound Curves, Power Optimized Mode PO1/PO1-0S

8.1 Power Curves, Power Optimized Mode PO1/PO1-0S

	Air density [kg/m³]													
Wind speed [m/s]	1.225	0.95	0.975	1.0	1.025	1.05	1.075	1.1	1.125	1.15	1.175	1.2	1.25	1.275
3.0	12	4	5	5	6	7	7	8	9	9	10	11	13	14
3.5	65	38	41	43	46	48	50	53	55	58	60	63	68	70
4.0	140	96	100	104	108	112	116	120	124	128	132	136	144	148
4.5	230	166	172	178	184	190	195	201	207	213	218	224	236	242
5.0	336	248	256	264	272	280	288	296	304	312	320	328	344	351
5.5	460	344	355	365	376	386	397	407	418	429	439	450	471	481
6.0	610	460	474	487	501	515	528	542	556	569	583	597	624	638
6.5	788	597	615	632	649	667	684	701	719	736	753	770	805	822
7.0	996	758	780	802	823	845	866	888	910	931	953	974	1017	1038
7.5	1236	944	971	997	1024	1050	1077	1103	1130	1157	1183	1210	1262	1289
8.0	1507	1155	1187	1219	1251	1284	1316	1348	1380	1412	1443	1475	1539	1570
8.5	1814	1394	1432	1471	1509	1548	1586	1624	1662	1700	1738	1776	1851	1889
9.0	2155	1663	1708	1753	1799	1844	1888	1933	1978	2022	2067	2111	2199	2243
9.5	2521	1956	2008	2060	2112	2165	2216	2268	2319	2370	2420	2470	2570	2619
10.0	2892	2270	2328	2387	2445	2504	2560	2617	2673	2730	2784	2838	2945	2998
10.5	3245	2589	2652	2714	2777	2840	2899	2959	3018	3077	3133	3189	3298	3352
11.0	3556	2899	2964	3029	3094	3159	3219	3278	3337	3397	3450	3503	3604	3652
11.5	3815	3191	3257	3322	3387	3453	3509	3564	3620	3676	3723	3769	3855	3895
12.0	4008	3483	3524	3566	3647	3709	3757	3805	3853	3902	3937	3973	4035	4062
12.5	4124	3702	3756	3809	3862	3916	3952	3988	4024	4060	4081	4102	4137	4151
13.0	4178	3900	3941	3981	4022	4063	4084	4105	4126	4147	4157	4167	4183	4188
13.5	4187	4033	4057	4081	4105	4129	4140	4151	4162	4172	4177	4182	4189	4192
14.0	4196	4116	4130	4143	4157	4171	4176	4181	4186	4191	4192	4194	4197	4199
14.5	4200	4162	4169	4176	4182	4189	4191	4193	4195	4198	4198	4199	4200	4200
15.0	4200	4186	4188	4192	4194	4198	4198	4199	4199	4200	4200	4200	4200	4200
15.5	4200	4194	4196	4197	4198	4199	4200	4200	4200	4200	4200	4200	4200	4200
16.0	4200	4198	4198	4199	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200
16.5	4200	4199	4199	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200
17.0	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200
17.5	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200
18.0	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200
18.5	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200
19.0	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200
19.5	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200
20.0	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200
20.5	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200
21.0	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200
21.5	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200
22.0	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200
22.5	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200
23.0	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200
23.5	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200
24.0	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200
24.5	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200
25.0	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200

Table 8-1: Power curve, Power Optimized Mode PO1/PO1-0S

Original Instruction: T05 0067-7063 VER 03

T05 0067-7063 Ver 03 - Approved - Exported from DMS: 2018-02-19 by FRPIC

8.2 Ct Values, Power Optimized Mode PO1/PO1-0S

	Air density kg/m³													
Wind speed [m/s]	1.225	0.950	0.975	1.0	1.025	1.05	1.075	1.1	1.125	1.15	1.175	1.2	1.25	1.275
3.0	0.880	0.885	0.885	0.885	0.884	0.884	0.883	0.883	0.882	0.881	0.881	0.880	0.879	0.879
3.5	0.870	0.875	0.875	0.874	0.874	0.873	0.873	0.872	0.872	0.871	0.871	0.870	0.870	0.869
4.0	0.838	0.842	0.842	0.841	0.841	0.841	0.840	0.840	0.839	0.839	0.839	0.838	0.837	0.837
4.5	0.813	0.814	0.814	0.813	0.813	0.812	0.812	0.812	0.812	0.813	0.813	0.813	0.813	0.812
5.0	0.812	0.811	0.811	0.811	0.812	0.812	0.812	0.812	0.812	0.812	0.812	0.812	0.812	0.812
5.5	0.812	0.814	0.814	0.814	0.814	0.814	0.814	0.813	0.813	0.813	0.813	0.812	0.812	0.811
6.0	0.807	0.811	0.811	0.811	0.810	0.810	0.810	0.809	0.809	0.809	0.808	0.808	0.807	0.807
6.5	0.804	0.808	0.807	0.807	0.806	0.806	0.806	0.805	0.805	0.805	0.804	0.804	0.803	0.803
7.0	0.801	0.806	0.805	0.805	0.805	0.804	0.804	0.803	0.803	0.802	0.802	0.801	0.800	0.799
7.5	0.794	0.801	0.800	0.800	0.799	0.798	0.798	0.797	0.797	0.796	0.795	0.795	0.793	0.793
8.0	0.787	0.796	0.795	0.794	0.794	0.793	0.792	0.791	0.790	0.790	0.789	0.788	0.786	0.786
8.5	0.786	0.796	0.795	0.794	0.793	0.792	0.791	0.791	0.790	0.789	0.788	0.787	0.785	0.784
9.0	0.783	0.795	0.794	0.793	0.792	0.791	0.790	0.789	0.788	0.786	0.785	0.784	0.782	0.780
9.5	0.770	0.792	0.790	0.789	0.787	0.786	0.784	0.782	0.780	0.778	0.775	0.773	0.767	0.764
10.0	0.739	0.780	0.777	0.774	0.770	0.767	0.763	0.760	0.756	0.752	0.748	0.743	0.734	0.729
10.5	0.687	0.747	0.742	0.737	0.732	0.727	0.721	0.715	0.710	0.704	0.698	0.692	0.681	0.675
11.0	0.626	0.697	0.691	0.685	0.679	0.672	0.666	0.659	0.653	0.646	0.640	0.633	0.619	0.612
11.5	0.566	0.644	0.637	0.631	0.624	0.618	0.610	0.603	0.596	0.589	0.581	0.574	0.558	0.551
12.0	0.507	0.595	0.587	0.580	0.573	0.565	0.557	0.549	0.541	0.533	0.524	0.516	0.498	0.489
12.5	0.448	0.547	0.538	0.530	0.522	0.513	0.504	0.495	0.486	0.476	0.467	0.457	0.439	0.429
13.0	0.393	0.499	0.490	0.480	0.471	0.461	0.451	0.441	0.431	0.421	0.412	0.402	0.384	0.375
13.5	0.345	0.452	0.441	0.431	0.420	0.409	0.400	0.390	0.380	0.371	0.362	0.354	0.338	0.330
14.0	0.305	0.404	0.394	0.383	0.373	0.363	0.354	0.345	0.336	0.327	0.320	0.312	0.298	0.291
14.5	0.271	0.360	0.351	0.341	0.332	0.322	0.314	0.306	0.298	0.290	0.284	0.277	0.265	0.259
15.0	0.241	0.320	0.311	0.303	0.294	0.285	0.279	0.272	0.265	0.258	0.252	0.247	0.236	0.231
15.5	0.217	0.286	0.279	0.271	0.263	0.256	0.250	0.244	0.238	0.232	0.227	0.222	0.212	0.208
16.0	0.196	0.257	0.250	0.244	0.237	0.230	0.225	0.220	0.214	0.209	0.205	0.200	0.192	0.188
16.5	0.178	0.232	0.226	0.220	0.214	0.208	0.204	0.199	0.194	0.189	0.186	0.182	0.174	0.171
17.0	0.162	0.211	0.205	0.200	0.195	0.189	0.185	0.181	0.177	0.173	0.169	0.165	0.159	0.156
17.5	0.148	0.192	0.187	0.183	0.178	0.173	0.169	0.165	0.162	0.158	0.154	0.151	0.145	0.142
18.0	0.136	0.176	0.171	0.167	0.163	0.159	0.155	0.152	0.148	0.145	0.142	0.139	0.133	0.131
18.5	0.125	0.161	0.157	0.154	0.150	0.146	0.143	0.139	0.136	0.133	0.131	0.128	0.123	0.121
19.0	0.115	0.148	0.144	0.141	0.137	0.134	0.131	0.128	0.125	0.122	0.120	0.117	0.113	0.111
19.5	0.106	0.136	0.133	0.130	0.127	0.124	0.121	0.118	0.116	0.113	0.111	0.109	0.104	0.103
20.0	0.099	0.126	0.123	0.120	0.117	0.115	0.112	0.110	0.107	0.105	0.103	0.101	0.097	0.095
20.5	0.092	0.117	0.115	0.112	0.109	0.106	0.104	0.102	0.100	0.098	0.096	0.094	0.090	0.089
21.0	0.086	0.109	0.107	0.104	0.102	0.099	0.097	0.095	0.093	0.091	0.089	0.087	0.084	0.083
21.5	0.081	0.103	0.100	0.098	0.096	0.093	0.091	0.089	0.088	0.086	0.084	0.082	0.079	0.078
22.0	0.076	0.096	0.094	0.092	0.089	0.087	0.085	0.084	0.082	0.080	0.079	0.077	0.074	0.073
22.5	0.071	0.090	0.088	0.086	0.084	0.082	0.080	0.078	0.077	0.075	0.074	0.072	0.070	0.068
23.0	0.066	0.084	0.082	0.080	0.078	0.076	0.075	0.073	0.072	0.070	0.069	0.068	0.065	0.064
23.5	0.062	0.079	0.077	0.075	0.073	0.072	0.070	0.069	0.067	0.066	0.065	0.064	0.061	0.060
24.0	0.059	0.074	0.072	0.071	0.069	0.067	0.066	0.065	0.063	0.062	0.061	0.060	0.058	0.057
24.5	0.055	0.070	0.068	0.067	0.065	0.064	0.062	0.061	0.060	0.059	0.058	0.057	0.055	0.054
25.0	0.052	0.066	0.064	0.063	0.062	0.060	0.059	0.058	0.057	0.055	0.054	0.053	0.052	0.051

Table 8-2: c_t values, Power Optimized Mode PO1/PO1-0S

Original Instruction: T05 0067-7063 VER 03

T05 0067-7063 Ver 03 - Approved - Exported from DMS: 2018-02-19 by FRPIC

8.3 Sound Curves, Power Optimized Mode PO1/PO1-0S

Sound Power Level at Hub Height		
Conditions for Sound Power Level:	**Measurement standard IEC 61400-11 ed. 3** **Maximum turbulence at hub height: 30%** **Inflow angle (vertical): 0 ±2°** **Air density: 1.225 kg/m³**	
Wind speed at hub height [m/s]	**Sound Power Level at Hub Height [dBA]** **Power Optimized Mode PO1** **(Blades with serrated trailing edge)**	**Sound Power Level at Hub Height [dBA]** **Power Optimized Mode PO1-0S** **(Blades without serrated trailing edge)**
3	92.2	94.5
4	92.8	95.4
5	94.0	97.1
6	97.0	100.2
7	100.0	103.1
8	102.8	105.6
9	105.1	107.7
10	106.0	108.5
11	106.0	108.5
12	106.0	108.5
13	106.0	108.5
14	106.0	108.5
15	106.0	108.5
16	106.0	108.5
17	106.0	108.5
18	106.0	108.5
19	106.0	108.5
20	106.0	108.5

Table 8-3: Sound curves, Power Optimized Mode PO1/PO1-0S

Original instruction: T05 0067-7063 VER 03

T05 0067-7063 Ver 03 - Approved - Exported from DMS: 2018-02-19 by FRFIC

9 Power Curves, Ct Values and Sound Curves, Power Optimized Mode PO1/PO1-0S (HWO)

9.1 Power Curves, Power Optimized Mode PO1/PO1-0S (HWO)

	Air density [kg/m³]													
Wind speed [m/s]	1.225	0.950	0.975	1.000	1.025	1.050	1.075	1.100	1.125	1.150	1.175	1.200	1.250	1.275
3.0	12	4	5	5	6	7	7	8	9	9	10	11	13	14
3.5	65	38	41	43	46	48	50	53	55	58	60	63	68	70
4.0	140	96	100	104	108	112	116	120	124	128	132	136	144	148
4.5	230	166	172	178	184	190	195	201	207	213	218	224	236	242
5.0	336	248	256	264	272	280	288	296	304	312	320	328	344	351
5.5	460	344	355	365	376	386	397	407	418	429	439	450	471	481
6.0	610	460	474	487	501	515	528	542	556	569	583	597	624	638
6.5	788	597	615	632	649	667	684	701	719	736	753	770	805	822
7.0	996	758	780	802	823	845	866	888	910	931	953	974	1017	1038
7.5	1236	944	971	997	1024	1050	1077	1103	1130	1157	1183	1210	1262	1289
8.0	1507	1155	1187	1219	1251	1284	1316	1348	1380	1412	1443	1475	1539	1570
8.5	1814	1394	1432	1471	1509	1548	1586	1624	1662	1700	1738	1776	1851	1889
9.0	2155	1663	1708	1753	1799	1844	1888	1933	1978	2022	2067	2111	2199	2243
9.5	2521	1956	2008	2060	2112	2165	2216	2268	2319	2370	2420	2470	2570	2619
10.0	2892	2270	2328	2387	2445	2504	2560	2617	2673	2730	2784	2838	2945	2998
10.5	3245	2589	2652	2714	2777	2840	2899	2959	3018	3077	3133	3189	3298	3352
11.0	3556	2899	2964	3029	3094	3159	3219	3278	3337	3397	3450	3503	3604	3652
11.5	3815	3191	3257	3322	3387	3453	3509	3564	3620	3676	3723	3769	3855	3895
12.0	4008	3463	3524	3586	3647	3709	3757	3805	3853	3902	3937	3973	4035	4062
12.5	4124	3702	3756	3809	3862	3916	3952	3988	4024	4060	4081	4102	4137	4151
13.0	4178	3900	3941	3981	4022	4063	4084	4105	4126	4147	4157	4167	4183	4188
13.5	4187	4033	4057	4081	4105	4129	4140	4151	4162	4172	4177	4182	4189	4192
14.0	4196	4116	4130	4143	4157	4171	4176	4181	4186	4191	4192	4194	4197	4199
14.5	4200	4162	4169	4176	4182	4189	4191	4193	4195	4198	4198	4199	4200	4200
15.0	4200	4186	4188	4192	4194	4198	4198	4199	4199	4200	4200	4200	4200	4200
15.5	4200	4194	4196	4197	4198	4199	4200	4200	4200	4200	4200	4200	4200	4200
16.0	4200	4198	4198	4199	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200
16.5	4200	4199	4199	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200
17.0	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200
17.5	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200
18.0	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200
18.5	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200
19.0	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200
19.5	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200
20.0	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200
20.5	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200
21.0	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200
21.5	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200
22.0	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200
22.5	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200
23.0	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200
23.5	4198	4198	4198	4198	4198	4198	4198	4198	4198	4198	4198	4198	4198	4198
24.0	4173	4173	4173	4173	4173	4173	4173	4173	4173	4173	4173	4173	4173	4173
24.5	4118	4118	4118	4118	4118	4118	4118	4118	4118	4118	4118	4118	4118	4118
25.0	4036	4036	4036	4036	4036	4036	4036	4036	4036	4036	4036	4035	4036	4036
25.5	3937	3937	3937	3937	3937	3937	3937	3937	3937	3937	3937	3937	3937	3937
26.0	3830	3830	3830	3830	3830	3830	3830	3830	3830	3830	3830	3830	3830	3830
26.5	3716	3716	3716	3716	3716	3716	3716	3716	3716	3716	3716	3716	3716	3716
27.0	3590	3590	3590	3590	3590	3590	3590	3590	3590	3590	3590	3590	3590	3590
27.5	3422	3422	3422	3422	3422	3422	3422	3422	3422	3422	3422	3422	3422	3422
28.0	3219	3220	3219	3219	3219	3219	3219	3219	3219	3219	3219	3219	3219	3219
28.5	2987	2987	2987	2987	2987	2987	2987	2987	2987	2987	2987	2987	2987	2987
29.0	2733	2733	2733	2733	2733	2733	2733	2733	2733	2733	2733	2733	2733	2733
29.5	2484	2484	2484	2484	2484	2484	2484	2484	2484	2484	2484	2484	2484	2484
30.0	2305	2305	2305	2305	2305	2305	2305	2305	2305	2305	2305	2305	2305	2305

Table 9-1: Power curve, Power Optimized Mode PO1/PO1-0S (HWO)

Original instruction: T05 0067-7063 VER 03

T05 0067-7063 Ver 03 – Approved – Exported from DMS: 2018-02-19 by FRPIC

9.2 Ct Values, Power Optimized Mode PO1/PO1-0S (HWO)

	Air density kg/m³													
Wind speed [m/s]	1.225	0.950	0.975	1.000	1.025	1.050	1.075	1.100	1.125	1.150	1.175	1.200	1.250	1.275
3.0	0.880	0.885	0.885	0.885	0.884	0.884	0.883	0.883	0.882	0.881	0.881	0.880	0.879	0.879
3.5	0.870	0.875	0.875	0.874	0.874	0.873	0.873	0.872	0.872	0.871	0.871	0.870	0.870	0.869
4.0	0.838	0.842	0.842	0.841	0.841	0.841	0.840	0.840	0.839	0.839	0.839	0.838	0.837	0.837
4.5	0.813	0.814	0.814	0.813	0.813	0.812	0.812	0.812	0.812	0.813	0.813	0.813	0.813	0.812
5.0	0.812	0.811	0.811	0.811	0.812	0.812	0.812	0.812	0.812	0.812	0.812	0.812	0.812	0.812
5.5	0.812	0.814	0.814	0.814	0.814	0.814	0.814	0.813	0.813	0.813	0.813	0.812	0.812	0.811
6.0	0.807	0.811	0.811	0.811	0.810	0.810	0.810	0.809	0.809	0.809	0.808	0.808	0.807	0.807
6.5	0.804	0.808	0.807	0.807	0.806	0.806	0.806	0.805	0.805	0.805	0.804	0.804	0.803	0.803
7.0	0.801	0.806	0.805	0.805	0.805	0.804	0.804	0.803	0.803	0.802	0.802	0.801	0.800	0.799
7.5	0.794	0.801	0.800	0.800	0.799	0.798	0.798	0.797	0.797	0.796	0.795	0.795	0.793	0.793
8.0	0.787	0.796	0.795	0.794	0.794	0.793	0.792	0.791	0.790	0.790	0.789	0.788	0.786	0.786
8.5	0.786	0.796	0.795	0.794	0.793	0.792	0.791	0.791	0.790	0.789	0.788	0.787	0.785	0.784
9.0	0.783	0.795	0.794	0.793	0.792	0.791	0.790	0.789	0.788	0.786	0.785	0.784	0.782	0.780
9.5	0.770	0.792	0.790	0.789	0.787	0.786	0.784	0.782	0.780	0.778	0.775	0.773	0.767	0.764
10.0	0.739	0.780	0.777	0.774	0.770	0.767	0.763	0.760	0.756	0.752	0.748	0.743	0.734	0.729
10.5	0.687	0.747	0.742	0.737	0.732	0.727	0.721	0.715	0.710	0.704	0.698	0.692	0.681	0.675
11.0	0.626	0.697	0.691	0.685	0.679	0.672	0.666	0.659	0.653	0.646	0.640	0.633	0.619	0.612
11.5	0.566	0.644	0.637	0.631	0.624	0.618	0.610	0.603	0.596	0.589	0.581	0.574	0.559	0.551
12.0	0.507	0.595	0.587	0.580	0.573	0.565	0.557	0.549	0.541	0.533	0.524	0.516	0.498	0.489
12.5	0.448	0.547	0.538	0.530	0.522	0.513	0.504	0.495	0.486	0.476	0.467	0.457	0.439	0.429
13.0	0.393	0.499	0.490	0.480	0.471	0.461	0.451	0.441	0.431	0.421	0.412	0.402	0.384	0.375
13.5	0.345	0.452	0.441	0.431	0.420	0.409	0.400	0.390	0.380	0.371	0.362	0.354	0.338	0.330
14.0	0.305	0.404	0.394	0.383	0.373	0.363	0.354	0.345	0.336	0.327	0.320	0.312	0.298	0.291
14.5	0.271	0.360	0.351	0.341	0.332	0.322	0.314	0.306	0.298	0.290	0.284	0.277	0.265	0.259
15.0	0.241	0.320	0.311	0.303	0.294	0.285	0.279	0.272	0.265	0.258	0.252	0.247	0.236	0.231
15.5	0.217	0.286	0.279	0.271	0.263	0.256	0.250	0.244	0.238	0.232	0.227	0.222	0.212	0.208
16.0	0.196	0.257	0.250	0.244	0.237	0.230	0.225	0.220	0.214	0.209	0.205	0.200	0.192	0.188
16.5	0.178	0.232	0.226	0.220	0.214	0.208	0.204	0.199	0.194	0.189	0.186	0.182	0.174	0.171
17.0	0.162	0.211	0.205	0.200	0.195	0.189	0.185	0.181	0.177	0.173	0.169	0.165	0.159	0.156
17.5	0.148	0.192	0.187	0.183	0.178	0.173	0.169	0.165	0.162	0.158	0.154	0.151	0.145	0.142
18.0	0.136	0.176	0.171	0.167	0.163	0.159	0.155	0.152	0.148	0.145	0.142	0.139	0.133	0.131
18.5	0.125	0.161	0.157	0.154	0.150	0.146	0.143	0.139	0.136	0.133	0.131	0.128	0.123	0.121
19.0	0.115	0.148	0.144	0.141	0.137	0.134	0.131	0.128	0.125	0.122	0.120	0.117	0.113	0.111
19.5	0.106	0.136	0.133	0.130	0.127	0.124	0.121	0.118	0.116	0.113	0.111	0.109	0.104	0.103
20.0	0.099	0.126	0.123	0.120	0.117	0.115	0.112	0.110	0.107	0.105	0.103	0.101	0.097	0.095
20.5	0.092	0.117	0.115	0.112	0.109	0.106	0.104	0.102	0.100	0.098	0.096	0.094	0.090	0.089
21.0	0.086	0.109	0.107	0.104	0.102	0.099	0.097	0.095	0.093	0.091	0.089	0.087	0.084	0.083
21.5	0.081	0.103	0.100	0.098	0.096	0.093	0.091	0.089	0.088	0.086	0.084	0.082	0.079	0.078
22.0	0.076	0.096	0.094	0.092	0.089	0.087	0.085	0.084	0.082	0.080	0.079	0.077	0.074	0.073
22.5	0.071	0.090	0.088	0.086	0.084	0.082	0.080	0.078	0.077	0.075	0.074	0.072	0.070	0.068
23.0	0.066	0.084	0.082	0.080	0.078	0.076	0.075	0.073	0.072	0.070	0.069	0.068	0.065	0.064
23.5	0.062	0.079	0.077	0.075	0.073	0.072	0.070	0.069	0.067	0.066	0.065	0.064	0.061	0.060
24.0	0.058	0.074	0.072	0.070	0.069	0.067	0.066	0.064	0.063	0.062	0.061	0.060	0.057	0.056
24.5	0.055	0.068	0.067	0.065	0.064	0.062	0.061	0.060	0.059	0.058	0.057	0.056	0.054	0.053
25.0	0.051	0.063	0.062	0.061	0.059	0.058	0.057	0.056	0.055	0.053	0.052	0.052	0.050	0.049
25.5	0.047	0.059	0.058	0.056	0.055	0.054	0.053	0.052	0.051	0.050	0.049	0.048	0.046	0.045
26.0	0.043	0.054	0.053	0.052	0.051	0.050	0.049	0.048	0.047	0.046	0.045	0.044	0.043	0.042
26.5	0.040	0.050	0.049	0.048	0.047	0.046	0.045	0.044	0.043	0.042	0.041	0.041	0.039	0.039
27.0	0.037	0.046	0.045	0.044	0.043	0.042	0.041	0.040	0.040	0.039	0.038	0.037	0.036	0.036
27.5	0.033	0.042	0.041	0.040	0.039	0.038	0.037	0.037	0.036	0.035	0.035	0.034	0.033	0.032
28.0	0.030	0.037	0.037	0.036	0.035	0.034	0.034	0.033	0.032	0.032	0.031	0.031	0.030	0.029
28.5	0.027	0.033	0.033	0.032	0.031	0.031	0.030	0.029	0.029	0.028	0.028	0.027	0.026	0.026
29.0	0.024	0.029	0.029	0.028	0.027	0.027	0.026	0.026	0.025	0.025	0.025	0.024	0.023	0.023
29.5	0.021	0.026	0.025	0.025	0.024	0.024	0.023	0.023	0.022	0.022	0.022	0.021	0.021	0.020
30.0	0.019	0.023	0.022	0.022	0.022	0.021	0.021	0.020	0.020	0.020	0.019	0.019	0.019	0.018

Table 9-2: c_t values, Power Optimized Mode PO1/PO1-0S (HWO)

VESTAS PROPRIETARY NOTICE

Original Instruction: T05 0067-7063 VER 03

T05 0067-7063 Ver 03 - Approved - Exported from GMS: 2018-02-19 by FRNIC

9.3 Sound Curves, Power Optimized Mode PO1/PO1-0S (HWO)

Sound Power Level at Hub Height		
Conditions for Sound Power Level:	**Measurement standard IEC 61400-11 ed. 3** **Maximum turbulence at hub height: 30%** **Inflow angle (vertical): 0 ±2°** **Air density: 1.225 kg/m³**	
Wind speed at hub height [m/s]	**Sound Power Level at Hub Height [dBA]** **Power Optimized Mode PO1 (HWO) (Blades with serrated trailing edge)**	**Sound Power Level at Hub Height [dBA]** **Power Optimized Mode PO1-0S (HWO) (Blades without serrated trailing edge)**
3	92.2	94.5
4	92.8	95.4
5	94.0	97.1
6	97.0	100.2
7	100.0	103.1
8	102.8	105.6
9	105.1	107.7
10	106.0	108.5
11	106.0	108.5
12	106.0	108.5
13	106.0	108.5
14	106.0	108.5
15	106.0	108.5
16	106.0	108.5
17	106.0	108.5
18	106.0	108.5
19	106.0	108.5
20	106.0	108.5

Table 9-3: Sound curves, Power Optimized Mode PO1/PO1-0S (HWO)

Original Instruction: T05 0067-7063 VER 03

T05 0067-7063 Ver 03 - Approved - Exported from DMS: 2018-02-19 by FRPIC

10 Power Curves, Ct Values and Sound Curves, Sound Optimized Mode SO1

10.1 Power Curves, Sound Optimized Mode SO1

	Air density [kg/m³]													
Wind speed [m/s]	1.225	0.95	0.975	1.0	1.025	1.05	1.075	1.1	1.125	1.15	1.175	1.2	1.25	1.275
3.0	12	4	5	5	6	7	7	8	9	9	10	11	13	14
3.5	65	38	41	43	46	48	50	53	55	58	60	63	68	70
4.0	140	96	100	104	108	112	116	120	124	128	132	136	144	148
4.5	230	166	172	178	184	190	195	201	207	213	218	224	236	242
5.0	336	248	256	264	272	280	288	296	304	312	320	328	344	351
5.5	460	344	355	365	376	386	397	407	418	429	439	450	471	481
6.0	610	460	474	487	501	515	528	542	556	569	583	597	624	638
6.5	788	597	615	632	649	667	684	701	719	736	753	770	805	822
7.0	996	758	780	802	823	845	866	888	910	931	953	974	1017	1038
7.5	1236	944	971	997	1024	1050	1077	1103	1130	1157	1183	1210	1262	1289
8.0	1510	1156	1188	1220	1253	1285	1317	1349	1381	1414	1446	1478	1542	1574
8.5	1815	1394	1433	1471	1510	1548	1586	1625	1663	1701	1739	1777	1853	1890
9.0	2150	1658	1703	1748	1793	1838	1883	1927	1972	2016	2061	2105	2194	2237
9.5	2501	1939	1991	2043	2095	2147	2198	2249	2300	2351	2401	2451	2550	2600
10.0	2855	2236	2294	2352	2410	2468	2525	2581	2637	2693	2747	2801	2906	2957
10.5	3184	2538	2601	2664	2727	2790	2849	2908	2966	3025	3078	3131	3231	3278
11.0	3454	2843	2908	2972	3037	3101	3156	3211	3266	3321	3365	3410	3491	3528
11.5	3680	3142	3204	3266	3327	3389	3436	3484	3532	3579	3613	3646	3705	3729
12.0	3848	3419	3473	3528	3582	3636	3673	3709	3745	3781	3804	3826	3862	3876
12.5	3949	3655	3697	3740	3782	3824	3847	3870	3893	3916	3927	3938	3955	3960
13.0	3990	3842	3868	3893	3919	3944	3954	3963	3972	3982	3984	3987	3992	3993
13.5	3996	3928	3939	3950	3962	3973	3977	3982	3986	3990	3992	3994	3996	3998
14.0	4000	3977	3981	3986	3990	3995	3996	3997	3998	3999	3999	4000	4000	4000
14.5	4000	3993	3994	3996	3997	3999	3999	3999	4000	4000	4000	4000	4000	4000
15.0	4000	3998	3999	3999	3999	4000	4000	4000	4000	4000	4000	4000	4000	4000
15.5	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
16.0	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
16.5	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
17.0	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
17.5	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
18.0	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
18.5	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
19.0	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
19.5	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
20.0	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
20.5	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
21.0	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
21.5	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
22.0	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
22.5	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
23.0	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
23.5	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
24.0	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
24.5	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
25.0	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000

Table 10-1: Power curve, Sound Optimized Mode SO1

Original Instruction: T05 0067-7063 VER 03

T05 0067-7063 Ver 03 – Approved - Exported from DMS: 2018-02-19 by FRPIC

10.2 Ct Values, Sound Optimized Mode SO1

	Air density kg/m³													
Wind speed [m/s]	1.225	0.950	0.975	1.0	1.025	1.05	1.075	1.1	1.125	1.15	1.175	1.2	1.25	1.275
3.0	0.880	0.885	0.885	0.885	0.884	0.884	0.883	0.883	0.882	0.881	0.881	0.880	0.879	0.879
3.5	0.870	0.875	0.875	0.874	0.874	0.873	0.873	0.872	0.872	0.871	0.871	0.870	0.870	0.869
4.0	0.838	0.842	0.842	0.841	0.841	0.841	0.840	0.840	0.839	0.839	0.839	0.838	0.837	0.837
4.5	0.813	0.814	0.814	0.813	0.813	0.812	0.812	0.812	0.812	0.813	0.813	0.813	0.813	0.812
5.0	0.812	0.811	0.811	0.811	0.812	0.812	0.812	0.812	0.812	0.812	0.812	0.812	0.812	0.812
5.5	0.812	0.814	0.814	0.814	0.814	0.814	0.814	0.813	0.813	0.813	0.813	0.812	0.812	0.811
6.0	0.807	0.811	0.811	0.811	0.810	0.810	0.810	0.809	0.809	0.809	0.808	0.808	0.807	0.807
6.5	0.804	0.808	0.807	0.807	0.806	0.806	0.806	0.805	0.805	0.805	0.804	0.804	0.803	0.803
7.0	0.801	0.806	0.805	0.805	0.805	0.804	0.804	0.803	0.803	0.802	0.802	0.801	0.800	0.799
7.5	0.794	0.801	0.800	0.800	0.799	0.798	0.798	0.797	0.797	0.796	0.795	0.795	0.793	0.793
8.0	0.794	0.803	0.802	0.801	0.800	0.800	0.799	0.798	0.798	0.797	0.796	0.795	0.794	0.793
8.5	0.791	0.800	0.800	0.799	0.798	0.797	0.796	0.796	0.795	0.794	0.793	0.792	0.790	0.789
9.0	0.789	0.799	0.798	0.797	0.796	0.796	0.795	0.794	0.793	0.792	0.791	0.790	0.787	0.786
9.5	0.769	0.787	0.786	0.785	0.784	0.783	0.781	0.780	0.778	0.776	0.774	0.772	0.767	0.764
10.0	0.728	0.761	0.759	0.757	0.755	0.752	0.749	0.746	0.743	0.740	0.736	0.732	0.724	0.719
10.5	0.670	0.722	0.718	0.714	0.711	0.707	0.702	0.698	0.693	0.688	0.682	0.676	0.663	0.657
11.0	0.604	0.677	0.672	0.666	0.661	0.656	0.649	0.642	0.635	0.629	0.620	0.612	0.595	0.586
11.5	0.541	0.632	0.625	0.618	0.611	0.604	0.596	0.587	0.579	0.570	0.561	0.551	0.531	0.521
12.0	0.481	0.586	0.577	0.569	0.561	0.552	0.542	0.532	0.522	0.512	0.502	0.492	0.471	0.461
12.5	0.424	0.538	0.528	0.518	0.508	0.498	0.487	0.477	0.466	0.455	0.445	0.434	0.414	0.405
13.0	0.371	0.490	0.479	0.467	0.456	0.444	0.433	0.422	0.411	0.400	0.390	0.381	0.362	0.354
13.5	0.327	0.437	0.425	0.414	0.402	0.391	0.381	0.371	0.361	0.351	0.343	0.335	0.319	0.312
14.0	0.289	0.387	0.377	0.366	0.355	0.344	0.336	0.327	0.319	0.310	0.303	0.296	0.282	0.276
14.5	0.257	0.343	0.333	0.324	0.314	0.305	0.297	0.290	0.283	0.275	0.269	0.263	0.251	0.246
15.0	0.228	0.303	0.295	0.286	0.278	0.270	0.264	0.257	0.251	0.244	0.239	0.234	0.224	0.219
15.5	0.206	0.271	0.264	0.256	0.249	0.242	0.237	0.231	0.225	0.220	0.215	0.210	0.202	0.197
16.0	0.186	0.243	0.237	0.231	0.225	0.218	0.213	0.208	0.203	0.198	0.194	0.190	0.182	0.179
16.5	0.169	0.220	0.215	0.209	0.203	0.198	0.193	0.189	0.185	0.180	0.176	0.173	0.166	0.162
17.0	0.154	0.200	0.195	0.190	0.185	0.180	0.176	0.172	0.168	0.164	0.161	0.157	0.151	0.148
17.5	0.141	0.182	0.178	0.173	0.169	0.164	0.161	0.157	0.154	0.150	0.147	0.144	0.138	0.136
18.0	0.130	0.167	0.163	0.159	0.155	0.151	0.148	0.144	0.141	0.138	0.135	0.132	0.127	0.125
18.5	0.119	0.153	0.150	0.146	0.142	0.139	0.136	0.133	0.130	0.127	0.124	0.122	0.117	0.115
19.0	0.110	0.141	0.137	0.134	0.131	0.127	0.125	0.122	0.119	0.116	0.114	0.112	0.108	0.106
19.5	0.102	0.130	0.127	0.124	0.121	0.118	0.115	0.113	0.110	0.108	0.106	0.104	0.100	0.098
20.0	0.094	0.120	0.118	0.115	0.112	0.109	0.107	0.105	0.102	0.100	0.098	0.096	0.093	0.091
20.5	0.088	0.112	0.109	0.107	0.104	0.101	0.099	0.097	0.095	0.093	0.091	0.090	0.086	0.085
21.0	0.082	0.104	0.102	0.099	0.097	0.095	0.093	0.091	0.089	0.087	0.085	0.084	0.080	0.079
21.5	0.077	0.098	0.096	0.093	0.091	0.089	0.087	0.085	0.084	0.082	0.080	0.079	0.076	0.074
22.0	0.072	0.091	0.089	0.087	0.085	0.083	0.082	0.080	0.078	0.077	0.075	0.074	0.071	0.070
22.5	0.068	0.086	0.084	0.082	0.080	0.078	0.076	0.075	0.073	0.072	0.070	0.069	0.067	0.065
23.0	0.063	0.080	0.078	0.076	0.075	0.073	0.071	0.070	0.068	0.067	0.066	0.065	0.062	0.061
23.5	0.060	0.075	0.073	0.072	0.070	0.068	0.067	0.066	0.064	0.063	0.062	0.061	0.059	0.058
24.0	0.056	0.071	0.069	0.068	0.066	0.064	0.063	0.062	0.061	0.059	0.058	0.057	0.055	0.054
24.5	0.053	0.067	0.065	0.064	0.062	0.061	0.060	0.058	0.057	0.056	0.055	0.054	0.052	0.051
25.0	0.050	0.063	0.061	0.060	0.059	0.057	0.056	0.055	0.054	0.053	0.052	0.051	0.049	0.049

Table 10-2: C_t values, Sound Optimized Mode SO1

Original Instruction: T05 0067-7063 VER 03

T05 0067-7063 Ver 03 – Approved – Exported from DMS: 2018-02-19 by EPMC

10.3 Sound Curves, Sound Optimized Mode SO1

Sound Power Level at Hub Height	
Conditions for Sound Power Level:	**Measurement standard IEC 61400-11 ed. 3** **Maximum turbulence at hub height: 30%** **Inflow angle (vertical): 0 ±2°** **Air density: 1.225 kg/m³**
Wind speed at hub height [m/s]	**Sound Power Level at Hub Height [dBA]** **Sound Optimized Mode SO1 (Blades with serrated trailing edge)**
3	92.2
4	92.8
5	94.0
6	97.0
7	100.0
8	102.7
9	104.2
10	105.0
11	105.0
12	105.0
13	105.0
14	105.0
15	105.0
16	105.0
17	105.0
18	105.0
19	105.0
20	105.0

Table 10-3: Sound curves, Sound Optimized Mode SO1

Original Instruction: T05 0067-7063 VER 03

T05 0067-7063 Ver 03 - Approved - Exported from DMS: 2018-02-19 by FRPIC

11 Power Curves, Ct Values and Sound Curves, SO1 (HWO)

11.1 Power Curves, SO1 (HWO)

Wind speed [m/s]	Air density [kg/m³]													
	1.225	0.950	0.975	1.000	1.025	1.050	1.075	1.100	1.125	1.150	1.175	1.200	1.250	1.275
3.0	12	4	5	5	6	7	7	8	9	9	10	11	13	14
3.5	65	38	41	43	46	48	50	53	55	58	60	63	68	70
4.0	140	96	100	104	108	112	116	120	124	128	132	136	144	148
4.5	230	166	172	178	184	190	195	201	207	213	218	224	236	242
5.0	336	248	256	264	272	280	288	296	304	312	320	328	344	351
5.5	460	344	355	365	376	386	397	407	418	429	439	450	471	481
6.0	610	460	474	487	501	515	528	542	556	569	583	597	624	638
6.5	788	597	615	632	649	667	684	701	719	736	753	770	805	822
7.0	996	756	780	802	823	845	866	888	910	931	953	974	1017	1038
7.5	1236	944	971	997	1024	1050	1077	1103	1130	1157	1183	1210	1262	1289
8.0	1510	1156	1188	1220	1253	1285	1317	1349	1381	1414	1446	1478	1542	1574
8.5	1815	1394	1433	1471	1510	1548	1586	1625	1663	1701	1739	1777	1853	1890
9.0	2150	1658	1703	1748	1793	1838	1883	1927	1972	2016	2061	2105	2194	2237
9.5	2501	1939	1991	2043	2095	2147	2198	2249	2300	2351	2401	2451	2550	2600
10.0	2855	2236	2294	2352	2410	2468	2525	2581	2637	2693	2747	2801	2906	2957
10.5	3184	2538	2601	2664	2727	2790	2849	2908	2966	3025	3078	3131	3231	3278
11.0	3454	2843	2908	2972	3037	3101	3156	3211	3266	3321	3365	3410	3491	3528
11.5	3680	3142	3204	3266	3327	3389	3436	3484	3532	3579	3613	3646	3705	3729
12.0	3848	3419	3473	3528	3582	3636	3673	3709	3745	3781	3804	3826	3862	3876
12.5	3949	3655	3697	3740	3782	3824	3847	3870	3893	3916	3927	3938	3955	3960
13.0	3990	3842	3868	3893	3919	3944	3954	3963	3972	3982	3984	3987	3992	3993
13.5	3996	3928	3939	3950	3962	3973	3977	3982	3986	3990	3992	3994	3996	3998
14.0	4000	3977	3981	3986	3990	3995	3996	3997	3998	3999	3999	4000	4000	4000
14.5	4000	3993	3994	3996	3997	3999	3999	3999	4000	4000	4000	4000	4000	4000
15.0	4000	3998	3999	3999	3999	4000	4000	4000	4000	4000	4000	4000	4000	4000
15.5	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
16.0	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
16.5	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
17.0	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
17.5	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
18.0	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
18.5	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
19.0	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
19.5	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
20.0	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
20.5	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
21.0	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
21.5	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
22.0	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
22.5	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
23.0	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
23.5	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
24.0	3999	3999	3999	3999	3999	3999	3999	3999	3999	3999	3999	3999	3999	3999
24.5	3989	3989	3989	3989	3989	3989	3989	3989	3989	3989	3989	3989	3989	3989
25.0	3961	3961	3961	3961	3961	3961	3961	3961	3961	3961	3961	3961	3961	3961
25.5	3904	3904	3904	3904	3904	3904	3904	3904	3904	3904	3904	3904	3904	3904
26.0	3823	3823	3823	3823	3823	3823	3823	3823	3823	3823	3823	3823	3823	3823
26.5	3715	3715	3715	3715	3715	3715	3715	3715	3715	3715	3715	3715	3715	3715
27.0	3590	3590	3590	3590	3590	3590	3590	3590	3590	3590	3590	3590	3590	3590
27.5	3422	3422	3422	3422	3422	3422	3422	3422	3422	3422	3422	3422	3422	3422
28.0	3220	3219	3219	3219	3219	3219	3219	3220	3220	3220	3220	3220	3220	3220
28.5	2987	2987	2987	2987	2987	2987	2987	2987	2987	2987	2987	2987	2987	2987
29.0	2733	2733	2733	2733	2733	2733	2733	2733	2733	2733	2733	2733	2733	2733
29.5	2484	2484	2484	2484	2484	2484	2484	2484	2484	2484	2484	2484	2484	2484
30.0	2305	2305	2305	2305	2305	2305	2305	2305	2305	2305	2305	2305	2305	2305

Table 11-1: Power curve, SO1 (HWO)

VESTAS PROPRIETARY NOTICE

Original Instruction: T05 0067-7063 VER 03

T05 0067-7063 Ver 03 – Approved - Exported from DMS: 2018-02-19 by FRPIC

11.2 Ct Values, SO1 (HWO)

	Air density kg/m³													
Wind speed [m/s]	1.225	0.950	0.975	1.000	1.025	1.050	1.075	1.100	1.125	1.150	1.175	1.200	1.250	1.275
3.0	0.880	0.885	0.885	0.885	0.884	0.884	0.883	0.883	0.882	0.881	0.881	0.880	0.879	0.879
3.5	0.870	0.875	0.875	0.874	0.874	0.873	0.873	0.872	0.872	0.871	0.871	0.870	0.870	0.869
4.0	0.838	0.842	0.842	0.841	0.841	0.841	0.840	0.840	0.839	0.839	0.839	0.838	0.837	0.837
4.5	0.813	0.814	0.814	0.813	0.813	0.812	0.812	0.812	0.812	0.813	0.813	0.813	0.813	0.812
5.0	0.812	0.811	0.811	0.811	0.812	0.812	0.812	0.812	0.812	0.812	0.812	0.812	0.812	0.812
5.5	0.812	0.814	0.814	0.814	0.814	0.814	0.814	0.813	0.813	0.813	0.813	0.812	0.812	0.811
6.0	0.807	0.811	0.811	0.811	0.810	0.810	0.810	0.809	0.809	0.809	0.808	0.808	0.807	0.807
6.5	0.804	0.808	0.807	0.807	0.806	0.806	0.806	0.805	0.805	0.805	0.804	0.804	0.803	0.803
7.0	0.801	0.806	0.805	0.805	0.805	0.804	0.804	0.803	0.803	0.802	0.802	0.801	0.800	0.799
7.5	0.794	0.801	0.800	0.800	0.799	0.798	0.798	0.797	0.797	0.796	0.795	0.795	0.793	0.793
8.0	0.794	0.803	0.802	0.801	0.800	0.800	0.799	0.798	0.798	0.797	0.796	0.795	0.794	0.793
8.5	0.791	0.800	0.800	0.799	0.798	0.797	0.796	0.796	0.795	0.794	0.793	0.792	0.790	0.789
9.0	0.789	0.799	0.798	0.797	0.796	0.796	0.795	0.794	0.793	0.792	0.791	0.790	0.787	0.786
9.5	0.769	0.787	0.786	0.785	0.784	0.783	0.781	0.780	0.778	0.776	0.774	0.772	0.767	0.764
10.0	0.728	0.761	0.759	0.757	0.755	0.752	0.749	0.746	0.743	0.740	0.736	0.732	0.724	0.719
10.5	0.670	0.722	0.718	0.714	0.711	0.707	0.702	0.698	0.693	0.688	0.682	0.676	0.663	0.657
11.0	0.604	0.677	0.672	0.666	0.661	0.656	0.649	0.642	0.635	0.629	0.620	0.612	0.595	0.586
11.5	0.541	0.632	0.625	0.618	0.611	0.604	0.596	0.587	0.579	0.570	0.561	0.551	0.531	0.521
12.0	0.481	0.588	0.577	0.569	0.561	0.552	0.542	0.532	0.522	0.512	0.502	0.492	0.471	0.461
12.5	0.424	0.538	0.528	0.518	0.508	0.498	0.487	0.477	0.466	0.455	0.445	0.434	0.414	0.405
13.0	0.371	0.490	0.479	0.467	0.456	0.444	0.433	0.422	0.411	0.400	0.390	0.381	0.362	0.354
13.5	0.327	0.437	0.425	0.414	0.402	0.391	0.381	0.371	0.361	0.351	0.343	0.335	0.319	0.312
14.0	0.289	0.387	0.377	0.366	0.355	0.344	0.336	0.327	0.319	0.310	0.303	0.296	0.282	0.276
14.5	0.257	0.343	0.333	0.324	0.314	0.305	0.297	0.290	0.283	0.275	0.269	0.263	0.251	0.246
15.0	0.228	0.303	0.295	0.286	0.278	0.270	0.264	0.257	0.251	0.244	0.239	0.234	0.224	0.219
15.5	0.206	0.271	0.264	0.256	0.249	0.242	0.237	0.231	0.225	0.220	0.215	0.210	0.202	0.197
16.0	0.186	0.243	0.237	0.231	0.225	0.218	0.213	0.208	0.203	0.198	0.194	0.190	0.182	0.179
16.5	0.169	0.220	0.215	0.209	0.203	0.198	0.193	0.189	0.185	0.180	0.176	0.173	0.166	0.162
17.0	0.154	0.200	0.195	0.190	0.185	0.180	0.176	0.172	0.168	0.164	0.161	0.157	0.151	0.148
17.5	0.141	0.182	0.178	0.173	0.169	0.164	0.161	0.157	0.154	0.150	0.147	0.144	0.138	0.136
18.0	0.130	0.167	0.163	0.159	0.155	0.151	0.148	0.144	0.141	0.138	0.135	0.132	0.127	0.125
18.5	0.119	0.153	0.150	0.146	0.142	0.139	0.136	0.133	0.130	0.127	0.124	0.122	0.117	0.115
19.0	0.110	0.141	0.137	0.134	0.131	0.127	0.125	0.122	0.119	0.116	0.114	0.112	0.108	0.106
19.5	0.102	0.130	0.127	0.124	0.121	0.118	0.115	0.113	0.110	0.108	0.106	0.104	0.100	0.098
20.0	0.094	0.120	0.118	0.115	0.112	0.109	0.107	0.105	0.102	0.100	0.098	0.096	0.093	0.091
20.5	0.088	0.112	0.109	0.107	0.104	0.101	0.099	0.097	0.095	0.093	0.091	0.090	0.086	0.085
21.0	0.082	0.104	0.102	0.099	0.097	0.095	0.093	0.091	0.089	0.087	0.085	0.084	0.080	0.079
21.5	0.077	0.098	0.096	0.093	0.091	0.089	0.087	0.085	0.084	0.082	0.080	0.079	0.076	0.074
22.0	0.072	0.091	0.089	0.087	0.085	0.083	0.082	0.080	0.078	0.077	0.075	0.074	0.071	0.070
22.5	0.068	0.086	0.084	0.082	0.080	0.078	0.076	0.075	0.073	0.072	0.070	0.069	0.067	0.065
23.0	0.063	0.080	0.078	0.076	0.075	0.073	0.071	0.070	0.068	0.067	0.066	0.065	0.062	0.061
23.5	0.060	0.075	0.073	0.072	0.070	0.068	0.067	0.066	0.064	0.063	0.062	0.061	0.059	0.058
24.0	0.056	0.071	0.069	0.068	0.066	0.064	0.063	0.062	0.061	0.059	0.058	0.057	0.055	0.054
24.5	0.053	0.068	0.065	0.064	0.062	0.061	0.059	0.058	0.057	0.056	0.055	0.054	0.052	0.051
25.0	0.050	0.062	0.061	0.060	0.058	0.057	0.056	0.055	0.054	0.052	0.052	0.051	0.049	0.048
25.5	0.047	0.058	0.057	0.056	0.055	0.053	0.052	0.051	0.050	0.049	0.048	0.048	0.046	0.045
26.0	0.043	0.054	0.053	0.052	0.051	0.049	0.049	0.048	0.047	0.046	0.045	0.044	0.043	0.042
26.5	0.040	0.050	0.049	0.048	0.047	0.046	0.045	0.044	0.043	0.042	0.041	0.041	0.039	0.039
27.0	0.037	0.046	0.045	0.044	0.043	0.042	0.041	0.040	0.040	0.039	0.038	0.037	0.036	0.036
27.5	0.033	0.042	0.041	0.040	0.039	0.038	0.037	0.037	0.036	0.035	0.035	0.034	0.033	0.032
28.0	0.030	0.037	0.037	0.036	0.035	0.034	0.034	0.033	0.032	0.032	0.031	0.031	0.030	0.029
28.5	0.027	0.033	0.033	0.032	0.031	0.031	0.030	0.029	0.029	0.028	0.028	0.027	0.026	0.026
29.0	0.024	0.029	0.029	0.028	0.027	0.027	0.026	0.026	0.025	0.025	0.025	0.024	0.023	0.023
29.5	0.021	0.026	0.025	0.025	0.024	0.024	0.023	0.023	0.022	0.022	0.022	0.021	0.021	0.020
30.0	0.019	0.023	0.023	0.022	0.022	0.021	0.021	0.020	0.020	0.020	0.019	0.019	0.019	0.018

Table 11-2: C_t values, SO1 (HWO)

Original Instruction: T05 0067-7063 VER 03

T05 0067-7063 Ver 03 – Approved - Exported from DMS: 2018-02-19 by FRPIC

11.3 Sound Curves, SO1 (HWO)

Sound Power Level at Hub Height	
Conditions for Sound Power Level:	**Measurement standard IEC 61400-11 ed. 3** **Maximum turbulence at hub height: 30%** **Inflow angle (vertical): 0 ±2°** **Air density: 1.225 kg/m³**
Wind speed at hub height [m/s]	**Sound Power Level at Hub Height [dBA]** **SO1 (HWO) (Blades with serrated trailing edge)**
3	92.2
4	92.8
5	94.0
6	97.0
7	100.0
8	102.7
9	104.2
10	105.0
11	105.0
12	105.0
13	105.0
14	105.0
15	105.0
16	105.0
17	105.0
18	105.0
19	105.0
20	105.0

Table 11-3: Sound curves, SO1 (HWO)

Original Instruction: T05 0067-7063 VER 03

T05 0067-7063 Ver 03 - Approved - Exported from DMS: 2018-02-19 by FNRIC

12 Power Curves, Ct Values and Sound Curves, Sound Optimized Mode SO2

12.1 Power Curves, Sound Optimized Mode SO2

	Air density [kg/m³]													
Wind speed [m/s]	1.225	0.95	0.975	1.0	1.025	1.05	1.075	1.1	1.125	1.15	1.175	1.2	1.25	1.275
3.0	12	4	5	5	6	7	7	8	9	9	10	11	13	14
3.5	65	38	41	43	46	48	50	53	55	58	60	63	68	70
4.0	140	96	100	104	108	112	116	120	124	128	132	136	144	148
4.5	230	166	172	178	184	190	195	201	207	213	218	224	236	242
5.0	336	248	256	264	272	280	288	296	304	312	320	328	344	351
5.5	460	344	355	365	376	386	397	407	418	429	439	450	471	481
6.0	610	460	474	487	501	515	528	542	556	569	583	597	624	638
6.5	788	597	615	632	649	667	684	701	719	736	753	771	805	822
7.0	997	759	781	803	824	846	868	889	911	933	954	976	1019	1041
7.5	1235	943	970	997	1023	1050	1076	1103	1129	1156	1182	1209	1261	1288
8.0	1501	1151	1183	1215	1247	1279	1310	1342	1374	1406	1438	1469	1533	1564
8.5	1781	1371	1409	1446	1484	1521	1558	1595	1633	1670	1707	1744	1818	1854
9.0	2051	1588	1630	1673	1715	1758	1800	1842	1884	1926	1968	2010	2092	2134
9.5	2310	1796	1844	1891	1938	1986	2032	2079	2126	2172	2218	2264	2356	2402
10.0	2557	1994	2046	2098	2150	2202	2253	2304	2355	2406	2456	2507	2606	2654
10.5	2792	2189	2246	2302	2358	2415	2470	2525	2580	2636	2688	2740	2842	2892
11.0	3012	2406	2465	2525	2585	2644	2699	2754	2809	2864	2913	2963	3055	3097
11.5	3226	2650	2711	2771	2832	2892	2944	2996	3048	3100	3142	3184	3260	3295
12.0	3423	2940	2996	3052	3108	3164	3206	3247	3289	3330	3361	3392	3446	3468
12.5	3586	3258	3302	3346	3390	3434	3460	3486	3513	3539	3555	3570	3596	3606
13.0	3693	3518	3545	3572	3600	3627	3639	3652	3664	3676	3682	3688	3696	3699
13.5	3763	3674	3689	3703	3717	3732	3737	3743	3748	3754	3757	3760	3764	3766
14.0	3820	3781	3788	3795	3802	3809	3811	3814	3816	3818	3819	3820	3821	3821
14.5	3856	3841	3844	3847	3850	3854	3854	3854	3855	3855	3855	3855	3856	3856
15.0	3884	3878	3880	3881	3882	3883	3883	3884	3884	3884	3884	3884	3884	3884
15.5	3908	3906	3906	3907	3907	3908	3908	3908	3908	3908	3908	3908	3908	3908
16.0	3932	3931	3931	3932	3932	3932	3932	3932	3932	3932	3932	3932	3932	3932
16.5	3955	3955	3955	3955	3955	3955	3955	3955	3955	3955	3955	3955	3955	3955
17.0	3974	3974	3974	3974	3974	3974	3974	3974	3974	3974	3974	3974	3974	3974
17.5	3991	3991	3991	3991	3991	3991	3991	3991	3991	3991	3991	3991	3991	3991
18.0	3997	3997	3997	3997	3997	3997	3997	3997	3997	3997	3997	3997	3997	3997
18.5	3999	3999	3999	3999	3999	3999	3999	3999	3999	3999	3999	3999	3999	3999
19.0	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
19.5	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
20.0	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
20.5	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
21.0	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
21.5	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
22.0	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
22.5	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
23.0	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
23.5	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
24.0	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
24.5	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
25.0	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000

Table 12-1: Power curve, Sound Optimized Mode SO2

VESTAS PROPRIETARY NOTICE

Original Instruction: T05 0067-7063 VER 03

T05 0067-7063 Ver 03 - Approved - Exported from DMS: 2018-02-19 by FRPIC

12.2 Ct Values, Sound Optimized Mode SO2

	Air density kg/m³													
Wind speed [m/s]	1.225	0.950	0.975	1.0	1.025	1.05	1.075	1.1	1.125	1.15	1.175	1.2	1.25	1.275
3.0	0.886	0.885	0.885	0.885	0.884	0.884	0.883	0.883	0.882	0.881	0.881	0.880	0.879	0.879
3.5	0.876	0.875	0.875	0.874	0.874	0.873	0.873	0.872	0.872	0.871	0.871	0.870	0.870	0.869
4.0	0.842	0.842	0.842	0.841	0.841	0.841	0.840	0.840	0.839	0.839	0.839	0.838	0.837	0.837
4.5	0.814	0.814	0.814	0.813	0.813	0.812	0.812	0.812	0.812	0.813	0.813	0.813	0.813	0.812
5.0	0.812	0.811	0.811	0.811	0.812	0.812	0.812	0.812	0.812	0.812	0.812	0.812	0.812	0.812
5.5	0.812	0.814	0.814	0.814	0.814	0.814	0.814	0.813	0.813	0.813	0.813	0.812	0.812	0.811
6.0	0.807	0.811	0.811	0.811	0.810	0.810	0.810	0.809	0.809	0.809	0.806	0.808	0.807	0.807
6.5	0.806	0.810	0.810	0.810	0.809	0.809	0.809	0.808	0.808	0.808	0.807	0.807	0.806	0.806
7.0	0.804	0.810	0.809	0.809	0.808	0.808	0.807	0.807	0.806	0.806	0.805	0.805	0.804	0.803
7.5	0.801	0.808	0.807	0.807	0.806	0.806	0.805	0.804	0.804	0.803	0.803	0.802	0.801	0.800
8.0	0.792	0.799	0.798	0.798	0.797	0.797	0.796	0.795	0.795	0.794	0.793	0.793	0.791	0.791
8.5	0.751	0.759	0.758	0.757	0.757	0.756	0.755	0.755	0.754	0.753	0.753	0.752	0.751	0.750
9.0	0.688	0.695	0.695	0.694	0.693	0.693	0.692	0.692	0.691	0.690	0.690	0.689	0.688	0.687
9.5	0.627	0.634	0.633	0.633	0.632	0.631	0.631	0.630	0.630	0.629	0.628	0.628	0.626	0.626
10.0	0.574	0.580	0.580	0.579	0.579	0.578	0.577	0.577	0.576	0.576	0.575	0.575	0.573	0.572
10.5	0.526	0.534	0.534	0.533	0.533	0.532	0.532	0.531	0.530	0.530	0.529	0.528	0.525	0.523
11.0	0.482	0.500	0.499	0.498	0.497	0.496	0.494	0.493	0.491	0.489	0.487	0.484	0.479	0.475
11.5	0.444	0.476	0.474	0.472	0.470	0.468	0.465	0.462	0.459	0.456	0.452	0.448	0.439	0.434
12.0	0.409	0.465	0.461	0.457	0.453	0.448	0.443	0.438	0.432	0.427	0.421	0.415	0.402	0.396
12.5	0.374	0.458	0.451	0.444	0.437	0.430	0.422	0.414	0.406	0.398	0.390	0.382	0.366	0.359
13.0	0.337	0.438	0.428	0.418	0.409	0.399	0.390	0.381	0.371	0.362	0.354	0.345	0.330	0.322
13.5	0.303	0.402	0.392	0.381	0.371	0.361	0.352	0.343	0.334	0.326	0.318	0.311	0.297	0.290
14.0	0.273	0.364	0.354	0.345	0.335	0.325	0.317	0.309	0.301	0.293	0.286	0.280	0.267	0.261
14.5	0.246	0.327	0.318	0.310	0.301	0.292	0.285	0.278	0.270	0.263	0.257	0.252	0.240	0.235
15.0	0.221	0.292	0.284	0.277	0.269	0.261	0.255	0.249	0.242	0.236	0.231	0.226	0.216	0.212
15.5	0.200	0.263	0.256	0.250	0.243	0.236	0.230	0.225	0.219	0.214	0.209	0.205	0.196	0.192
16.0	0.182	0.239	0.232	0.226	0.220	0.214	0.209	0.204	0.199	0.195	0.191	0.186	0.179	0.175
16.5	0.167	0.217	0.212	0.206	0.201	0.195	0.191	0.186	0.182	0.178	0.174	0.170	0.163	0.160
17.0	0.153	0.198	0.194	0.189	0.184	0.179	0.175	0.171	0.167	0.163	0.160	0.156	0.150	0.147
17.5	0.141	0.182	0.177	0.173	0.168	0.164	0.160	0.157	0.153	0.150	0.147	0.144	0.138	0.135
18.0	0.129	0.167	0.163	0.159	0.155	0.151	0.147	0.144	0.141	0.138	0.135	0.132	0.127	0.125
18.5	0.119	0.153	0.150	0.146	0.142	0.139	0.136	0.133	0.130	0.127	0.124	0.122	0.117	0.115
19.0	0.110	0.141	0.137	0.134	0.131	0.127	0.125	0.122	0.119	0.116	0.114	0.112	0.108	0.106
19.5	0.102	0.130	0.127	0.124	0.121	0.118	0.115	0.113	0.110	0.108	0.106	0.104	0.100	0.098
20.0	0.094	0.120	0.118	0.115	0.112	0.109	0.107	0.105	0.102	0.100	0.098	0.096	0.093	0.091
20.5	0.088	0.112	0.109	0.107	0.104	0.101	0.099	0.097	0.095	0.093	0.091	0.090	0.086	0.085
21.0	0.082	0.104	0.102	0.099	0.097	0.095	0.093	0.091	0.089	0.087	0.085	0.084	0.080	0.079
21.5	0.077	0.098	0.096	0.093	0.091	0.089	0.087	0.085	0.084	0.082	0.080	0.079	0.076	0.074
22.0	0.072	0.091	0.089	0.087	0.085	0.083	0.082	0.080	0.078	0.077	0.075	0.074	0.071	0.070
22.5	0.068	0.086	0.084	0.082	0.080	0.078	0.076	0.075	0.073	0.072	0.070	0.069	0.067	0.065
23.0	0.063	0.080	0.078	0.076	0.075	0.073	0.071	0.070	0.068	0.067	0.066	0.065	0.062	0.061
23.5	0.060	0.075	0.073	0.072	0.070	0.068	0.067	0.066	0.064	0.063	0.062	0.061	0.059	0.058
24.0	0.056	0.071	0.069	0.068	0.066	0.064	0.063	0.062	0.061	0.059	0.058	0.057	0.055	0.054
24.5	0.053	0.067	0.065	0.064	0.062	0.061	0.060	0.058	0.057	0.056	0.055	0.054	0.052	0.051
25.0	0.050	0.063	0.061	0.060	0.059	0.057	0.056	0.055	0.054	0.053	0.052	0.051	0.049	0.049

Table 12-2: C_t values, Sound Optimized Mode SO2

Original Instruction: T05 0067-7063 VER 03

T05 0067-7063 Ver 03 - Approved - Exported from DMS: 2018-02-19 by FRPIC

13.3 Sound Curves, SO2 (HWO)

Sound Power Level at Hub Height	
Conditions for Sound Power Level:	**Measurement standard IEC 61400-11 ed. 3** **Maximum turbulence at hub height: 30%** **Inflow angle (vertical): 0 ±2°** **Air density: 1.225 kg/m³**
Wind speed at hub height [m/s]	**Sound Power Level at Hub Height [dBA]** **SO2 (HWO) (Blades with serrated trailing edge)**
3	92.2
4	92.8
5	94.0
6	97.0
7	99.9
8	101.6
9	102.3
10	102.3
11	102.4
12	102.7
13	103.0
14	103.0
15	103.0
16	103.0
17	103.0
18	103.0
19	103.0
20	103.0

Table 13-3: Sound curves, SO2 (HWO)

Original Instruction: T05 0067-7063 VER 03

T05 0067-7063 Ver 03 - Approved - Exported from DMS: 2018.02.19 by FRPIC

14.2 Ct Values, Sound Optimized Mode SO3

	Air density kg/m³													
Wind speed [m/s]	1.225	0.950	0.975	1.0	1.025	1.05	1.075	1.1	1.125	1.15	1.175	1.2	1.25	1.275
3.0	0.880	0.885	0.885	0.885	0.884	0.884	0.883	0.883	0.882	0.881	0.881	0.880	0.879	0.879
3.5	0.870	0.875	0.875	0.874	0.874	0.873	0.873	0.872	0.872	0.871	0.871	0.870	0.870	0.869
4.0	0.838	0.842	0.842	0.841	0.841	0.841	0.840	0.840	0.839	0.839	0.839	0.838	0.837	0.837
4.5	0.813	0.814	0.814	0.813	0.813	0.812	0.812	0.812	0.812	0.813	0.813	0.813	0.813	0.812
5.0	0.812	0.811	0.811	0.811	0.812	0.812	0.812	0.812	0.812	0.812	0.812	0.812	0.812	0.812
5.5	0.812	0.814	0.814	0.814	0.814	0.814	0.814	0.813	0.813	0.813	0.813	0.812	0.812	0.811
6.0	0.807	0.811	0.811	0.811	0.810	0.810	0.810	0.809	0.809	0.809	0.808	0.808	0.807	0.807
6.5	0.807	0.811	0.811	0.810	0.810	0.810	0.809	0.809	0.808	0.808	0.808	0.807	0.806	0.806
7.0	0.805	0.810	0.810	0.809	0.809	0.808	0.808	0.807	0.807	0.806	0.806	0.805	0.804	0.804
7.5	0.793	0.799	0.798	0.798	0.797	0.797	0.796	0.796	0.795	0.794	0.794	0.793	0.792	0.791
8.0	0.746	0.752	0.751	0.751	0.750	0.750	0.749	0.749	0.748	0.748	0.747	0.746	0.745	0.745
8.5	0.674	0.680	0.679	0.679	0.678	0.678	0.677	0.677	0.676	0.676	0.675	0.675	0.674	0.673
9.0	0.604	0.609	0.609	0.608	0.608	0.607	0.607	0.606	0.606	0.605	0.605	0.604	0.603	0.603
9.5	0.545	0.550	0.549	0.549	0.548	0.548	0.547	0.547	0.546	0.546	0.546	0.545	0.544	0.544
10.0	0.495	0.500	0.499	0.499	0.498	0.498	0.497	0.497	0.497	0.496	0.496	0.495	0.494	0.493
10.5	0.452	0.457	0.457	0.457	0.456	0.456	0.455	0.455	0.455	0.454	0.453	0.453	0.450	0.449
11.0	0.411	0.424	0.424	0.423	0.422	0.422	0.420	0.419	0.418	0.417	0.415	0.413	0.408	0.405
11.5	0.375	0.399	0.398	0.397	0.396	0.394	0.392	0.390	0.387	0.385	0.382	0.379	0.371	0.367
12.0	0.344	0.388	0.385	0.381	0.378	0.375	0.371	0.366	0.362	0.358	0.353	0.348	0.338	0.333
12.5	0.315	0.383	0.377	0.371	0.365	0.359	0.353	0.346	0.340	0.334	0.327	0.321	0.309	0.302
13.0	0.285	0.360	0.361	0.353	0.344	0.336	0.328	0.321	0.313	0.305	0.299	0.292	0.279	0.273
13.5	0.259	0.342	0.333	0.324	0.315	0.307	0.299	0.292	0.285	0.277	0.271	0.265	0.253	0.248
14.0	0.236	0.314	0.306	0.297	0.289	0.281	0.274	0.267	0.260	0.253	0.248	0.242	0.231	0.226
14.5	0.216	0.287	0.279	0.271	0.264	0.256	0.250	0.244	0.237	0.231	0.226	0.221	0.212	0.207
15.0	0.197	0.260	0.253	0.246	0.239	0.232	0.227	0.221	0.216	0.210	0.206	0.201	0.193	0.189
15.5	0.180	0.237	0.231	0.224	0.218	0.212	0.207	0.202	0.197	0.192	0.188	0.184	0.177	0.173
16.0	0.165	0.216	0.211	0.205	0.200	0.194	0.190	0.185	0.181	0.176	0.173	0.169	0.162	0.159
16.5	0.152	0.198	0.193	0.188	0.183	0.178	0.174	0.170	0.166	0.162	0.159	0.155	0.149	0.146
17.0	0.140	0.182	0.177	0.173	0.168	0.164	0.160	0.157	0.153	0.149	0.146	0.143	0.138	0.135
17.5	0.130	0.168	0.163	0.159	0.155	0.151	0.148	0.145	0.141	0.138	0.135	0.132	0.127	0.125
18.0	0.120	0.155	0.151	0.148	0.144	0.140	0.137	0.134	0.131	0.128	0.125	0.123	0.118	0.116
18.5	0.112	0.144	0.140	0.137	0.134	0.130	0.127	0.125	0.122	0.119	0.117	0.114	0.110	0.108
19.0	0.104	0.133	0.130	0.127	0.123	0.120	0.118	0.115	0.113	0.110	0.108	0.106	0.102	0.100
19.5	0.097	0.123	0.121	0.118	0.115	0.112	0.110	0.107	0.105	0.103	0.101	0.099	0.095	0.093
20.0	0.090	0.115	0.112	0.110	0.107	0.104	0.102	0.100	0.098	0.096	0.094	0.092	0.089	0.087
20.5	0.084	0.107	0.105	0.103	0.100	0.098	0.096	0.094	0.092	0.090	0.088	0.086	0.083	0.081
21.0	0.079	0.101	0.098	0.096	0.094	0.091	0.090	0.088	0.086	0.084	0.082	0.081	0.078	0.076
21.5	0.075	0.095	0.093	0.091	0.089	0.086	0.085	0.083	0.081	0.079	0.078	0.076	0.074	0.072
22.0	0.071	0.089	0.087	0.085	0.083	0.081	0.080	0.078	0.076	0.075	0.073	0.072	0.069	0.068
22.5	0.066	0.084	0.082	0.080	0.078	0.076	0.075	0.073	0.072	0.070	0.069	0.068	0.065	0.064
23.0	0.062	0.078	0.077	0.075	0.073	0.072	0.070	0.069	0.067	0.066	0.065	0.064	0.061	0.060
23.5	0.059	0.074	0.072	0.071	0.069	0.068	0.066	0.065	0.064	0.062	0.061	0.060	0.058	0.057
24.0	0.056	0.070	0.068	0.067	0.065	0.064	0.063	0.061	0.060	0.059	0.058	0.057	0.055	0.054
24.5	0.053	0.066	0.065	0.063	0.062	0.060	0.059	0.058	0.057	0.056	0.055	0.054	0.052	0.051
25.0	0.050	0.062	0.061	0.060	0.058	0.057	0.056	0.055	0.054	0.053	0.052	0.051	0.049	0.048

Table 14-2: C_t values, Sound Optimized Mode SO3

Original Instruction: T05 0067-7063 VER 03

T05 0067-7063 Ver 03 - Approved - Exported from DMS: 2018-02-19 by FRPIC

14.3 Sound Curves, Sound Optimized Mode SO3

Sound Power Level at Hub Height	
Conditions for Sound Power Level:	**Measurement standard IEC 61400-11 ed. 3** **Maximum turbulence at hub height: 30%** **Inflow angle (vertical): 0 ±2°** **Air density: 1.225 kg/m³**
Wind speed at hub height [m/s]	**Sound Power Level at Hub Height [dBA]** **Sound Optimized Mode SO3 (Blades with serrated trailing edge)**
3	92.2
4	92.8
5	94.0
6	97.0
7	99.8
8	100.8
9	101.0
10	101.0
11	101.0
12	101.0
13	101.0
14	101.0
15	101.0
16	101.0
17	101.0
18	101.0
19	101.0
20	101.0

Table 14-3: Sound curves, Sound Optimized Mode SO3

Original Instruction: T05 0067-7063 VER 03

T05 0067-7063 Ver 03 – Approved – Exported from DMS: 2018-02-19 by FRPIC

15.2 Ct Values, SO3 (HWO)

	Air density kg/m³													
Wind speed [m/s]	1.225	0.950	0.975	1.000	1.025	1.050	1.075	1.100	1.125	1.150	1.175	1.200	1.250	1.275
3.0	0.880	0.885	0.885	0.885	0.884	0.884	0.883	0.883	0.882	0.881	0.881	0.880	0.879	0.879
3.5	0.870	0.875	0.875	0.874	0.874	0.873	0.873	0.872	0.872	0.871	0.871	0.870	0.870	0.869
4.0	0.838	0.842	0.842	0.841	0.841	0.841	0.840	0.840	0.839	0.839	0.839	0.838	0.837	0.837
4.5	0.813	0.814	0.814	0.813	0.813	0.812	0.812	0.812	0.812	0.813	0.813	0.813	0.813	0.812
5.0	0.812	0.811	0.811	0.811	0.812	0.812	0.812	0.812	0.812	0.812	0.812	0.812	0.812	0.812
5.5	0.812	0.814	0.814	0.814	0.814	0.814	0.814	0.813	0.813	0.813	0.813	0.812	0.812	0.811
6.0	0.807	0.811	0.811	0.811	0.810	0.810	0.810	0.809	0.809	0.809	0.808	0.808	0.807	0.807
6.5	0.807	0.811	0.811	0.810	0.810	0.810	0.809	0.809	0.808	0.808	0.808	0.807	0.806	0.806
7.0	0.805	0.810	0.810	0.809	0.809	0.808	0.808	0.807	0.807	0.806	0.806	0.805	0.804	0.804
7.5	0.793	0.799	0.798	0.798	0.797	0.797	0.796	0.796	0.795	0.794	0.794	0.793	0.792	0.791
8.0	0.746	0.752	0.751	0.751	0.750	0.750	0.749	0.749	0.748	0.748	0.747	0.746	0.745	0.745
8.5	0.674	0.680	0.679	0.679	0.678	0.678	0.677	0.677	0.676	0.676	0.675	0.675	0.674	0.673
9.0	0.604	0.609	0.609	0.608	0.608	0.607	0.607	0.606	0.606	0.605	0.605	0.604	0.603	0.603
9.5	0.545	0.550	0.549	0.549	0.548	0.548	0.547	0.547	0.546	0.546	0.546	0.545	0.544	0.544
10.0	0.495	0.500	0.499	0.499	0.498	0.498	0.497	0.497	0.497	0.496	0.496	0.495	0.494	0.493
10.5	0.452	0.457	0.457	0.457	0.456	0.456	0.455	0.455	0.455	0.454	0.453	0.453	0.450	0.449
11.0	0.411	0.424	0.424	0.423	0.422	0.422	0.420	0.419	0.418	0.417	0.415	0.413	0.409	0.405
11.5	0.375	0.399	0.398	0.397	0.396	0.394	0.392	0.390	0.387	0.385	0.382	0.379	0.371	0.367
12.0	0.344	0.388	0.385	0.381	0.378	0.375	0.371	0.366	0.362	0.358	0.353	0.348	0.338	0.333
12.5	0.315	0.383	0.377	0.371	0.365	0.359	0.353	0.346	0.340	0.334	0.327	0.321	0.309	0.302
13.0	0.285	0.369	0.361	0.353	0.344	0.336	0.328	0.321	0.313	0.305	0.299	0.292	0.279	0.273
13.5	0.259	0.342	0.333	0.324	0.315	0.307	0.299	0.292	0.285	0.277	0.271	0.265	0.253	0.248
14.0	0.236	0.314	0.306	0.297	0.289	0.281	0.274	0.267	0.260	0.253	0.248	0.242	0.231	0.226
14.5	0.216	0.287	0.279	0.271	0.264	0.256	0.250	0.244	0.237	0.231	0.226	0.221	0.212	0.207
15.0	0.197	0.260	0.253	0.246	0.239	0.232	0.227	0.221	0.216	0.210	0.206	0.201	0.193	0.189
15.5	0.180	0.237	0.231	0.224	0.218	0.212	0.207	0.202	0.197	0.192	0.188	0.184	0.177	0.173
16.0	0.165	0.216	0.211	0.205	0.200	0.194	0.190	0.185	0.181	0.176	0.173	0.169	0.162	0.159
16.5	0.152	0.198	0.193	0.188	0.183	0.178	0.174	0.170	0.166	0.162	0.159	0.155	0.149	0.146
17.0	0.140	0.182	0.177	0.173	0.168	0.164	0.160	0.157	0.153	0.149	0.146	0.143	0.138	0.135
17.5	0.130	0.168	0.163	0.159	0.155	0.151	0.148	0.145	0.141	0.138	0.135	0.132	0.127	0.125
18.0	0.120	0.155	0.151	0.148	0.144	0.140	0.137	0.134	0.131	0.128	0.125	0.123	0.118	0.116
18.5	0.112	0.144	0.140	0.137	0.134	0.130	0.127	0.125	0.122	0.119	0.117	0.114	0.110	0.108
19.0	0.104	0.133	0.130	0.127	0.123	0.120	0.118	0.115	0.113	0.110	0.108	0.106	0.102	0.100
19.5	0.097	0.123	0.121	0.118	0.115	0.112	0.110	0.107	0.105	0.103	0.101	0.099	0.095	0.093
20.0	0.090	0.115	0.112	0.110	0.107	0.104	0.102	0.100	0.098	0.096	0.094	0.092	0.089	0.087
20.5	0.084	0.107	0.105	0.103	0.100	0.098	0.096	0.094	0.092	0.090	0.088	0.086	0.083	0.081
21.0	0.079	0.101	0.098	0.096	0.094	0.091	0.090	0.088	0.086	0.084	0.082	0.081	0.078	0.076
21.5	0.075	0.095	0.093	0.091	0.089	0.086	0.085	0.083	0.081	0.079	0.078	0.076	0.074	0.072
22.0	0.071	0.089	0.087	0.085	0.083	0.081	0.080	0.078	0.076	0.075	0.073	0.072	0.069	0.068
22.5	0.066	0.084	0.082	0.080	0.078	0.076	0.075	0.073	0.072	0.070	0.069	0.068	0.065	0.064
23.0	0.062	0.078	0.077	0.075	0.073	0.072	0.070	0.069	0.067	0.066	0.065	0.064	0.061	0.060
23.5	0.059	0.074	0.072	0.071	0.069	0.068	0.066	0.065	0.064	0.062	0.061	0.060	0.058	0.057
24.0	0.056	0.070	0.068	0.067	0.065	0.064	0.062	0.061	0.060	0.059	0.058	0.057	0.055	0.054
24.5	0.052	0.066	0.064	0.063	0.061	0.060	0.059	0.058	0.057	0.055	0.054	0.053	0.052	0.051
25.0	0.049	0.062	0.060	0.059	0.058	0.056	0.055	0.054	0.053	0.052	0.051	0.050	0.049	0.048
25.5	0.046	0.058	0.057	0.055	0.054	0.053	0.052	0.051	0.050	0.049	0.048	0.047	0.046	0.045
26.0	0.043	0.054	0.053	0.051	0.050	0.049	0.048	0.047	0.046	0.045	0.045	0.044	0.042	0.042
26.5	0.040	0.050	0.049	0.048	0.046	0.045	0.045	0.044	0.043	0.042	0.041	0.041	0.039	0.039
27.0	0.037	0.046	0.045	0.044	0.043	0.042	0.041	0.040	0.039	0.039	0.038	0.037	0.036	0.035
27.5	0.033	0.041	0.041	0.040	0.039	0.038	0.037	0.037	0.036	0.035	0.035	0.034	0.033	0.032
28.0	0.030	0.037	0.037	0.036	0.035	0.034	0.034	0.033	0.032	0.032	0.031	0.031	0.030	0.029
28.5	0.027	0.033	0.033	0.032	0.031	0.030	0.030	0.029	0.029	0.028	0.028	0.027	0.026	0.026
29.0	0.024	0.029	0.029	0.028	0.027	0.027	0.026	0.026	0.025	0.025	0.025	0.024	0.023	0.023
29.5	0.021	0.026	0.025	0.025	0.024	0.024	0.023	0.023	0.022	0.022	0.022	0.021	0.021	0.020
30.0	0.019	0.023	0.022	0.022	0.022	0.021	0.021	0.020	0.020	0.020	0.019	0.019	0.019	0.018

Table 15-2: c_t values, SO3 (HWO)

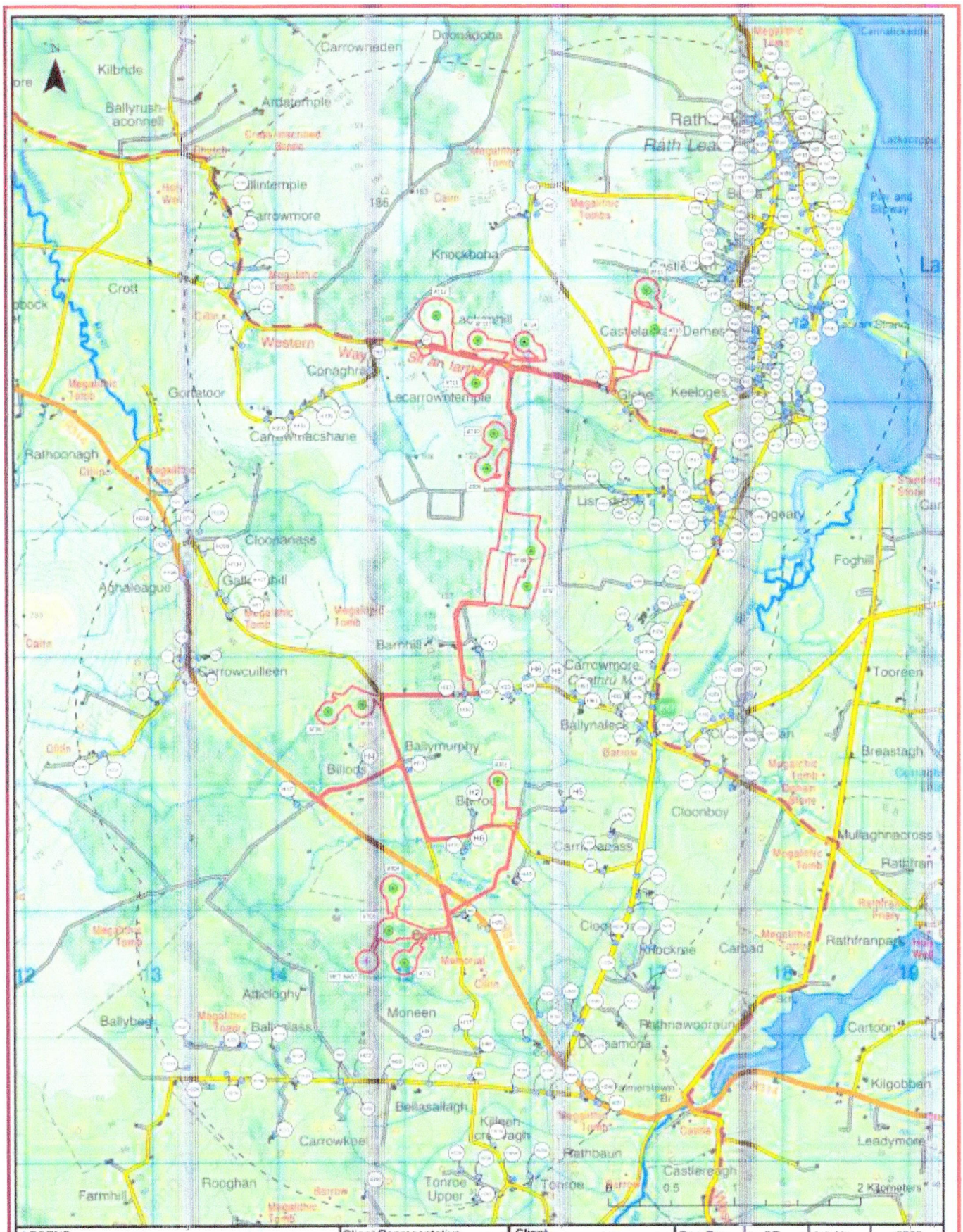
15.3 Sound Curves, SO3 (HWO)

Sound Power Level at Hub Height	
Conditions for Sound Power Level:	**Measurement standard IEC 61400-11 ed. 3** **Maximum turbulence at hub height: 30%** **Inflow angle (vertical): 0 ±2°** **Air density: 1.225 kg/m³**
Wind speed at hub height [m/s]	**Sound Power Level at Hub Height [dBA]** **SO3 (HWO) (Blades with serrated trailing edge)**
3	92.2
4	92.8
5	94.0
6	97.0
7	99.8
8	100.8
9	101.0
10	101.0
11	101.0
12	101.0
13	101.0
14	101.0
15	101.0
16	101.0
17	101.0
18	101.0
19	101.0
20	101.0

Table 15-3: Sound curves, SO3 (HWO)

Original Instruction: T05 0067-7063 VER 03

T05 0067-7063 Ver 03 - Approved - Exported from DMS: 2018-02-19 by FRPIC



LEGEND

- Residential Curtilage Points
- 2km Buffer
- Met Mast Location Point
- Turbine Location Points
- Wind Farm Site Redline

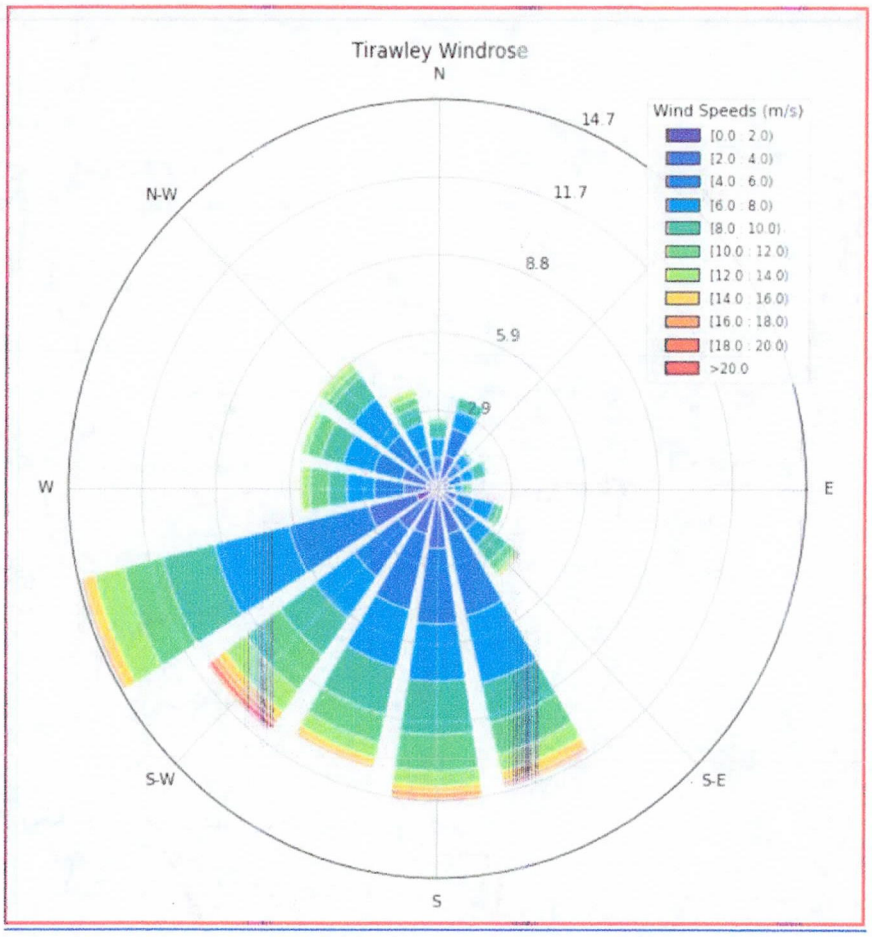
Client Representative: JENNINGS O'DONOVAN

Client: CONSTANT ENERGY LIMITED

Project: TIRAWLEY WIND FARM CO. MAYO

Title: RESIDENTIAL DWELLINGS WITHIN 2KM OF THE WINDFARM SITE

Drg. By	DT	Job No.	6289
Checked By	MG	Figure	2.3
Approved	MG	Rev	1
Scale	1:26,000 (A3)		
Stage	Planning		
Date	20/04/2026		



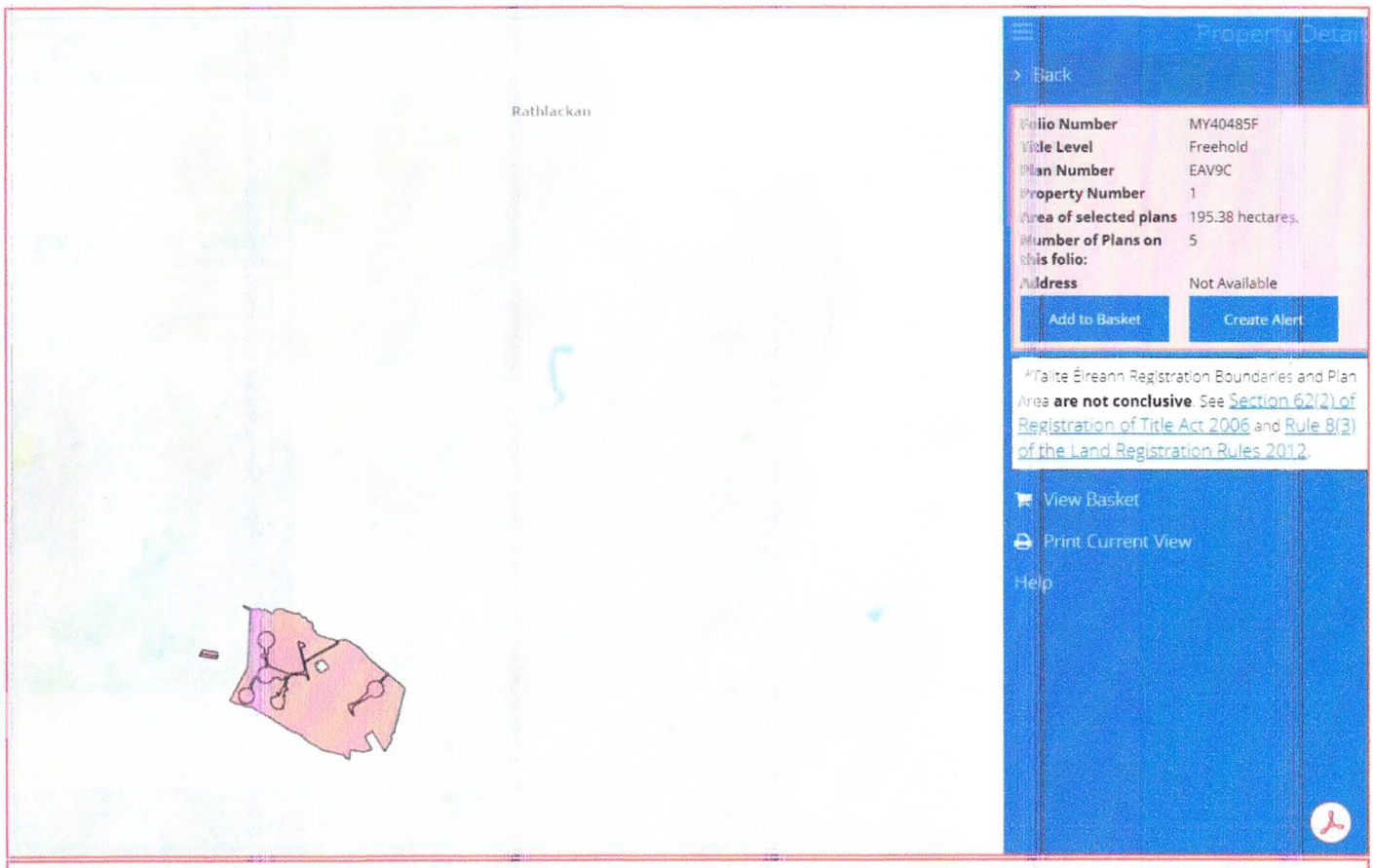
Response from MLavelle: Note the prevailing wind from the WSW to ESE, which will transmit the noise & turbulence to the houses at Rathlackan.

I do not see any map showing the land under control of the applicant coloured blue. Folio MY40485F indicates an area of 195.38ha, yet the application indicates a much smaller area.

I do not see any Townland identified Maps for Agreements for Oversail or Overhang on the Turbine Delivery Route from Ballina to the 14 entrances.

Tirawley Wind Farm Land Owners List

No	Registered Owners	Folios
1	Martin Bryce	MY10087F MY38230
2	David Massey	MY40485F
3	Gerard Kearney	MY38228
4	Michael Rooney	MY28446
5	Dasos Foraois Management Limited	MY28002 MY74914F MY39417F
6	David Lavin	MY28441
7	Mary Costello	MY38714F
8	James Kilcullen	MY38282
9	Mayo Renewable Power Limited	MY76397F
10	Constant Energy (Applicant is owner. Letter of consent not required)	MY25829 MY52871F MY39419F
11	John Joe Langan	MY46067


Rathlackan
Property Detail
Back
Folio Number MY40485F
Title Level Freehold
Plan Number EAV9C
Property Number 1
Area of selected plans 195.38 hectares.
Number of Plans on this folio: 5
Address Not Available
Add to Basket
Create Alert
*Tailte Éireann Registration Boundaries and Plan Area are not conclusive. See Section 62(2) of Registration of Title Act 2006 and Rule 8(3) of the Land Registration Rules 2012.
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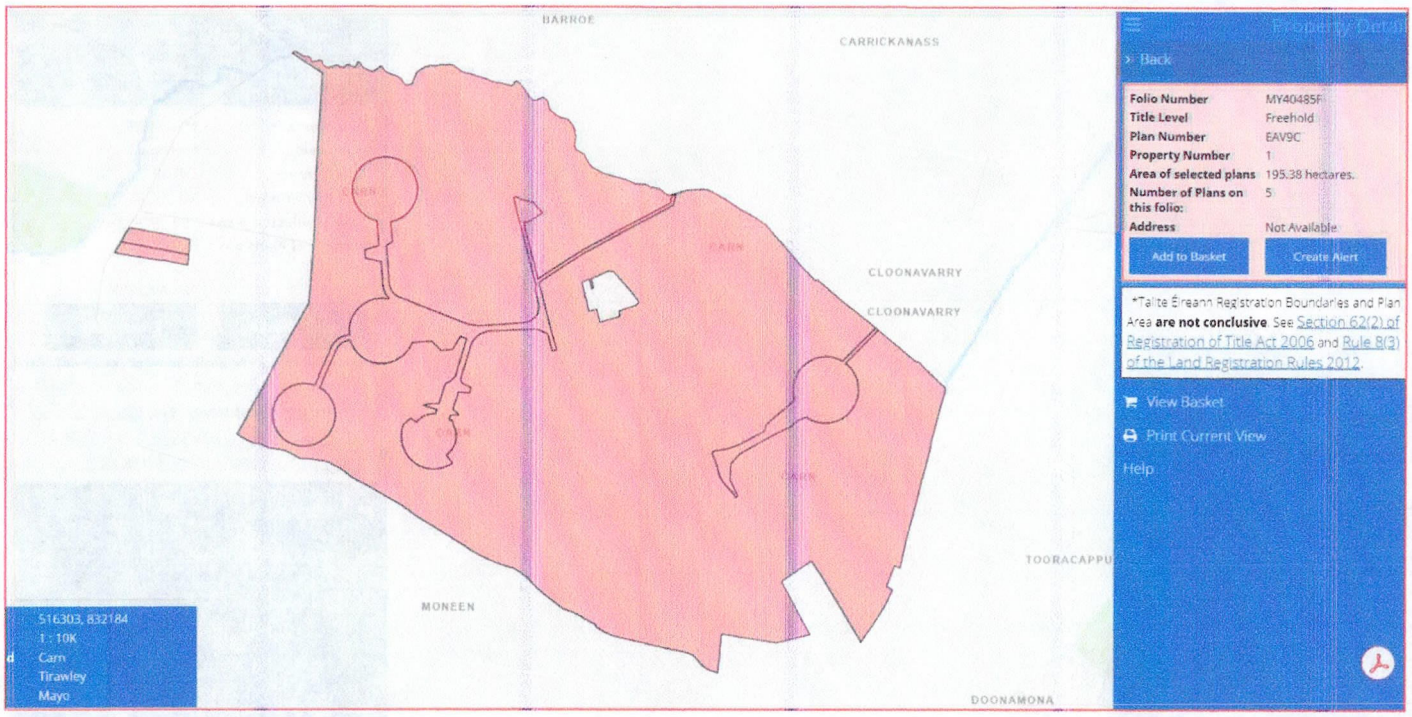
CARN
CARN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CARRICKANASS
CLOONAVARRY
CLOONAVARRY
TOORACAPPUL
MONEEN
DOONAMONA
516303, 832184
1 : 10K
Carn
Tirawley
Mayo
Property Detail
Back
Folio Number MY40485F
Title Level Freehold
Plan Number EAV9C
Property Number 1
Area of selected plans 195.38 hectares.
Number of Plans on this folio: 5
Address Not Available
Add to Basket
Create Alert
*Tailte Éireann Registration Boundaries and Plan Area are not conclusive. See Section 62(2) of Registration of Title Act 2006 and Rule 8(3) of the Land Registration Rules 2012.
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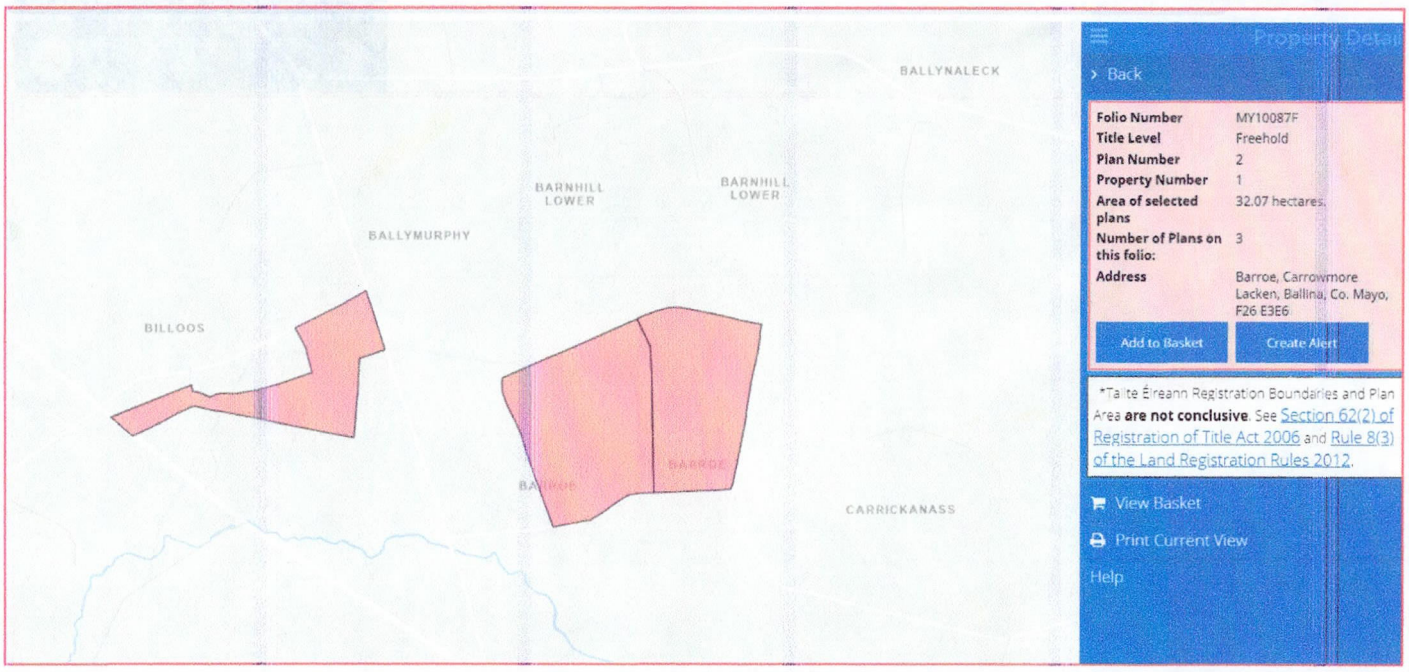
BALLYNALECK
BARNHILL LOWER
BARNHILL LOWER
BALLYMURPHY
BILLOOS
CARRICKANASS
Property Detail
Back
Folio Number MY10087F
Title Level Freehold
Plan Number 2
Property Number 1
Area of selected plans 32.07 hectares.
Number of Plans on this folio: 3
Address Barroe, Carrowmore Lacken, Ballina, Co. Mayo, F26 E3E6
Add to Basket
Create Alert
*Tailte Éireann Registration Boundaries and Plan Area are not conclusive. See Section 62(2) of Registration of Title Act 2006 and Rule 8(3) of the Land Registration Rules 2012.
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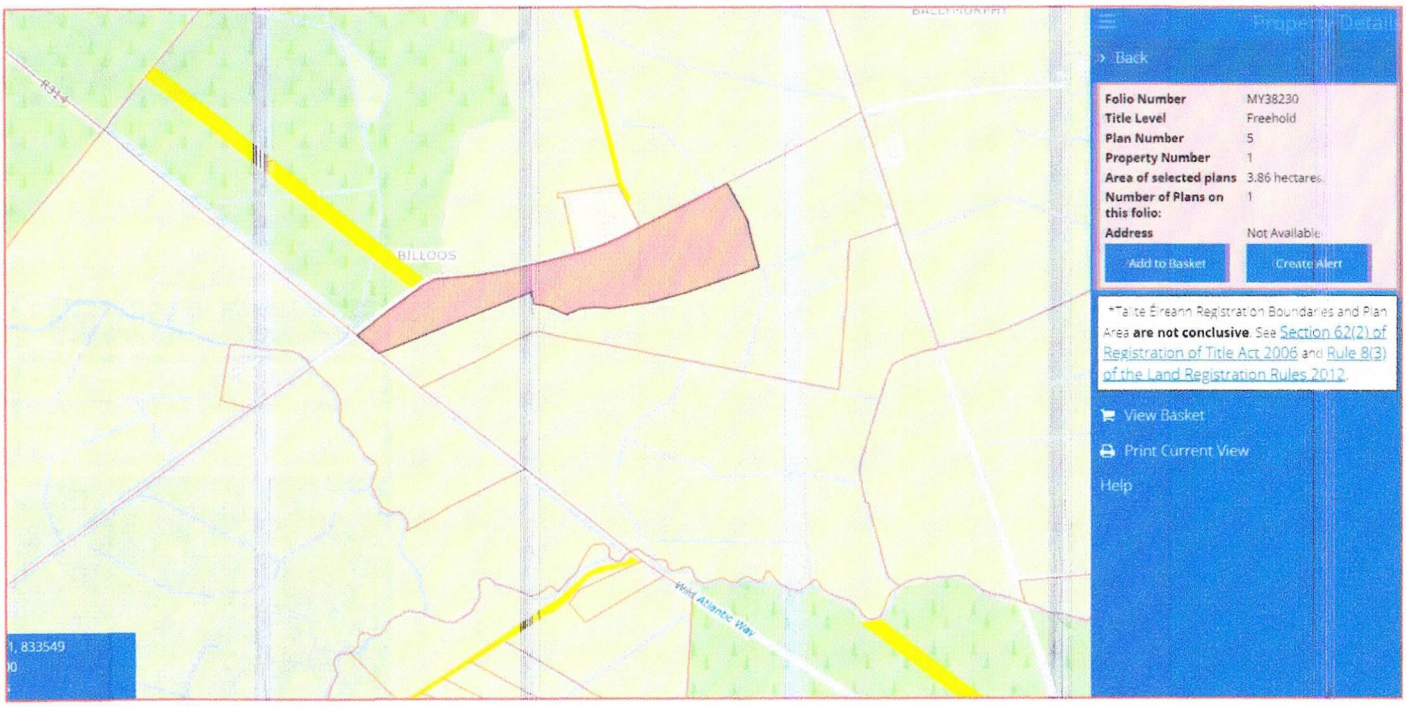
BILLOOS
Wild Atlantic Way
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Title Level Freehold
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Property Number 1
Area of selected plans 3.86 hectares.
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Address Not Available
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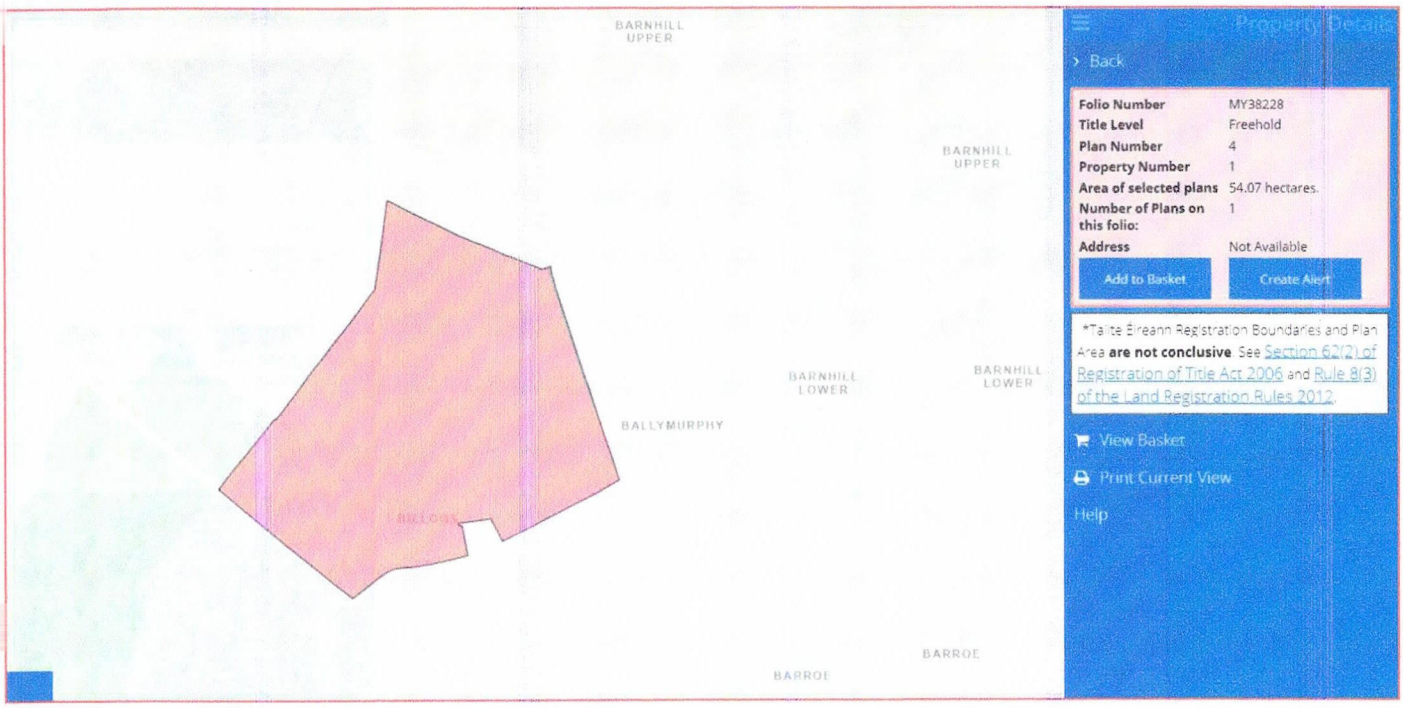
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BALLYMURPHY
BILLOOS
BARROE
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Property Number 1
Area of selected plans 54.07 hectares.
Number of Plans on this folio: 1
Address Not Available
Add to Basket
Create Alert
*Tailte Éireann Registration Boundaries and Plan Area are not conclusive. See Section 62(2) of Registration of Title Act 2006 and Rule 8(3) of the Land Registration Rules 2012.
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Print Current View
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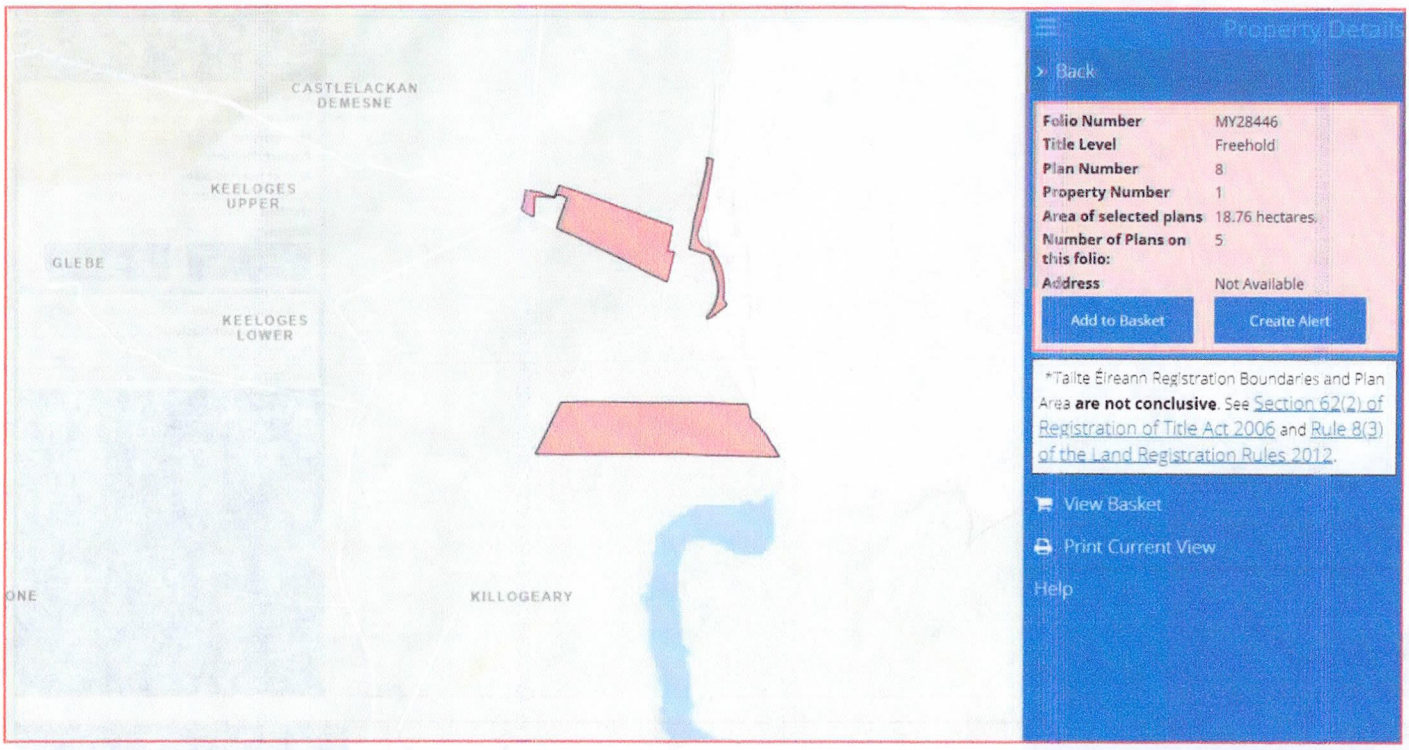
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KEELOGES UPPER
GLEBE
KEELOGES LOWER
KILLOGEARY
Property Details
Back
Folio Number MY28446
Title Level Freehold
Plan Number 8
Property Number 1
Area of selected plans 18.76 hectares.
Number of Plans on this folio: 5
Address Not Available
Add to Basket
Create Alert
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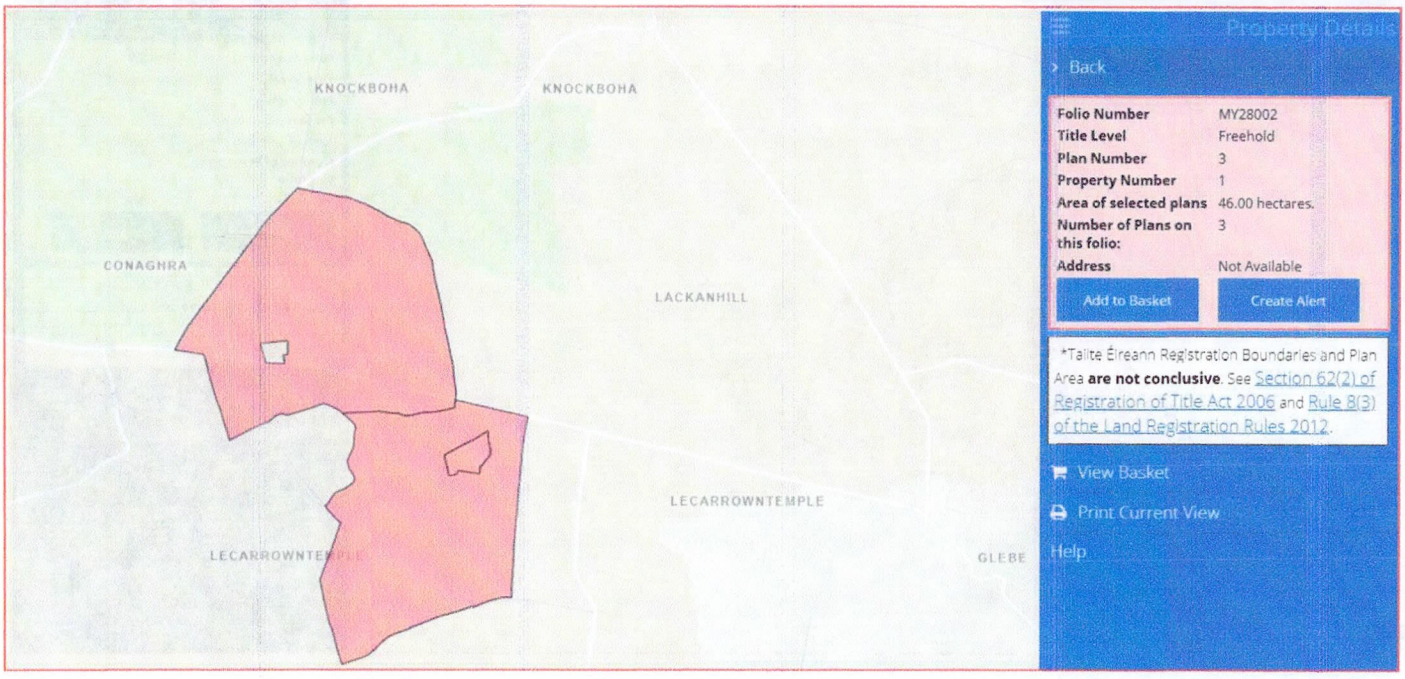
KNOCKBOHA
KNOCKBOHA
CONAGHRA
LACKANHILL
LECARROWNTEMPLE
GLEBE
Property Details
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Title Level Freehold
Plan Number 3
Property Number 1
Area of selected plans 46.00 hectares.
Number of Plans on this folio: 3
Address Not Available
Add to Basket
Create Alert
*Tailte Éireann Registration Boundaries and Plan Area are not conclusive. See Section 62(2) of Registration of Title Act 2006 and Rule 8(3) of the Land Registration Rules 2012.
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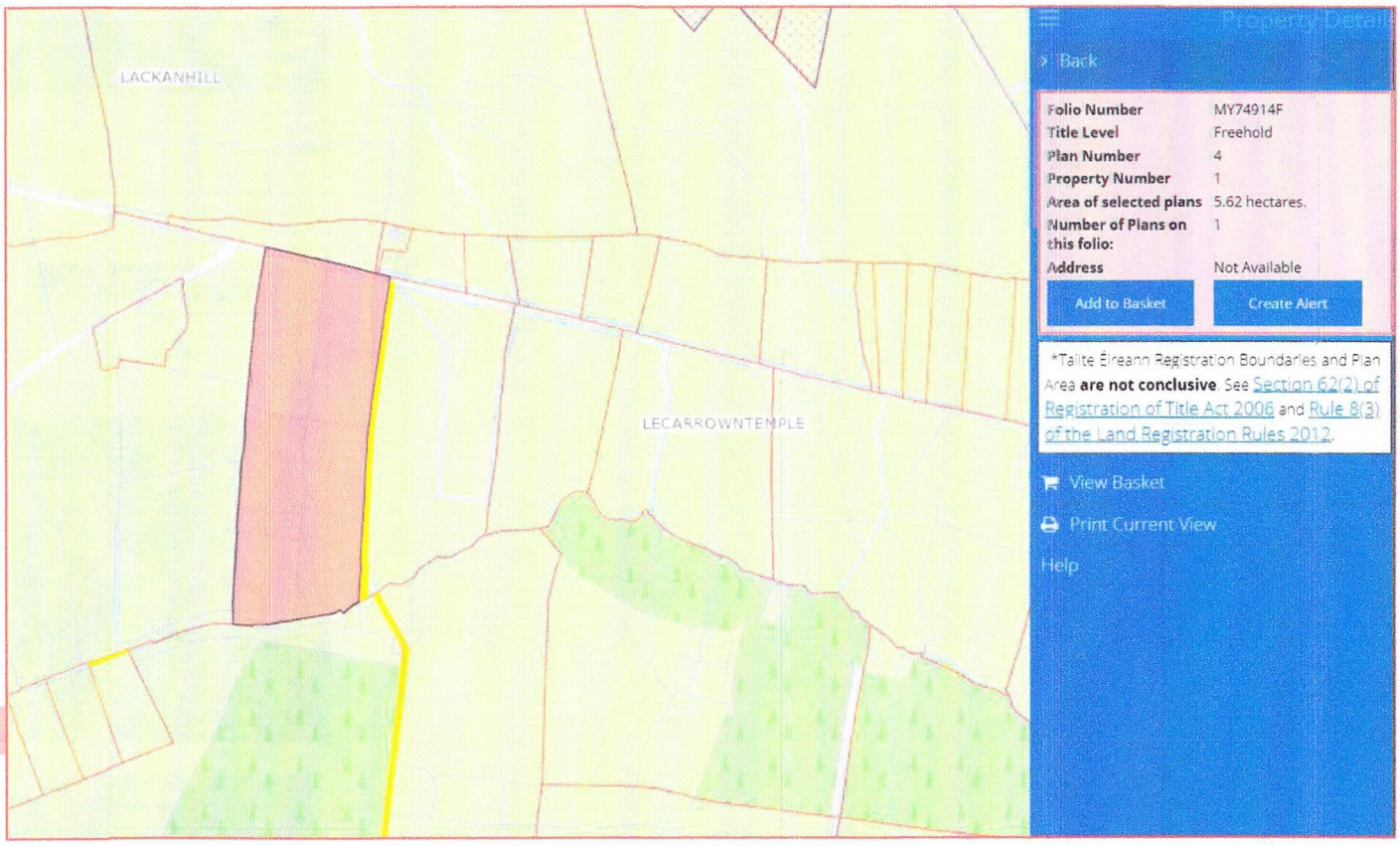
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Property Details
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Title Level Freehold
Plan Number 4
Property Number 1
Area of selected plans 5.62 hectares.
Number of Plans on this folio: 1
Address Not Available
Add to Basket
Create Alert
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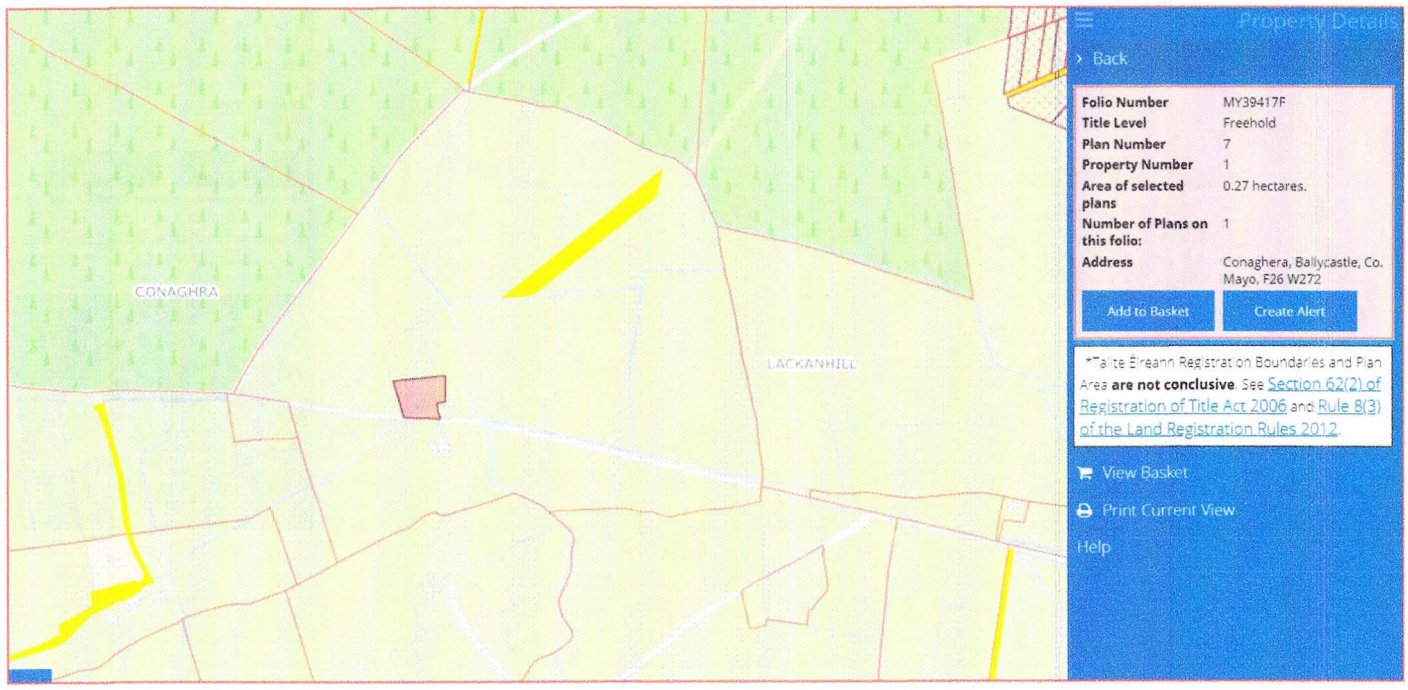
CONAGHRA
LACKANHILL
Property Details
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Title Level Freehold
Plan Number 7
Property Number 1
Area of selected plans 0.27 hectares.
Number of Plans on this folio: 1
Address Conaghera, Ballycastle, Co. Mayo, F26 W272
Add to Basket
Create Alert
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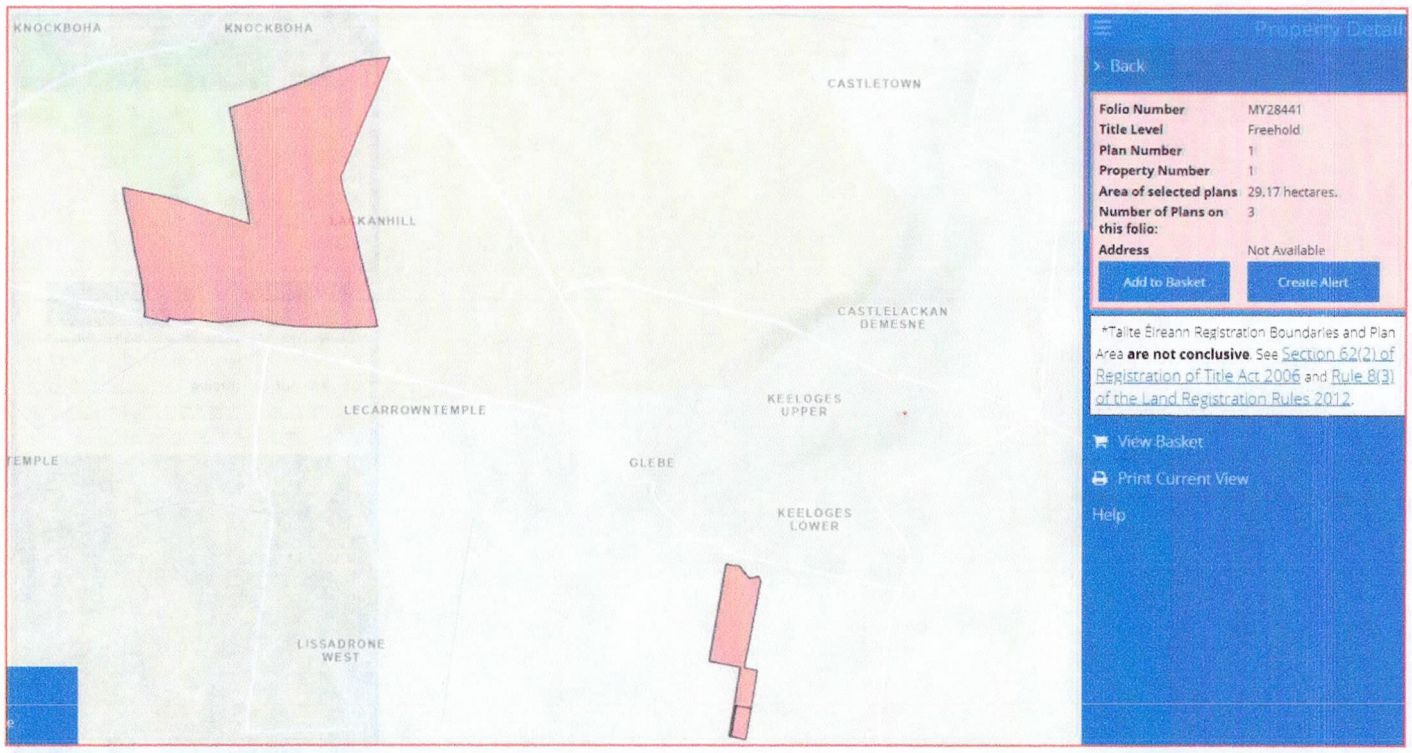
KNOCKBOHA
KNOCKBOHA
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CASTLELACKAN DEMESNE
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KEELOGES UPPER
TEMPLE
GLEBE
KEELOGES LOWER
LISSADRONE WEST
Property Detail
Back
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Title Level Freehold
Plan Number 1
Property Number 1
Area of selected plans 29.17 hectares.
Number of Plans on this folio: 3
Address Not Available
Add to Basket
Create Alert
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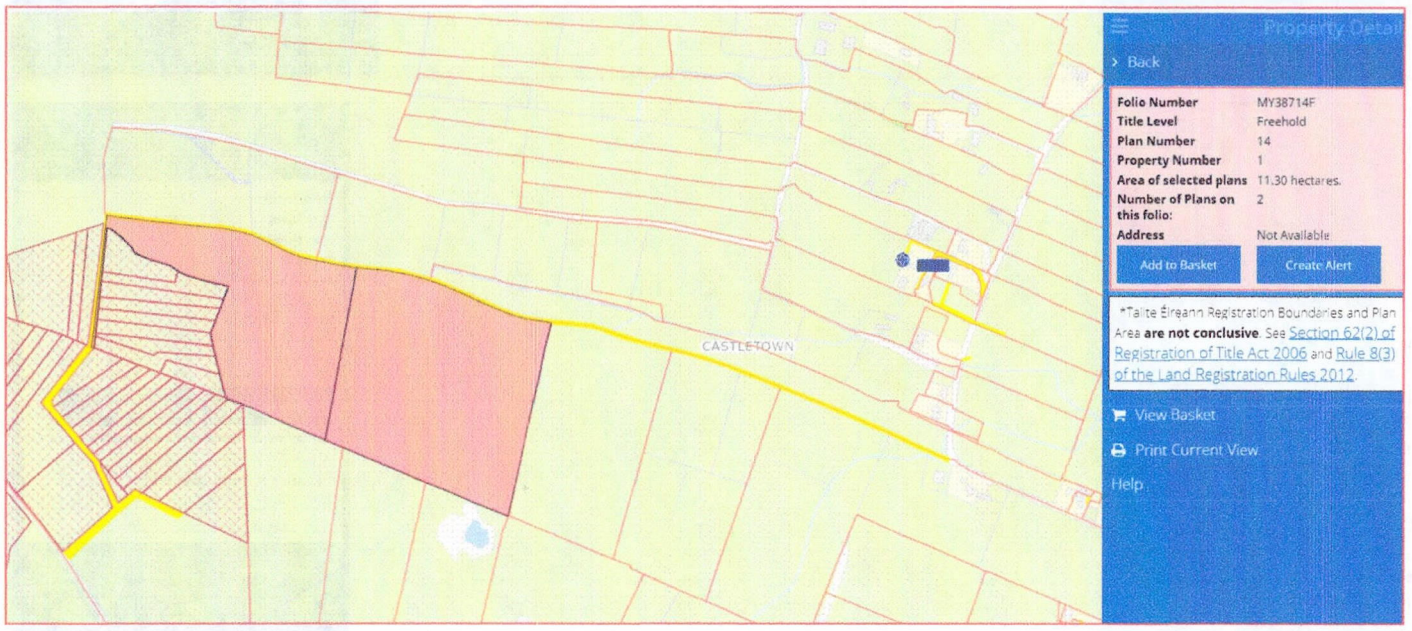
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Title Level Freehold
Plan Number 14
Property Number 1
Area of selected plans 11.30 hectares.
Number of Plans on this folio: 2
Address Not Available
Add to Basket
Create Alert
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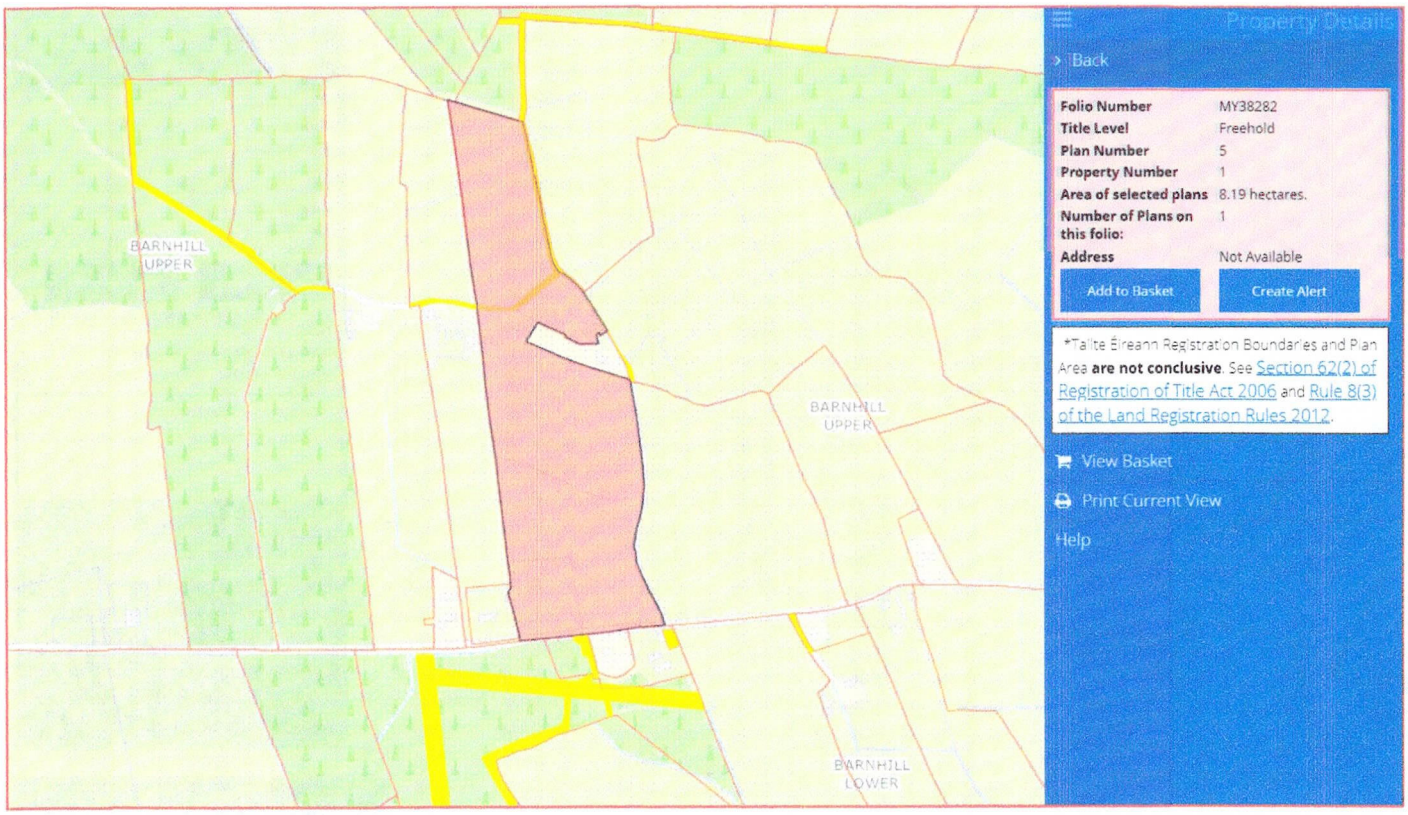
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BARNHILL UPPER
BARNHILL LOWER
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Add to Basket
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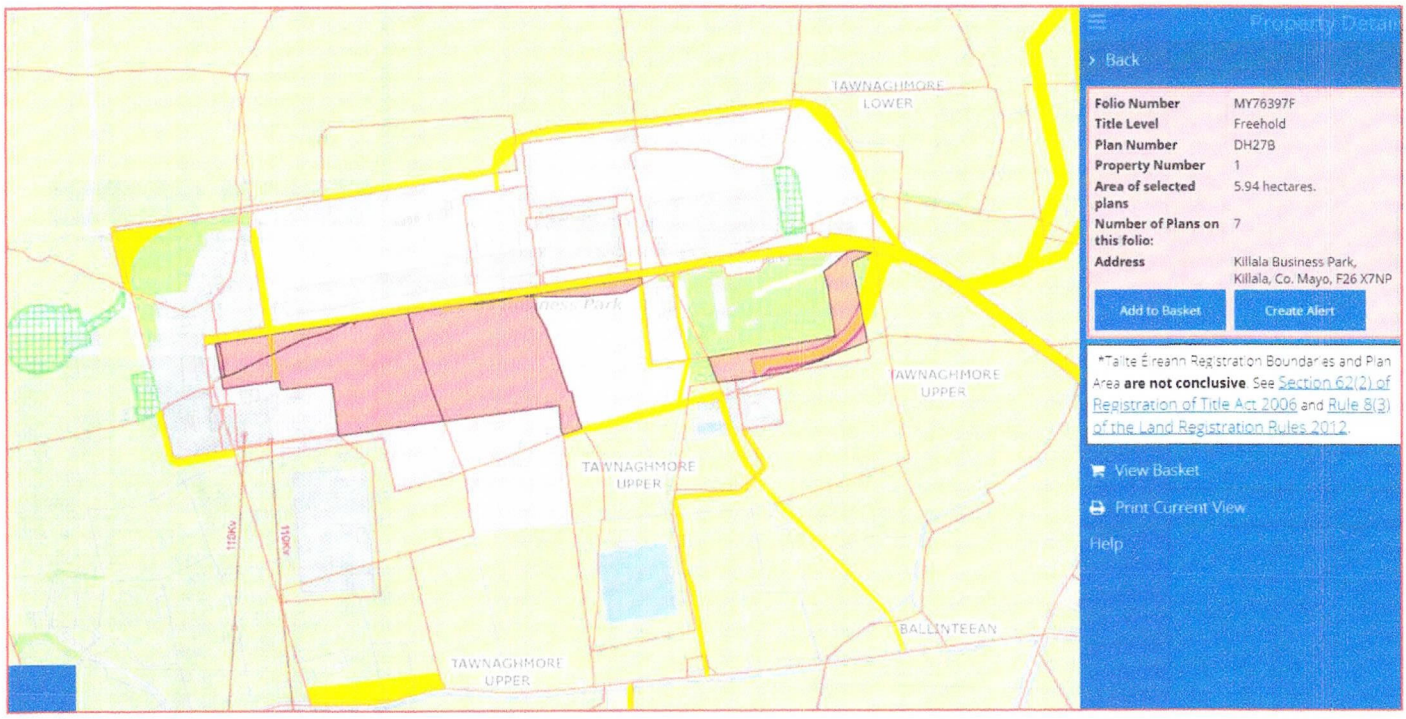
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TAWNAGHMORE UPPER
TAWNAGHMORE UPPER
BALLINTEEAN
TAWNAGHMORE UPPER
Property Details
Back
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Title Level Freehold
Plan Number DH27B
Property Number 1
Area of selected plans 5.94 hectares.
Number of Plans on this folio: 7
Address Killala Business Park, Killala, Co. Mayo, F26 X7NP
Add to Basket
Create Alert
*Tailte Éireann Registration Boundaries and Plan Area are not conclusive. See Section 62(2) of Registration of Title Act 2006 and Rule 8(3) of the Land Registration Rules 2012.
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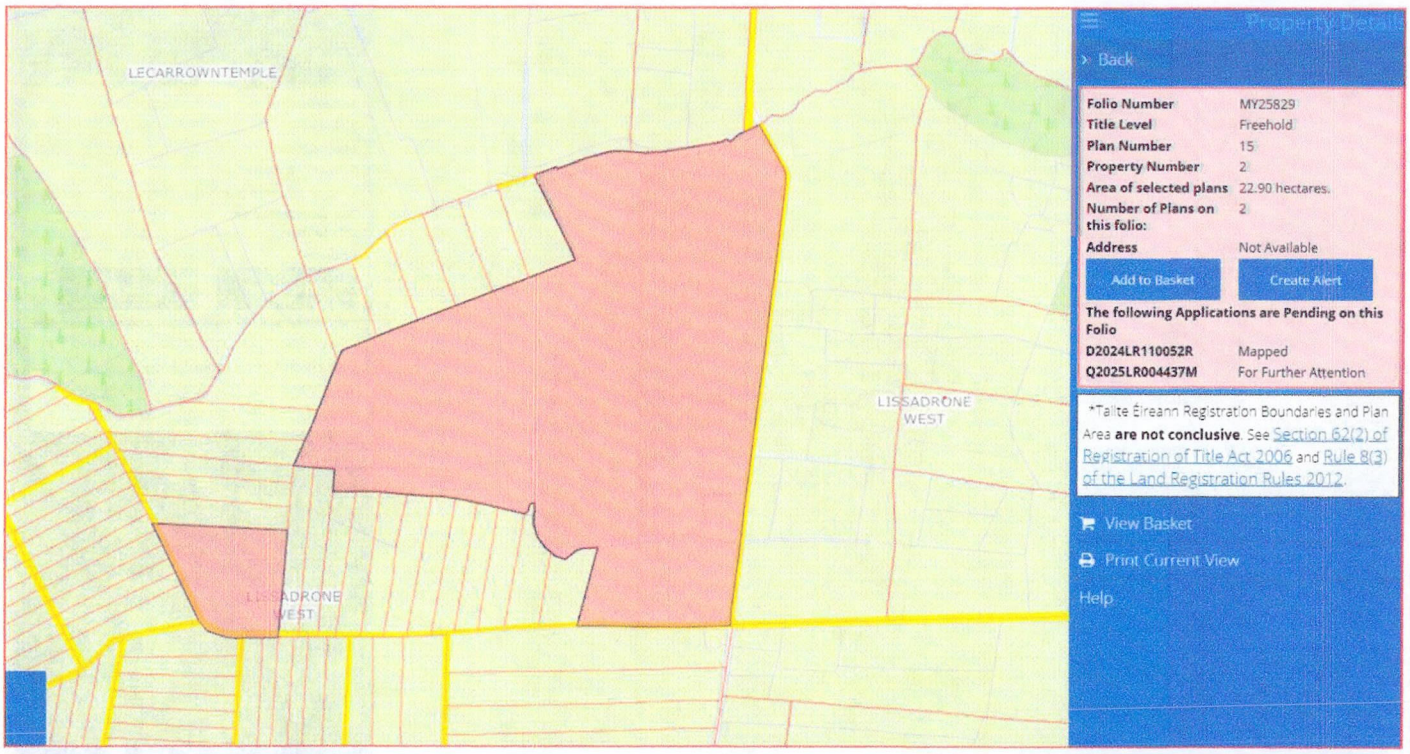
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LISSADRONE WEST
LISSADRONE WEST
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Title Level Freehold
Plan Number 15
Property Number 2
Area of selected plans 22.90 hectares.
Number of Plans on this folio: 2
Address Not Available
Add to Basket
Create Alert
The following Applications are Pending on this Folio
D2024LR110052R Mapped
Q2025LR004437M For Further Attention
*Tailte Éireann Registration Boundaries and Plan Area are not conclusive. See Section 62(2) of Registration of Title Act 2006 and Rule 8(3) of the Land Registration Rules 2012.
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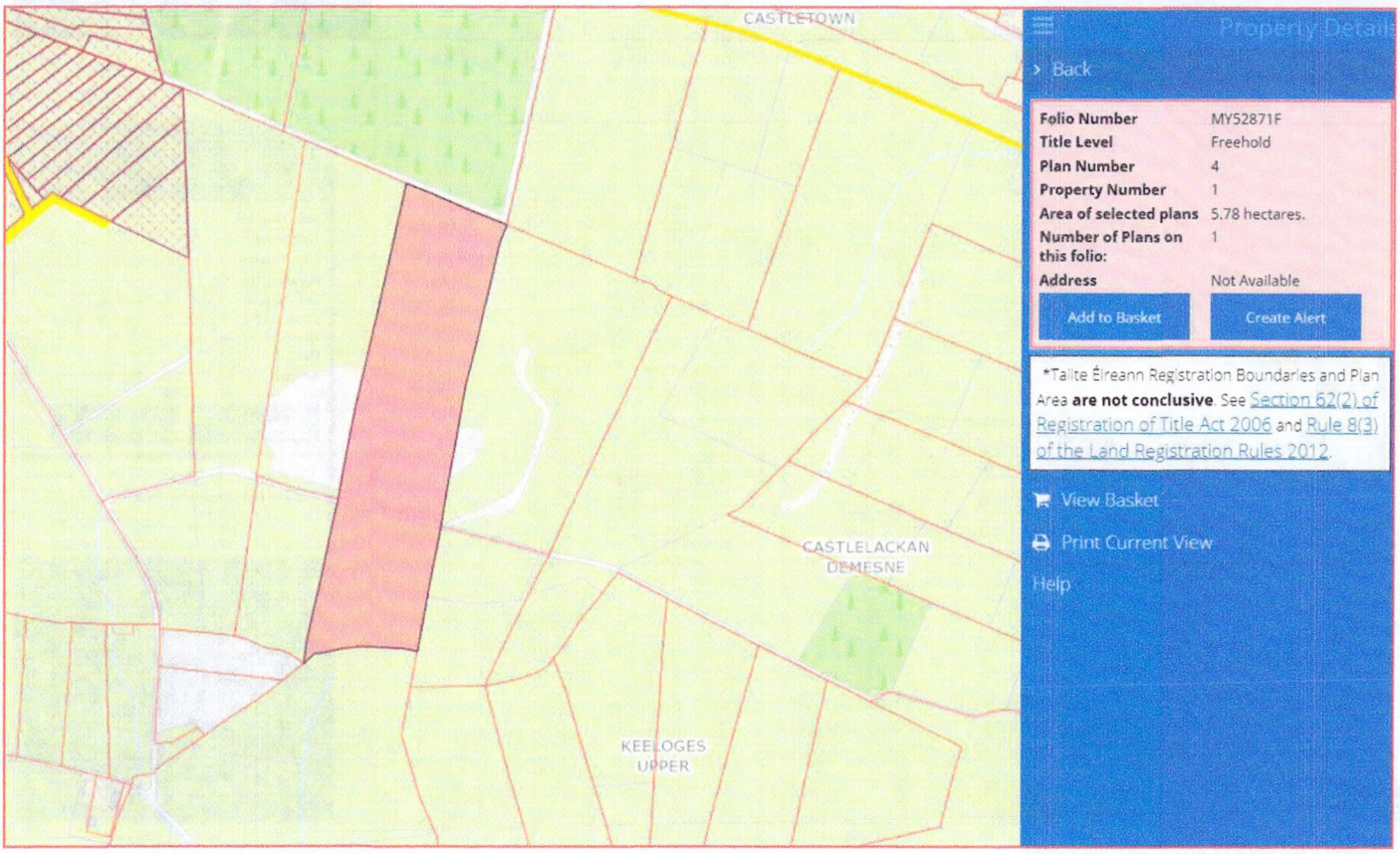
CASTLETOWN
CASTLELACKAN DEMESNE
KEELOGES UPPER
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Plan Number 4
Property Number 1
Area of selected plans 5.78 hectares.
Number of Plans on this folio: 1
Address Not Available
Add to Basket
Create Alert
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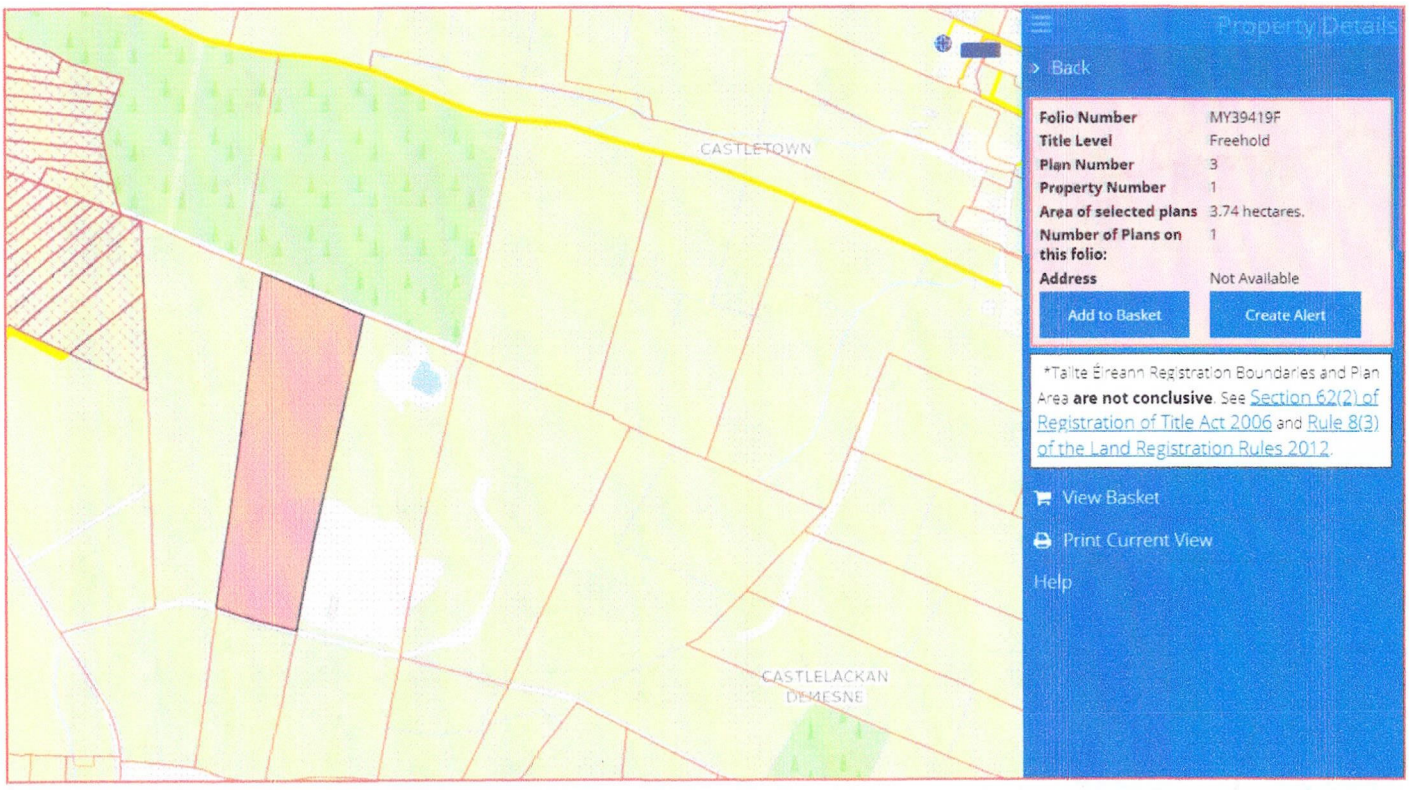
CASTLETOWN
CASTLELACKAN DEMESNE
Property Details
Back
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Title Level Freehold
Plan Number 3
Property Number 1
Area of selected plans 3.74 hectares.
Number of Plans on this folio: 1
Address Not Available
Add to Basket
Create Alert
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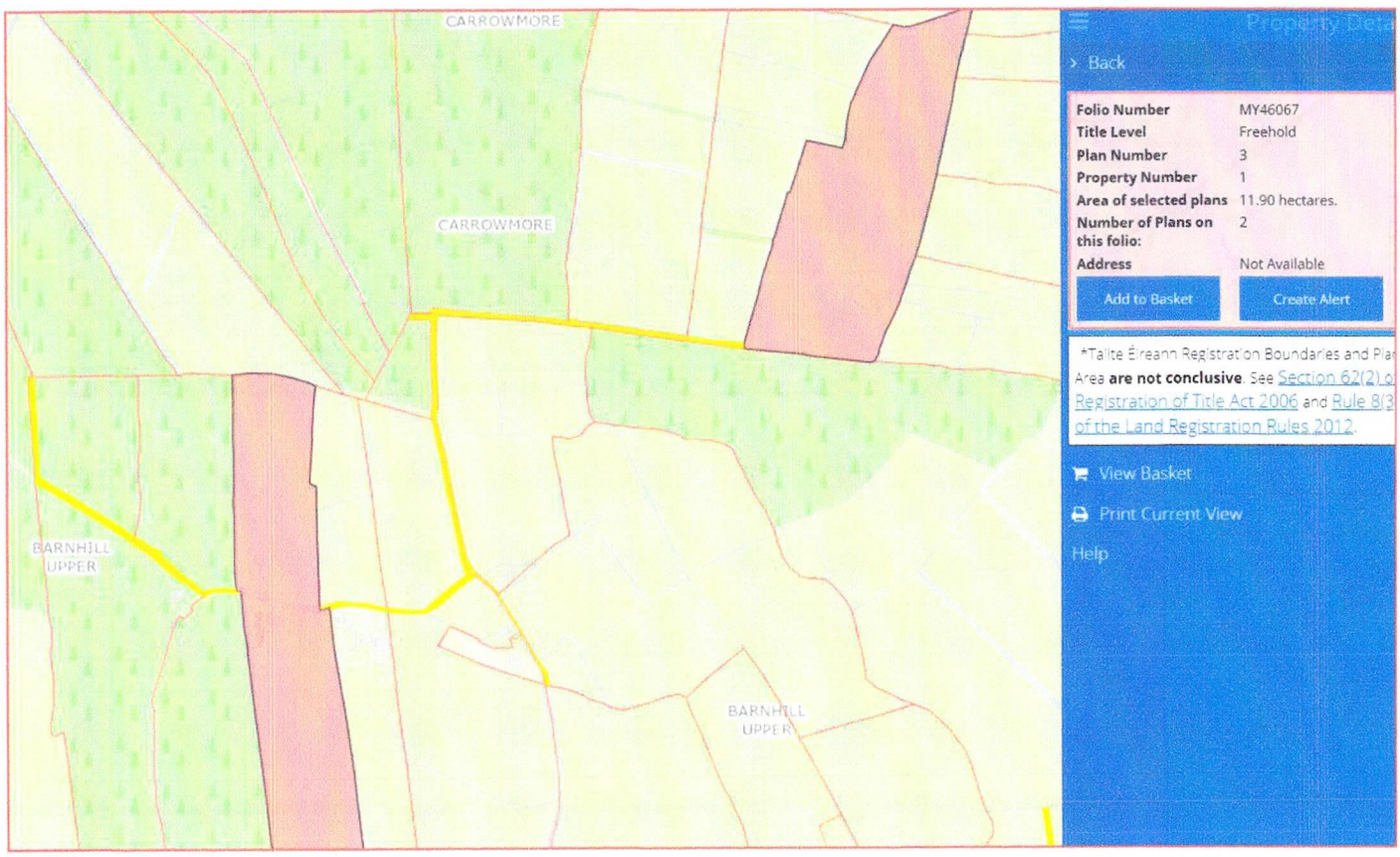
CARROWMORE
CARROWMORE
BARNHILL UPPER
BARNHILL UPPER
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Number of Plans on this folio: 2
Address Not Available
Add to Basket
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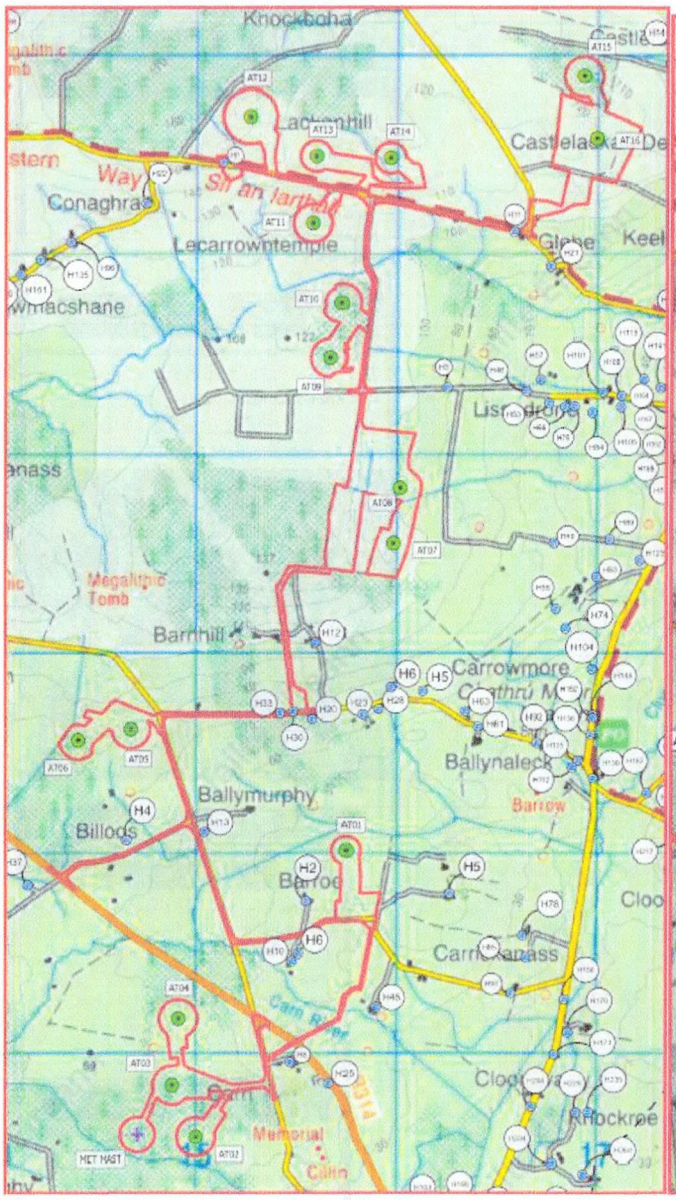
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Castlelacke
Conaghra
Lecarrowntemple
Glebe
Lissadrone
Megalithic Tomb
Barnhill
Carrowmore
Ballynaleck
Barrow
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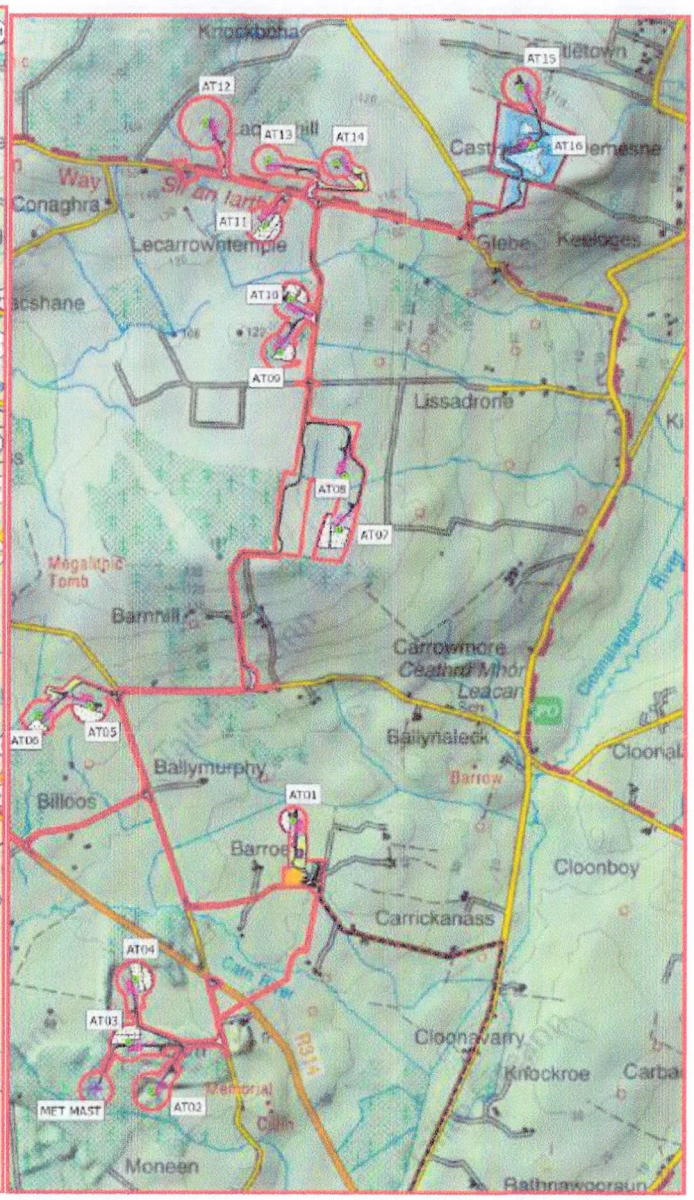
Carn River
Memorial Cairn
Knockroe
MET MAST
R314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Castlelacke
Conaghra
Lecarrowntemple
Glebe
Keeloges
Lissadrone
Megalithic Tomb
Barnhill
Carrowmore
Ballynaleck
Barrow
Ballymurphy
Billoos
Cloonboy
Carrickanass
Cloonavarry
Knockroe
Memorial Cairn
MET MAST
Moneen
Bathnawooraun
R314

Reference Appendix 1- 2020 : A Madison County, Iowa, Cardiologist's Investigation and Response to Industrial Wind Turbines in the Rural Residential Countryside Regarding Concerns of Adverse Health Effects And, Exploration of the Relevant Accompanying Larger Issues. W. Ben Johnson, M.D. December 7, 2020.

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Executive Summary

While ongoing for decades, more recently recorded consecutive years of rising oceans and mean global temperatures with increasing patterns of intensifying storms and fires have only heightened Man's resolve to fundamentally change worldwide dependence on fossil fuels. We are now responding with a sense of urgency. "Renewable" energies, particularly wind and solar, among other renewable sources, have been promoted as"winning solutions". Photovoltaic (solar) energy has become more affordable and is utilized more in sunnier locales. Commercially, beginning in northern Europe, Industrial wind turbines have, over three decades, spread rapidly across the globe. With increases in size to achieve increased power generation capacity, they appeared in the U.S. initially as a novelty but have been rapidly proliferated without a "proper introduction". Seemingly simple and intuitively harmless in design and implementation, when placed too close to human habitation, serious problems have occurred. It is as though we "leaped before we looked".

I am a Cardiologist who specialized in heart rhythm problems and I am providing a personal statement primarily focused on the adverse health effects (AHEs) arising from industrial wind turbines (IWTs).

A bit of history ties my interest to this concern:

Over two years ago, the "legitimacy" of industrial wind turbines as a source of SAFE and sustainable electricity was suddenly thrust into my life. This appeared as a "benign letter" from a local energy provider. Proposed, was a 52 turbine farm to be erected close to my property... a place protected by a conservation easement for having a few remnant prairie hillsides. In the surrounding miles, grazing and row-crop agriculture was the focused livelihood. These communities are the definition of an extremely quiet "rural residential" landscape. I knew almost nothing about wind turbines and, like nearly everyone, thought they were quiet, good for the world and assumed they were safe. In the ensuing weeks, public meetings were held where interested citizens had a chance to voice their opinions and concerns. Despite very time-limited presentations, it became obvious that

opinions had rapidly polarized, shifting the debate from county vs an outside faceless large corporation to neighbor vs neighbor. Mid-American Energy (MAE), the Wind contractor, was there to answer questions but provided no hand-outs nor substantial didactic information. They sat in a group being largely silent, they only returned brief, limited answers when questioned. There was an industry physician-consultant from Boston who presented his opinions but no facts or data, and directly dismissed that noise related complaints were "real". Instead, (he implied) that those complaints were mostly imaginary physical or mental consequences from the presence of the IWTs. Any reasonable person present walked away after the meetings having no idea what health ramifications from IWTs might occur. The word "obfuscation" (the action of making something obscure, unclear or unintelligible) appeared in my mind.

Wind Energy's Position about Adverse Health Effects:

In these initial Board of Adjustment, and then later Board of Health meetings, **Wind Energy maintained their "position":**

1) **that** Industrial Wind Turbines are safe - yet without qualifications of how that self-designation of "SAFE" was given" – no studies, records and evaluations of structure failures, etc. They almost always follow the "safe statement" with boasting of the number of IWTs they have placed in Iowa and the revenue to the state, jobs created, and on and on, but never have provided evidence that scientifically proves "they are safe". Wind energy has limited "original" investigative research. Often a panel judges whether existing data supports the assertions by scientists that IWTs do cause AHEs. The subsequent peer review become akin to judging "opinions with opinions". Importantly, "indirect" impacts, which Wind Energy routinely ignores, are just as significant to the people who are impacted as are "direct" impacts. In fact, there is an enormous amount of data linking IWTs noise emissions to direct and indirect AHEs. Thorough and objective reviews of Wind energy's claims have been challenged and previously "debunked" (Punch and James, 2016). When challenging Wind Energy's representatives with the assertion that "industrial wind turbines have never been proven or shown to be safe", the don't respond – almost as a "taught response". Yet, after a Board of Health meeting, even one of the "pro-wind" Iowa Environmental Council academic speakers did agree with me that IWTs have **not** been proven to be safe.

2) **that** they (MAE) receive very few complaints... eventually they resolve. They contend that the "nocebo effect" accounts for most resident complaints. In this context, the nocebo effect is the association of symptoms and complaints "brought-on" by existing negative attitudes toward IWTs.

3) **that** there is no credible evidence that IWTs cause cardiovascular disease or metabolic disease.

4) **that** they reluctantly admit that some of "their studies" show that IWTs cause "annoyance" but reflect that it has no substantial health impact. Wind Energy, never comments about IWT-associated "severe annoyance" that causes resident evacuations of their home (which is also considered an adverse health effect).

5) **that** they will not admit that IWT noise causes sleep disruption. Strongly connected to this is their assertion that infrasound and low-frequency noise (ILFN) as a product of IWTs, accounts for a small part of the IWT noise and that infrasound cannot be heard and therefore cannot cause harm. Indeed, they firmly contend that ILFN is of no concern and strongly insist it should not be regulated.

I have carefully reviewed Wind Energy's position on all these adverse health effects. I have searched for definitions, textbooks, articles, and the presence and quality of reported peer-review. When defending their assertion that IWTs are safe, Wind Energy speaks both slowly, and definitively then "hides" behind the spoken words "no credible evidence". A reasonable person would ask "What would Wind Energy consider as credible evidence" and, as a concerned resident, what "credible evidence" have you produced that proves that IWTs are safe?

Purpose of this Manual

In this manual, I have collected information – first for myself - to clarify and resolve my questions and concerns. As the answers became evident (though admittedly difficult to find, clarify and integrate), the story of how this "intrusion" happened became clear and I share it with you. This manual will hopefully later serve as a resource for all who will question what health risks (as known in 2020) may be associated with living close to industrial wind turbines. This information took several years to collect. The process by which Wind Industry acquires county permitting is "rushed through" in literally only several weeks making this information, given that inconsiderate timeline, virtually unobtainable.

In this manual, I present evidence supporting my opinion that Industrial Wind Turbines (IWTs) will cause adverse health effects when located near residential properties in formerly quiet rural residential communities. Beyond the potential serious health implications... we all need to fully understand and reflect carefully on the full implication of what these behemoth oscillating blades mounted high on towers will do to our personal and social and environmental communities.

I present relevant aspects of IWT-generated noise - including noise classification and its quantitative labelling through frequency and decibels measures and types of weighting through various filter types and how accurate noise exposure quantification is affected by filtering choices. The unique characteristics of IWT noise are reviewed and compared with other environmental noises. I will review the categories of noise frequencies across the entire range of emission of IWTs and important aspects of noise propagation and attenuation. Please view the table of contents for contained subjects; ALL of these subjects are relevant. The reader **must NOT stop** at the simple debate of "he said vs she said" about health impacts. I found the answers largely in what "wasn't said" and past "acoustical history" and current corporate behavior.

I will highlight important historical events that add to the context of today's IWT regulation. For example, we need to be fully aware that VERY in-depth evaluations were done in the mid-1980s by NASA and the Dept of Energy-funded research. Scientists (N.D. Kelley, et. al.), in their thorough (basic science-level) investigations, were asked to evaluate the potential possible implementation of IWTs for adverse impacts. Their focus was on understanding the physics of wind turbine operation and energy production. They also studied noise types produced by IWTs and observed and reported on the first confirmed cases of adverse health effects that developed with IWT prototypes up to 4 MW in generating capacity. Their initial determinations of ILFN and associated serious AHEs were first raised then and remain relevant to this day, although ignored by Wind Energy and its proponents. Also revealing is the history of acoustical evaluation of health-impacted occupants of some newly erected buildings from the 1970s to 1990s that was characterized as "sick-building syndrome". Recognized in affected subjects, were similar symptoms connected to working near gas-fired turbines. Careful evaluations confirmed that ILFN from indoor HVAC (heating/cooling units) produced the symptoms. Fortunately, buildings can be re-designed, defects in air ducts fixed, and additional sound insulation placed, but the only way to eliminate ILFN from IWTs is to turn them off or distance them from residents and their property far enough away that the ILFN can no longer be heard nor "perceived".

There are other issues besides adverse health effects:

It is important to ask questions and demand that they be answered; DO NOT assume that what Wind Energy is telling you is correct. Questions, such as "where did these setbacks come from? How, based on what we know, can we have setback distances that are so close and still be considered 'safe'? Whose responsibility is it to review these setbacks and decide if they are safe? How did Wind Energy's proclamation that ILFN 'is not a health concern' ever become "accepted?" Why is potentially harmful noise pollution allowed to trespass across the private land of non-participating neighbors – particularly when pollution regulation for other industries occurs up to/at the property line?" I still ask whether the MAE's land easements (for the entire host property) and the value of that land is used as collateral for the financing of the purchase and erection of the wind farms? If it is, what happens to that land ownership in the event that America comes to: 1) reject the denial of Wind Energy's adverse health consequences, **and also** 2) see that Wind Energy is not "green" and requires concomitant availability of back-up natural gas-burning that essentially negates any "renewable" aspects **and** 3) realize that the real cost of that electricity is roughly 3 times the cost of conventional electric power/kw of energy produced once the subsidies are factored out. Shouldn't we be building energy power plants that work nearly all the time (instead only one-third) and have a productive life of at least 40-50 years **and** 4) understand the extraordinary expense not only to maintain a functioning turbine but also related to eventual turbine/site decommissioning and non-recyclable blade disposal costs.

Where does all that money come from? Fifty-eight-year leases are a long time – generations come and go, political party majorities and Presential decrees that control the narratives keep flipping and MUCH better power production sources will become available. We need to think more about this before "leaping further."

I include in "Part 9" important findings while searching for an explanation of why inflicting harm on people living in host communities is "acceptable". To understand why things don't make sense you often have to explore the motives of – (in this case, including, but not limited to) Wind Energy. Beyond the motives, are the real actions

and developed agendas that allow an industry to secure, maintain and perpetuate "their narrative." I have included several examples of what some would call "blatant" deception. For example, there is a formal presentation made by a Danish healthcare practitioner (Dr. Johansson) to Vestas' executives where "the truth was told" but his warnings were ignored. I will leave the reader to draw his own conclusions. Sadly, the whole process continues largely unchanged. Wind Energy apparently deems their current approach as a successful business plan and continues their practices largely unchanged. We, as the users who consume electricity, have a right to know the truth behind the industry's talking points.

It would be unfair to criticize wind energy production as an answer to global warming without offering other solutions. That said, one might assume that if an obvious better choice was available without all the problems and negative health impacts as I have reviewed, it would've been pursued. However, there are alternatives that are ignored. My comments are listed in part 10, "Carbon Management".

Stay Focused on the "Broad" Definition of Health

When the public or politicians are asked if wind turbines are dangerous or cause health problems, they sometimes "mentally imagine" the worst – post-apocalyptic or post-wartime images or even human suffering with death and hospitalization of the order we now see with the Covid-19 pandemic. Even "captured" politicians, proponents, and/or Wind Energy trade organizations couldn't sell that when subjected to any scientific scrutiny. Instead, we need to remain "broad-minded" to what health actually is - which is NOT limited to a defined set of continuously disabling symptoms that evolve in everyone over the short term and likely affects everyone the same. It is also not limited to a health effect that is progressive until death develops or when eventual disease syndromes become established with an established diagnosis. Adverse health consequences of environmental noise can be the asymptomatic (unrecognized) development of hypertension or vascular atherosclerosis or insulin resistance or can be much simply defined as the "the loss of wellbeing". Indeed, some of the most common and impactful adverse health effects may come "as" headaches, tinnitus, dizziness, subtle confusion, unexplained loss of ambition or productivity, emotional lability or obvious or subtle depressive symptoms. Noise adverse health effects may initiate and accelerate disease progression, that **may,** when combined with genetic or known "accelerators" of disease (smoking, alcohol abuse, etc.) over a life-time, manifest as a recognized cardiovascular disease event – stroke, fatal or nor-fatal heart attacks.

The World Health Organization (WHO) defines "health" as a state of complete physical, mental and social wellbeing... The WHO definition links health explicitly with wellbeing and conceptualizes health as a human right requiring physical and social resources to achieve and maintain. Mental and physical health are inextricably connected, thus highlighting that "annoyance" – at almost any level – can contribute to adverse health effects (AHEs). As described by DeFrock (Australian), "Annoyance is a non-quantitative word that implies mildness in common use. A more accurate general descriptor would be mild, serious or 'intolerable' impacts." In the context of this report, "annoyance" generally means "High Annoyance" where it can result in indirect adverse health impacts. But even "mild" annoyance can create a negative or disagreeable reaction (which is NOT the nocebo effect) that can create a loss of wellbeing. Wellbeing refers to a positive rather than neutral state, framing health as a positive aspiration. Wellbeing is defined as "the state of being comfortable, healthy or happy". Shouldn't we protect an individual right to health and happiness – that defines wellbeing - by limiting intrusive noise pollution at one's private property line?

Cardiovascular Disease Explained (simplified)

In the Cardiology world, "atherosclerosis" is a term describing the development of (lipid (fats)-filled plaques) that get sequestered within the superficial inner layer of arteries that is contained by a "thin fibrous cap". These are initiated and develop through a complex process simply characterized as "inflammation". Standard cardiac "risk factors, e.g. smoking, diabetes and others) facilitate atherosclerosis development. As plaque evolves, there is a complex action via cellular and neurohumoral processes that appear to be quite similar to those seen originating from other triggering sources. Some of those sources include small-sized air pollution particulates, PTSD, and of particular importance, environmental noise. In my medical practice I treat atrial fibrillation. Nearly half of those patients also have obstructive sleep apnea (OSA) which is thought to have significant adverse inflammatory triggering that may promote concomitant ischemic heart disease, hypertension and insulin resistance. Although likely less intense as a "stressor" than OSA, I believe IWTs act similarly through a stress related inflammatory pathway to promote cardiovascular disease.

With noise as the trigger, it is thought cardiovascular disease is promoted from "from an increased physiologic stress response" from noise levels "in excess of defined intensities". It appears there are noise thresholds (which the WHO has attempted to define). Similar to OSA, it may also occur indirectly through noise-associated sleep disturbance which then produces a "stress response" via the sympathetic limb ("fight or flight") of the autonomic nervous system. The autonomic nervous system can trigger vessel inflammation which then can promote atherosclerosis. In general, the more and longer the stress continues, the older the individual (with more time to develop larger and more "unstable" plaques), the more the likelihood that disease will become evident or "expressed". With often unpredictable sudden "stress response triggers and/or anatomical plaque instability," the plaque ruptures, exposing the lipid-rich core that initiates "local clotting" that may enlarge and propagate causing potential artery closure that quickly produces a state of deprived "down-stream" oxygen delivery. In the heart, when this happens, it causes a heart attack – termed "myocardial infarction". Health means living a life where such consequences become less likely through avoiding or mitigating "unconscious inflammatory bodily responses" that promote the genesis of disease states. Atherosclerosis development should never, minimally, suddenly or eventually be allowed to continue so as to produce cardiovascular disease "endpoints".

World Health Organization Comments on Wind Turbines (2018 Report)

Acceptable environmental noise exposure levels are defined in the Oct. 2018 WHO report for aircraft, rail, general industry, and road traffic sources, with "strong recommendations". That rating reflects the quality and the amount of the scientific data relevant to those studied noise sources. Also, in that publication - for the first time - a suggested "conditional" exposure level for wind turbine noise exposure being expressed as "Lden" was published. Lden means average sound Level: day, evening, and night of AUDIBLE noise as "averaged" over a 24-hour period with penalties of 5 dBA for evening periods, and 10 dBA for nighttime periods. It is measured using an sound meter set to use the "dBA" filter and weighted by time of day for the penalties. That filter is the most common one promoted by Wind Energy in turbine acoustics and is "centered" around 1000 hertz. The problem with this is that it does not accurately reflect the acoustic energy of ILFN. The conditional wind turbine noise level exposure was a limit of 45 dBA Lden, equal to that of aircraft noise but substantially lower (more restrictive) than railway or road traffic. Assuming wind turbines operate 24 hours a day this limit is equivalent to a 38 dBA Leq 24-hour average sound level. The data review committee of the WHO document recommended "policymakers implement suitable measures to reduce exposure from wind turbines in that population exposure to levels above the guideline values". The "conditional" recommendation reflected that the data was not "robust enough (statistically, due to small numbers of subjects)" to support a "strong" recommendation. Importantly, they commented that there was no data suggesting that there was no risk. It is worth noting that the WHO's 38 dBA Leq 24 hour average is what would be calculated using the American National Standards Institute (ANSI) and Acoustical Society of America (ASA) Standard S12.9 Part 4 for assessing Land Use Compatibility. It is important to consider that the pre-specified health outcome evidence used was mostly limited to more serious adverse health consequences such as ischemic heart disease (atherosclerotic disease related), hypertension (elevated sympathetic tone and acquired loss of normal vessel relaxation related) as well as the prevalence of highly-annoyed populations (outdoors). Because wind turbine sound fluctuates as much as 11 dBA above the average this level would not eliminate stress from moderate annoyance or sleep disturbance.

I have also included "noise response curves" for severe annoyance in the appendix of part 6 (Adverse Health Effects) from the Wind Farm Noise Textbook (Hansen, Doolan, Hansen, 2017) that show published data (2001, 2008, 2016) from several studies. These two graphs IMPORTANTLY reflect an even greater annoyance from IWTs (which is dominated by low frequency noise) than what is reflected by dBA measurements (measuring only audible noise) as was used in the WHO report. This highlights that IWT noise is commonly described as "distinctly annoying" and is composed of noise from nearly all portions of the noise spectrum, rumble, roar and whoosh type sound. Indeed, the omnipresent component of ILFN is a real and prominent contributor to increased annoyance from IWT noise. IWT noise can be even heard when below background noises like leaf rustle, comprised of mainly mid and high frequency sound in communities at night likely due our perception of that low frequency noise component. Annoyance derived across the "wide-range" of frequency components of IWT noise NEEDS be accounted for when enacting "protective wind ordinances."

It is remarkable (to my knowledge) that Wind Energy has not commented on these incredibly high-level scientific assessments of potential concerns of environmental noise. The WHO virtually echoes that IWTs have never been shown to be safe. The WHO also clearly moves **toward** the level of declaration I make in this manual: that IWTs have AHEs including possibly serious cardiovascular effects. In fact**, there is strong credible evidence** that IWTs produce serious AHEs

I would suggest separate regulatory noise limits for both audible and ILFN noise exposures with both 40 dBA (for audible) and 60 dBC (for ILFN) noise limits – each expressed as "shall-not-exceed" dBA or dBC (Lmax(fast)). Compliance with these limits shall be measured by Class 1 sound level meters set to use the "fast" measurement circuits. Other circuits incorporate averaging which will understate the fluctuating character of wind turbines that is the likely cause of annoyance, sleep disturbance, and other AHEs. Despite that MAE would like to suggest otherwise, dBC measuring tools are "standard" on professional grade sound measuring equipment which can measure both at the same time. Noise levels can be easily obtained at the property line. Prior regulatory parameters of setback distances (e.g. 1500 feet) or 45 to 50 dBA as Leq averaged sound levels) will NOT be protective of human adverse health effects. They do NOT account for fluctuating audible and ILFN acoustic energy – that have been correlated to AHEs, or the location of non-participating residences on their properties. When any wind contractor sites a turbine, they should include a design safety factor to be certain that during periods of fluctuating sound emissions the project will not exceed either of those noise limits or it will be "out of compliance". If they are uncertain about audible and ILFN propagation/attenuation or the accuracy of computer modeling, then a greater distance-separation or use of a quieter wind turbine make and model should be used so as to completely eliminate the potential of harming residents". Sound limits are carefully defined to protect residents and should not reflect a compromise to facilitate industrial development. Non-compliance or less restrictive noise limits that result in resident harm is NOT acceptable as reasonable "collateral damage". Of note, George Hessler published a 2004 article that proposed dBC criteria in residential communities for low-frequency noise emissions from industrial sources that do not have fluctuating sound as a primary characteristic.

What are the Noises that IWT make?

IWT noise includes regular, dominant "pulsing" sensations perceived as either audible fluctuations in the sound or as bodily "pressures" due to air compression of the flowing air mass. These pressure waves are caused by changes in the lift of each of the 3 blades as they pass in front of the huge supporting tower. Also, as the blades rotate through the frequently vertically-stratified moving air mass, they may, under heavy "loading" conditions, lose lift (or stall) producing perceptible rhythmic swishing/thumping sound to which residents can become sensitized. Residents can often perceive these fluctuations as "whooshes" or "thumps" at considerable distances, well over a half mile - which is quite disagreeable and difficult to block from one's awareness and may occur at a distance where the IWT cannot yet be seen, especially during the night when people are sleeping in quiet bedrooms. There is a rhythmic pulsation generated at the trailing-edge blade noise by the steady rotation speed that produces "blade-swish whooshes and thumps" and irregular, low-frequency "roar" from the blades due to in-flow turbulence. Collectively, there is a continuum of frequencies stretching from pressure pulsations at infrasonic frequencies 0.5 Hz (cycles per second) up through the normal hearing range of 1000 to 2000 Hz that are generated by each turbine. The sound immissions from each wind turbine also interact with nearby turbines to produce a constantly changing and distracting medley of fluctuating sound called amplitude modulation. Depending on the frequency amplitude modulation of IWTs, ILFN is both heard and perceived and easily evokes mental and physical stress. Unlike "less complex" daily noises, IWT noise does not become "accepted" by our perception processes and then unconsciously ignored. The subtle but constant changes make it difficult to impossible to ignore. Further, residential construction of residential homes for sound insulation does not effectively block the lower frequency noises. Further, people have a right to sleep with open windows which effectively eliminate any protection offered by walls and roofs. Trying to mask IWT noise by producing bland artificial "background" noise inside a home can only mitigate some portions - but not all of "stress-creating" wind turbine noise. As coping residents engage in their daily tasks, while the turbines operate above, only a momentary lapse of that focus will remind them of the enveloping dome that separates them from the peaceful world they once enjoyed.

Included Important Historical Insights into Wind Energy Claims

I have included in Part #9 a number of related events, letters and a copy of a speech that unveil what Wind Energy (Vestas – largest worldwide producer of IWTs) has done to advance their "narrative" centered around the promotion of IWTs.

When the state of New South Wales (NSW) in southeastern Australia approached Vestas about implementing IWT power, the state government presented to Vestas an initial draft of guidelines that contained low frequency noise regulation that outlined that state's proposed future "recognition, acceptance and treatment" of ILFN. In the beginning of that March, 2012 letter, Vestas in their "Executive Summary" response letter, immediately made clear their opinions about careful, science-based, health-protective regulations that would govern implementation of a new energy technology in NSW. They bluntly summarized: "*Vestas opposes the Draft Guidelines, primarily because of the sheer number of additional requirements and barriers that would be placed in front of the wind energy industry without any clear evidence, justification or demonstrated need for this additional regulation*". By that time (2012), there had been several years of rigorous publications by scientific investigators and acousticians as well as likely thousands of reports of adverse effects including forced home evacuations. In general, NSW concerns were raised that mostly involved human health – in all forms.

These included setbacks (proposed at 2 km), visual amenity, noise, health, decommissioning, auditing and compliance, environmental impact statements, property values, blade throw, conditions of consent and compliance as well as others. Vestas' extraordinarily self-serving retorts to each of these concerns were "abrupt and terse" (and without basis) – other than they are viewed as too restrictive to advance IWT introduction – which they admit was **the** primary issue. Comments about noise from NSW in the draft were recommended to "*be deleted in their entirety*" so as "*not to give the impression that the NSW Government places any credibility in the false claims of the anti-wind activist groups on the topic of health impacts*". Decommissioning concerns were raised by NSW. Vestas did support a decommissioning and rehabilitation plan in the **environmental assessment** report, however, did not support the requirement to provide a decommissioning bond, nor have periodic updates in anticipated costs and implied that wind farm operators would maintain their assets for as long as possible since wind is "free." Vestas did not support the adoption of the noise guidelines as they claimed they were: unnecessary, discriminatory, and unclear. Again, the word "obfuscation" comes to mind. It should remain absolutely clear to any entity regulating IWTs into their jurisdiction that all these topics (and more) raised here ARE relevant and need to be addressed in writing in any Wind Ordinance; if it is not clarified, then compliance cannot be enforced.

ILFN: Convenient Flip-Flopping by Wind Energy for their Agendas

Further, to have health protective IWT noise regulation, as noted many times, recognition and regulation of ILFN is "critical". It is also my opinion when reviewing several "lines of historical action and commentary by Wind Energy" that Wind Energy recognized (certainly no later than the mid-1990s) the "threat" of ILFN to their business. As mentioned earlier, N.D. Kelley clearly identified the existence and the health threat from ILFN in the mid-1980s. In the same letter (above) and then in another one just a year before, Vestas reveals that they knew "true implications of ILFN and its health concerns". In the response to NSW suggested guidelines, Vestas denied that ILFN was a cause of AHEs and proclaimed: 1) it is therefore unnecessary to require the prediction and monitoring of low frequency noise emission from wind turbines, 2) the existing and well- validated industry standard models for acoustic propagation are not designed to deal with frequencies at the low end of the audible spectrum, specifically because noise emissions in this band are not considered to pose issues likely to affect the surrounding environment, 3) "accordingly" Vestas suggests the removal of the requirements to measure low frequency noise from the Draft Guidelines. Yet, less than a year **earlier**, Vestas AU had written a letter to the Danish EPA claiming that a new low frequency noise limit for wind turbines could not be met because there were no design changes to modern utility scale wind turbines that could further reduce wind turbine noise to meet the new low frequency limits. On the one hand they claim there is no problem, and on the other hand they claim that there is no solution to a problem that they admit is a characteristic of wind turbines. (My comment: There is something rotten in Denmark). It is clear to me that Vestas recognized that ILFN would be a defining concern for IWTs – particularly as power generating capacity increased (which Vestas was rapidly designing and implementing for future designs). The newer larger MW models use longer the blades and slower hub rpm. This results in more ILFN than for earlier lower MW models with shorter blades and faster rotation

speeds. The Wind Industry has adopted Vestas' stance about ILFN importance. We, as the potential residents to be affected and possibly suffer harm, need to clarify for ourselves the true existence of and potential harm from ILFN and react responsibly by regulating these harmful emissions generated by IWTs – especially with increasingly larger models that are more often being "clumped" together.

The Need for Informed Consent when KNOWN Unknown-Risks Exist.

The proposed affected residents, by a super-majority, opposes the plan (for Arbor Hills Wind Facility, Madison County) based on concerns of adverse health risks. At the same time, only a small-minority of easement owners (22%) actually live on the property and would have to endure the same health consequences. Reportedly they are not allowed, by contract, to raise health-related concerns that might arise while residing at the property. How this affects people living on that property to farm the land is not known. Having spoken to residents about their "signing experience" with a wind industry, they didn't recall that the representative declared the turbines "safe". They did, however, clearly remember that there was no listing or mentioning of possible adverse events, reports of serious or mild annoyance nor potential longer-term cardiovascular consequences. This failure to disclose potential risks to the participating landowner OR the non-participating (but still noise-affected neighboring resident) is bothersome and reflects a lack of due-diligence, oversight, and protective jurisprudence. With decades of ongoing concern and innumerable science-supported reports of occurring harm and well-researched plausible serious adverse health effects being published, one could reasonably describe the omission of informed consent as a failure of duty of the party seeking the easement to properly notify the lease of known risks. (Writer comment: While I not an attorney, very similar scenarios occur in human research where volunteers are asked to participate in a "condition" where there are unknown (or let alone known) potential health risks in return for financial compensation. To a reasonable person, such easement contracts demand greater transparency and much higher levels of subject protection. While it is true that Wind Industry contractors are not involved in a "medical study" per se, they are entering into a contract with potential known and unknown health consequences for which a consideration of payment is given in exchange for accepting the potential harmful consequences of exposure to that added risk, (IWT noise emissions).

This "Manual" is to Promote a Clearer and Accurate Description of Industrial Wind Turbines

I have written this personal statement for myself to collect, consider and organize the mass of information and misinformation present on IWTS. I personally have known the feelings of surprise, bewilderment, confusion, and hopeless frustration upon learning that a large industrial complex could be permitted into quiet rural residential locales that is zoned for agriculture. At county meetings where citizens voiced their concerns "on both sides" of the argument, there were some that mentioned it was their "right" to be able to earn income from the leasing of their property. Of those relatively few, there was no one that I can recall that said that it was acceptable that wind turbines could then produce noise that would actually harm their neighbors. None mentioned that their neighbors also have a "right" to enjoy the peaceful use of their properties. The authors of a comprehensive textbook "Wind Farm Noise" distilled all the conflicting pro- or anti-wind rhetoric in a simple declaration: **"it is time to stop debating whether or not a problem exists. It is well known that wind farm noise does result in sleep disturbance and health effects for some people and the time has come to decide what to do about it. The fact remains that some people are so affected by wind farm noise that their health suffers and some are forced to leave their home in order to achieve an acceptable quality of life."** We need to respect each other and look for energy solutions that make sense and most residents agree about. I have desperately sought for the truth as minimal information or, (upon fact-checking), frequently incorrect information was given by a power company who planned to produce a "secure profit". I hope this "true" version of truth is useful to those who need to make important decisions, protect themselves and their property and assist for clarification of concepts regarding Industrial wind turbine implementation and regulation. When finally understood in "all in its convoluted and conflicting enormity", it will hopefully be clear where the real questions remain.

Points to Remember: Returning to my initial assumptions upon hearing that IWTs might be placed closely to my property, I mentioned that "I thought they were quiet, good for the world and assumed they were safe". Exploring much further, I now know that NONE of those are true. IWTs make a lot of distressing noise, when

examined as a "possible solution for climate change" they don't make sense given cost, limited life, intermittency, dependence on CO2-producing energy back-up and affordable and adequate battery technology is possibly "beyond reach" and, they are clearly NOT safe for myriad number of reasons which I tried to describe in detail. IWTs cause adverse health effects with that definition being consistent with WHO definitions and currently practiced health care. We are now in an era in science where we know that environmental factors – particular noise – can and does cause adverse health effects which can include serious cardiovascular consequences. Advances in understanding the consequences of disturbed sleep raise concern for contributing to the development of Alzheimer's disease. Shortened sleep duration has been highly correlated with cardiovascular disease development and endpoints of hypertension and ischemic heart disease.

We know the brain while "sleeping" can still be "aware" of noise (when it reaches a certain intensity (loudness) threshold and responds to it through body motility, even full awakening or "regressing" in its process of reaching various stages where vital restorative recovery of normal brain function occurs. Sleep disruption occurs with audible and, likely more importantly with IWTs, with lower frequency noise. The WHO has recently listed wind turbines as a potentially important source of environmental noise. While "high-level correlative data" does not exist yet, the WHO lists noise thresholds for potential disease development at levels lower than road traffic. Other analyses using severe annoyance metrics that include ILFN exposure drive the threshold noise levels much lower yet. Observing current, more inclusive definitions of health, IWTS do produce AHEs as annoyance (from mild to severe), and have been shown to disrupt normal sleep stage progression.

Utilizing metrics of biologic plausibility, as described by Sir Austin Bradford Hill, if met, can establish a "causal link" between WTN and AHEs for epidemiological purposes. As examined by Jerry Punch and Rick James in their 2016 comprehensive review (ref. in text), all 9 of The Bradford Hill criteria have been identified in the scientific literature as pertinent to the relationship between IWT noise and AHEs. Dr. Hill states, *"None of my nine viewpoints can bring indisputable evidence for or against the cause-and-effect hypothesis and none can be required as a sine qua non. What they can do, with greater or less strength, is to help us to make up our minds on the fundamental question – is there any other way of explaining the set of facts before us, is there any other answer equally, or more likely than cause and effect?"* In his final address observation, he asserts: *"All scientific work is incomplete – whether it be observational or experimental. All scientific work is liable to be upset or modified by advancing knowledge. That does not confer upon us a freedom to ignore the knowledge we already have, or to postpone the action that it appears to demand at a given time."*

Finally, included at the end of part #15, Mathias Basner, MD, PhD – who is considered a world leader on health effects from environmental noise, produced an editorial (2019) where he reviewed the potential impacts of noise on our health. He acknowledged the problem of smaller populations in currently available studies which make statistical powering of conclusion difficult. He has stressed that NONE of the wind noise guidelines data from the 2018 WHO report found an "absence of risk". He finished his comments with *"the fact that more studies are needed should not lead us to postpone the urgently needed protection of the population from noise." The knowledge we have acquired so far IS SUFFICIENT to take preventive actions and substantiate them with respective legal noise regulation.*

We have all learned that all people suffer to some extent– it is part of being human. But to intentionally force suffering upon affected citizens for the financial benefit of others is immoral. To "mentally take refuge away from guilt" by assuming huge "pinwheels spinning in a neighbor's field are ***silent****" and believing Wind Energy's mantra of 'no credible evidence' that IWTs cause human harm is patently disrespectful, unprofessional, immoral, and grossly irresponsible. We can and must do better.*

Needed Declarations:

1) I am a Cardiologist who specializes in heart arrhythmias (Electrophysiologist) who focuses on abnormal fast and slow heart rates/patterns, implantable device (pacemakers, defibrillators) therapy, and have participated (investigated, published and presented) clinical research for decades. I also have been privileged to be involved with human research and served as the Chairman of the City-Wide Investigative Review Board overseeing the ethical conduct of ongoing local clinical trials. In those patient trials, high standards of participant protection and adverse event evaluation was paramount. I am drawn to understand the societal (local and international) impacts of IWTs – particularly health. I also felt compelled, through my years of human research experience, to protect the health, safety and welfare of myself and my fellow citizens.

2) I am not an Acoustician. An Acoustician is defined as an expert in the branch of physics concerned with the properties of sound. I have, however, corresponded at length with several Acousticians who have "specialized" their acoustical practice into the understanding, measurement and regulation of industrial wind turbine noise. They have shared with me their acquired in-depth understanding of IWT noise and its impact on people – from the details of measuring and interpreting noise to the impacts of that noise on people's lives. They have directly talked and worked with the victims of IWT noise exposure. They have been invited into these unfortunate people's homes and first-hand have measured, experienced and, on several occasions, have themselves suffered serious adverse health events from those noise exposures. They, through their professional lives, have seen the unfolding of IWT introduction around the world, interacted with key both pro- and anti-wind experts, and from their unique vantage point, provided a clearer understanding of the "real issues" and the history behind those issues. They have presented at national societal meetings, offered insightful theories and clarifications to their worldwide colleagues, published peer reviewed papers, testified in court trials, and at the request of governments. They are members of the Institute of Noise Control Engineering (INCE) and/or the Acoustical Society of America (ASA). The INCE/ASA Member has experience in noise impact assessment, the effects of noise on people, and control (complaints, annoyance, noise specifications) and is committed to their Canon of Ethics for unbiased professional services whose first mission is to protect the public's health and welfare. They are motivated to move forward into the "headwinds of greed and misinformation" because as professional experts, "they care about people".

3) The origins of the information I have presented and summarized, I believe to be reliable, verifiable and accurate. I, in no way, have manufactured history, slandered nor created (recently popularized) "alternative facts". I have expressed personal opinions based on collected information that I believe to be factual. My "physician opinions" come from four decades of interviewing, examining patients and applying basic human physiology and medical science in the effort to protect and improve their lives. I have read and re-read reviews and individual papers from both sides of the argument. In the enormous "confusion" of pro- and anti- Wind information, I have tried to focus on the quality of data being mindful of bias and full disclosure of and composition of reported "peer review" entities. I have looked specifically for the origins of noise regulation and the process by which current IWT siting practices became established.

July 1, 2020: Board of Zoning Madison County, Iowa

Re: Wind Turbine Ordinance for Madison County, Iowa

Dear Madison County Board of Zoning Members,

I have submitted his letter to support the process of obtaining a Wind Ordinance that best reflects the health, welfare and safety of our county. I am a board-certified Adult Cardiologist and Cardiac Electrophysiologist who lives in Madison County. As you very well know, the choice of having industrial wind turbines (IWTs) placed in our county is extraordinarily contentious. They are advertised as "green, less expensive and sustainable". The last several decades have seen a worldwide surge in the placement of these industrial-dimensioned turbines - beginning mostly in Europe and eventually coming to the U.S. where onshore implementation has been pursued aggressively. Studied very extensively in the mid-1980s, IWTs were rejected (seemingly) by the federal government, due to concerns of potential serious health hazards. The merits of those intensive studies finding harmful noise production by large-scale industrial wind turbines remain to this day and have never been discredited by Wind Energy. Industrial Wind Turbine approval and regulation have now been passed to states, and in some cases (as in Iowa), local municipalities and counties. Understanding all the complex issues of health concerns related to IWTs has taken, to date, nearly 2 years of my focused inquiry. New health concerns are raised continuously as independent research around the world continues. The Macksburg wind farm was placed several years ago. Currently, the Arbor Hills wind farm extension from Adair into Madison County is on hold pending the Iowa Supreme Court review of the procedural compliance by Madison county's Board of Adjustment in July, 2018 in a 3:2 vote to proceed with IWT placement.

As you know, the Madison County Board of Health (BOH) solicited and obtained information from local citizens, health professionals as well as Mid-American Energy. They were given enormous amounts of information to review and carefully consider in their consideration of the health impact that IWTs would have on the health of the county. They considered scientific information that was current at the time of their public hearings with a considerable amount of new information becoming available since the time of the initial Mid-American Energy

proposal presentation. Concern revolved not only around "annoyance" which has been deemed a health risk by the World Health Organization but also included more important concerns of sleep disturbance and chronic autonomic nervous system "hyper"- activation that, over significant time, may pose a risk to chronic cardiovascular disease and other adverse health events.

The BOH voted 2:1 declaring a potential adverse health risk exists with exposure to industrial wind turbines. They recommended, based on extensive data and peer-reviewed summaries (mostly the Punch/James article) that IWT setback should be 1.5 miles from property lines.

Of note, Madison County is NOT alone in their country governance process that includes a required opinion from the County of Health. In Chautaqua County, New York, the Board of Health Meeting on November 21, 2019 that called for a 1.5- mile setback and 35 dB(A). They requested that other municipalities in New York state to do the same. They are supported not just by their BOH but also the Western New York Health Alliance and the New York State Association of County Health Officials.

The 2016 review by Jerry L. Punch and Richard R. James "Wind turbine Noise and Human Health: A Four Decade History of Evidence that Wind Turbines Pose Risks" is, in my estimation, the most complete and fair review of this highly contentious topic.

You may find this Link extremely informing:

https://hearinghealthmatters.org/journalresearchposters/files/2016/09/16-10-21-Wind- Turbine-Noise-Post-Publication-Manuscript-HHTM-Punch-James.pdf

Their science-based review is organized by summarizing the past and present literature that addresses each of 12 selected statements that encapsulate specific claims or positions commonly taken by advocates for the Wind Industry. On page 5, Table 2 on page 28 in this publication are listed recommended minimum siting distances and maximum noise levels of industrial wind turbines based on the protection of human health. Seven referenced setback distances were listed with four recommending 1.25 miles or 2 km setbacks. The greatest distance listed was 4 km to protect against enhance amplitude modulated turbine noise which originates from the ILFN (infrasound, low-frequency noise) spectrum which Wind Energy denies poses any risk to humans. The shortest distance was 0.5 miles but with concomitant sound level requirements which would be impossible to achieve with the very large MAE proposed 2 MW IWT for Madison County.

Those concerns were felt to be reasonable and probable given the October, 2018 World Health Organization position document on Environmental Noise and Health as it concerned exposure to other (analogous) forms of noise from traffic, railway and aircraft noise. The key contentious point was that data was currently not "robust" enough nor "specific to" IWT noise to prove that IWT exposure caused sleep disturbance disabilities and, long-term, directly caused cardiovascular disease such as hypertension and facilitated atherosclerotic disease manifested as fatal and non-fatal myocardial infarctions. There was no disputing data but the quality of the data was deemed "conditional" by the WHO. Yet, importantly, the WHO for the first time, issued average exposure noise levels for IWT emitted noise (unwanted sound) as it did for the other 3 prior-tracked environmental noise sources.

Concerns were raised about IWT noise in previous 1999, 2009 as well as the 2018 statements. All statements primarily revolved around the adverse health consequence of sleep disturbance.

It is important to recognize that MAE representatives during the public hearing in our courthouse and quoted by Wind Energy over the last 35 years used the phrase: "if you can't hear it, it won't hurt you" when referring to potential adverse health effects arising from IWT production of "infrasound" noise. I very strongly disagree with MidAmerican Energy's glib statement having dealt with health consequences of "provoked" autonomic nervous systems in over 35 years of practice of subspecialty cardiovascular care. Like carbon monoxide, methane, radon gas from basements, radioactive fallout, inhaled asbestos - among many examples - what you can't hear (and in those cases, also can't see) **can** hurt and even kill you. Although long suspected that chronic noise exposure - including infrasound - was harmful, the objective nature of those risks is now being quantified.

I would agree that connecting minimal, let alone loud levels noise to hard endpoints of disability and even death is not intuitive. The vast majority of people think that IWTs are **"silent"** as their blades turn. That is what the general, unexposed public have come to imagine as they pass them on the interstate at 70 miles an hour with their windows closed or even open given all they could hear would be "background noise" of the turbulent air flowing through the window opening. One must drive to operating IWT sites in the country, park in the

"midst" of the operating turbine forest, get out of the car and simply listen, and focus and think about what that complex "clawing/scraping" noise that you can hear and infrasound that you can't "hear" but could "perceive" during sleep - especially if you become unlucky enough to become sensitized (hyperaware) to those sound emissions. Even more informational to understanding the true impact of IWT noise is listening to the turbines operating in the late evening at a time someone would be trying to fall asleep.

Fortunately, as you live your life - in your home or at school or work - if you live far enough away from that noise source, the immediate consequences of annoyance and the much later potentially serious health consequence of audible, infrasound and low-frequency noise can be largely avoided. I wish the citizens of Madison County to have both the rights to rent their land to Mid-American energy for electricity production AND to enjoy the right to live in a truly healthy environment where they safely raise their children and grow old and enjoy their chosen rural lifestyle and where Nature is not threatened by oscillating blades. The only problem is that MAE has offered some of our citizens the chance to lease land for monetary gain but with turbines so big and powerful and of such a design that they pose serious health risks to others if placed too close to their neighbor's property line which is almost always within the range of harmful IWT noise travel. Indeed only 22% of landowners having easements in The Madison County portion of the Arbor Hills proposal would be exposed to the noise exposure they accepted in return for money while nearly 75% of actively polled nearby resident **do not want them** principally because of what they have learned about the health risks.

I launched into this in-depth learning experience because I care about how these will affect our countryside - health, wildlife, property values, view scape among many other reasons. I immediately suspected motives and perceived lies and later learned of "captured" behavior and "conflicted" elected officials who have been given the privilege and responsibility of voting for us and our health and quality of life. The mere elimination of an easement contract to allow a supervisor to very actively promote the preferred language of Wind Energy's requested ordinance does not eliminate their current conflict or future conflict. My motive of speaking up is for transparency and accuracy of data in areas with which I am familiar.

I would ask that you read what you can in the time that you have.

Suggestions for Manual Use:

This information has been structured to allow focus on different aspects of IWT consideration.

Part 1 is the introduction.

Parts 2 through 13 cover basics of sleep, wind basics and types of IWT emissions. The history of our understanding of IWT noise emissions and the extremely important "evolution" of the current sound level limits as proposed by the World Health Organization (WHO) that are completely ignored by MAE.

I spent a lot of time describing adverse health effects (AHEs) with particularly concern about Wind Energy's denial of infrasound contributions to adverse health effects - modern, science-supported data is provided in stark contrast to their "non-response". I also included a variety of other topics - ALL of which are relevant in considering IWT intrusion into our county. I reviewed peer review and included critiques of Wind Energy's favorite ACWEA report. Although I will be the first to say that I don't actively "dig up dirt", becoming familiar with an organization's agenda is important and some extraordinary past actions by Vestas are included for your review and thoughtful integration into the manner of their proposals and starkly limited amount of information that their product is safe for our fellow citizen. Again, these are my opinions. I discuss my views on carbon management and what Iowa should be focusing on. Critical points about noise regulation is covered in part 11 with important concepts of ordinance examples and regulation then finally recommendations are given. I would very strongly request your consideration of requesting more accountability and oversight for MAE or other Wind Industry firms. Remember, they don't live here, we do.

Part 14 is the Summary which is much shorter than the accumulation of information in parts 2-13 and would serve as the quickest way to begin to be conversational about this complicated topic.

Part 15 is my Conclusion which focuses on adverse health effects. There I provide statements from the best sources I can find with their opinions and suggestions. We all agree.

I have included various graphs and statements provided in the various "parts". Please review them. I would very strongly ask you read a speech given to Vestas in Denmark by a Danish national health care spokesperson, Dr. Johansson. In three page he exposes what we now are witnessing in Iowa.

We need to see this Wind Ordinance crafting as an opportunity and a need to protect ourselves. It should not promote reckless development with short-sighted gains - with most of those gains not going to this county. One should fairly request provisions that ensure compliance and safety. If Supervisors say that "if you make it too complicated and restrictive, they won't come". That is industry's problem.
We only are asking for respect and concern for our health and way of life. Our Wind Ordinance should reflect our stated responsibility to protect the Health, Safety and Welfare of Madison County, Iowa.
Thank you for your Commitment to our County's future.
W. Ben Johnson, M.D.

Part 2 Sleep:

Importance:

The majority of the industrialized world struggles to obtain adequate and restorative sleep. We constantly weigh exhaustion with the need to accomplish more. Work schedules vary and are consuming and pressurized. We balance our needs with the needs of our families finding little time for ourselves. Inadequate sleep begets mental and physical stress which begets chronic mental and physical disease.
Disturbed sleep is the most concerning adverse health effect from industrial wind turbines. It is the key to a cascade of adverse physiologic consequences that may, in the extreme, be associated with a host of potentially serious cardiovascular outcomes. While it is clear that such a relationship exists from exposure to automobile and train and aircraft noises, the data is not robust enough to confirm the same concerns with industrial wind turbines although there is rapidly accumulating data to support that association.
It has, however, reached scientific support to invoke a "Precautionary Principle" as adverse health consequences may be serious consequences and proposed wind farm development is extraordinarily expensive, multiple decades long in proposal and is highly unlikely to achieve the goal of being clean or renewable. The "precautionary" principle has been defined as a broad, epistemological, philosophical and legal approach to innovations with the potential for causing harm when extensive scientific knowledge on the matter is lacking. Epistemological relates to the theory of knowledge, especially with regard to its methods, validity and scope and the distinction between justified belief and opinion. I believe that current science does provide a "justified belief" and NOT mere opinion even in the matter of IWT noise and triggering cardiovascular disease. This principle emphasizes caution, pausing and review before leaping into new innovations that may prove disastrous.
It is worthwhile reviewing the process and importance of sleep thus recognizing the profound implications of appropriate siting of turbines to lessen the consequences of sleep disruption in their homes. Increasing "setback" distance from residence to IWT is the ONLY way to lessen wind turbine adverse health impacts.
Non-REM sleep typically occupies 75-80% of total sleep each night. This period provides time for essential brain function recovery - tissue growth and repair, energy is stored and hormones that are essential for growth and development are released. REM sleep typically occupies 20-25% of total sleep each night. This phase is when dreaming occurs, is essential for processing and consolidating emotions, stress and memories. It is reportedly vital for learning and stimulating the brain regions used in learning and new skill development.
Non-REM sleep transitions through 3 successively "deeper" sleep levels during the night with increasingly longer, deeper REM periods occurring toward morning. If the REM or non-REM cycles are interrupted multiple times through the night (either as brief, non-conscious arousals or as periods - however brief - of awakening) then we may fail to reach the "deeper" periods of sleep where these "recharging events" can occur.
Consequences of interrupted, non-restorative sleep include feeling drowsy, irritable or depressed. Task efficiency decreases particularly with learning, remembering or making decisions. One can crave more unhealthy foods, which could cause weight gain. It has been described that quality sleep is as essential to survival "as food and water". As stated by the National Institutes of Health, "Sleep affects almost every type of tissue and system in the body - from the brain, heart and lungs to metabolism, immune function, mood and disease resistance. Research shows that a chronic lack of sleep, or getting poor quality sleep increases the risk of disorders including high blood pressure, cardiovascular disease, diabetes, depression and obesity".
The importance of reaching the "deeper" phases of sleep were highlighted with 10/31/2019 article published in the journal "Science" studying humans in deeper, non-REM sleep (confirmed with brain wave (EEG) recordings) while undergoing MRI imaging that measured the blood oxygen levels in the brain and how much cerebrospinal

fluid (brain "crankcase oil") was flowing in and out over the surface of the brain. They discovered that in this portion of non-REM sleep, neurons start to synchronize (turning off and on at the same time). During the momentary periods when cells were "off", they didn't require as much oxygen, so less blood (flow amount determined by vessel reactivity to need) would flow into the brain that effectively created a larger residual space within the skull surrounding the brain. At that time, cerebrospinal fluid would then "rush in", filling in the space left behind from the decreased blood volume in the vessels thus facilitating "waves" of cerebrospinal fluid to circulate around the brain effectively removing metabolic by-products that accumulated during the prior day. Your need for sleep and your sleep patterns change as you age, but this varies significantly. Babies initially sleep as much as 16 to 18 hours per day which may boost growth and development (especially of the brain). School age children and teens need about 9.5 hours of sleep per night. Generally, adults need between at least 6-7 hours. After age 60, nighttime sleep tends to be shorted, lighter and interrupted by multiple awakenings. Elderly people are also more likely to take medications that interfere with sleep. For these reasons, our younger and older county residents are considered more vulnerable in their age-related obstacles to achieve restorative sleep. In general, people are getting less sleep than they need due to longer work hours and the availability of round-the-clock entertainment and other activities. The idea of "catching up" on weekends actually never can be fully achieved.... although one may try...."sleeping-in on weekends" has been recently associated with heightened degrees of insulin resistances measures than simply returning to a normal sleep pattern.

I Have Seen the "Face" of IWT Harm

Three years ago, while inquiring about used farm machinery, I sought out a farmer who lived nearby in Guthrie county. Arriving at his farm perched along the "Mo-Miss Divide", I was fascinated at the distracting "surging" of spinning IWTs "for miles". Greeted by the farmer, I asked him about how "he and the turbines" got along. He noted that " a lot of people had moved away, and over half of those who agreed with their easement signing now regret having done so." Looking into his face, I could see the likely signature of chronic sleep deprivation (a distinctive appearance that I can easily recognize in those sent to me for atrial fibrillation consultations who have concomitant obstructive sleep apnea). His speech was a bit halting and searching.... I asked how his sleep was and whether he thought the turbines had created a problem sleeping. Looking inward, he paused, then scanned the ongoing turbine "wind chopping" and looked down then back up at me. "I don't think so... maybe you get used to it. A year ago, I built a new bedroom addition to my house putting in the best materials I could find with 2x6 construction, thicker insulation and heavier sheathing. It made it better.....(he paused) ...but on those windy nights I can still hear and feel that pounding...."I sensed an exhausted man who had resigned himself to "deal with it". He was imprisoned on his own farm with his entire livelihood around him.

Disturbed Sleep - A Worsening Modern Health Epidemic

We are a society plagued by increasing obesity (now about 40% of Americans are considered as obese with 7.7% being severely obese). The American Heart Association has now included obesity and severe obesity in children as cardiovascular risk factors. With the recent redefinition of hypertension going from 140/90 to 130/80, now >46% of American are considered hypertensive. The incidence of type II diabetes (the type related to "high" insulin levels due to acquired resistance of insulin action at the cellular level) continues to increase in incidence. Somewhere in this "modern health epidemic" is the problem of sleep quality and quantity. The 2019 annual statistical update from the American Heart Association included a new section on sleep and cardiovascular health cited data from the Centers for disease Control and Prevention that only 65% of Americans have a healthy sleep duration (at least 7 hours).

Recent Absolutely "Key" Large Scale Studies Linking Inadequate Sleep to Cardiovascular Events

Recent recognition that restorative sleep - quantified as total duration of sleep that is "effective" – if less than 6 hours per night has been associated with objective "end-points" of disease progression. Dr. Dominguez noted a "graded response" evident in the PESA (Progression of Early Subclinical Atherosclerosis) trial. This large trial (3974 middle-aged Madrid bank employees free of known clinical cardiovascular disease or history of stroke), wore a waist band activity monitor (actigraphy) for a week to record sleep quantity and quality. Movement during attempted sleep reflects often unconscious "brain awakening" that if brief (<15 seconds), may not remembered as having occurred. They also underwent 3-D vascular ultrasound and measurements of coronary artery calcium (via CAT scanning).

The actigraphy confirmed common under-reporting of sleep duration (patients reported 10.7% had < 6 hours via questionnaire vs 27.1% via actigraphy. Multivariate analysis was performed adjusting for smoking, hypertension, physical activity, depression, OSA, daily calories, alcohol intake and other confounding variables. The investigators noted that subjects who slept < 6 hours/night had a 27% greater volume of non-coronary plaque than those who slept 7-8 hours. They also had a 21% more vascular territories (seen on CAT Scans identified with dense calcium imaging integrated in arterial cholesterol plaque formation) laden with subclinical atherosclerosis - women>men in measured effect.

The presenter also stated that the more times an individual typically awoke per night, the greater the number of atherosclerotic carotid or femoral artery territories were documented on 3D vascular ultrasound. The statistical power of this study was extremely high (extraordinarily unlikely by chance to be incorrect).

In another study, cardiovascular investigator Fountas (in Athens) reviewed 11 prospective studies correlating daily sleep duration (self-reported) and cardiovascular morbidity and mortality. Collectively 1,000,541 patients (assembled from many similar, but smaller studies where available data could be combined for better statistical power for subsequent larger population analysis - termed "metaanalysis") without baseline clinical CV disease were followed an average of 9.3 years. Data were adjusted for confounding features. He found that if average sleep was < 6 hours, they had a statistically significant and clinically meaningful 11% increase in the risk of a diagnosis of fatal or nonfatal cardiovascular disease as compared with those sleeping 6-8 hrs. Moreover, those sleeping > 8 hours had a 32 % increase in those endpoints compared to 6-8 hours. (Longer sleep duration possibly related to morning exhaustion prompting additional sleep hours to "catch-up").

Both investigators highlighted the pathophysiologic changes related to sleep deprivation that likely increased the pathophysiology of the risk - sympathetic activation, increased inflammation and disrupted glucose metabolism. Again, inadequate or disrupted sleep was very highly statistically correlated to greater cardiovascular disease and their clinical events.

A YouTube Documentary worth seeing

https://urldefense.com/v3/__https://www.youtube.com/watch?v=vRpsO9qAX_A&t=1708s__;!!CqLityr3mSQ!ReCVeyUsTjv4BMmYx88rScisOuiYIMMwbnL4GAtN8Zj_1kLP8YXO-Z8zJaMCjv1rGRY$

The documentary reviews that absolute disconnect of "city-folk" with the realities of IWTs. A community assaulted with IWTs is interviewed... revealing the exhaustion in their lives and chronic nonspecific illnesses - nausea, headaches, etc. and importantly, a lot of dog/pet as well as livestock deaths. Particularly ocular problems were noted with blindness. One of the men interviewed had a lot of eye blinking and trouble focusing - all reflective of eye fatigue not uncommonly experienced by residents. I raise the concern of resonance vibration of fluid filled ocular structures near 5 Hz (infrasound) that could create the symptoms. Although a potentially serious problem, but because IWTs have never been evaluated for safety, it was never (with no current plans to) formally evaluated.

The finding of the "enlarged organs" found with necropsied pets has also been seen and commented upon by other physicians - again, we allow these processes to continue unevaluated.... apparently unconcerned about finding out the truth.

Disrupted Sleep Due to IWT Noise Emissions

Inadequate or disrupted sleep is the most common complaint from residents living near IWTs. It is extremely important to realize that not only does excessive audible noise cause, but with amplitude modulation from the ILFN noise spectrum occurring up to 3-4 km from a household, sleep disturbance can continue even with "reasonable distance, e.g. one-half mile" separation to avoid (usual) higher frequency audible noise. Sleep is "disrupted" through both unconscious arousals and with frank awakenings - both disrupting the healthy progressions through both non-REM and REM sleep periods.

At the 1500-foot setback proposed by Mr. Clifton (Madison County Supervisor), **average** sound levels (expressed as Leq) will be 45 dBA as measured outside the house as predicted by computer modeling. 45 dBA Leq means that there may be recorded peak/nadir or high/low values as another 6-11 dBA above/or below the 45 dBA Leq average. Albeit much less frequent that the average value, audible sound levels of 56 dbA are possible. Testimony under oath by Wind Energy representatives have confirmed these possible noise ranges that are expected from IWT sources. It also means to achieve bedroom levels of 30 dBA your windows will need to be closed tightly with all exterior audible sound not exceeding 45 dBA. Opening the bedroom window even a

little (cracked 6 inches) for cooling or fresh air circulation will marked increase noise entry into the bedroom - enough to necessitate IWT separation another approximately 2000 feet farther to achieve the same interior audible levels as when the windows were closed.

ILFN poses an **even greater** threat to sleep disruption. ILFN generally attenuates at half the rate as does audible sound. This means that (roughly) to achieve the same reduction in noise levels for audible sound, you have to go twice as far to achieve the same noise level with infrasound. Infrasound travels to some extent by resonating in the ground that can then easily resonate a house foundation and structures within the house - being insignificantly lessened by wall/roof insulation. ILFN "sound travel" is frequently described as "amplifying" in the house. Low-frequency noise is audible being 40-60 dBs in the 20-200 Hz range. This would be hard to ignore without sound protection equipment (ear plugs).

The sounds in that frequency range are heard/perceived by people in their beds at night when the house is otherwise quiet as "vibrations", rumble and roar. While not particularly "loud", they are perceived because there are no other noises in the community to provide masking of these low frequencies.

The details of sleep are important; the implications of chronic sleep disturbance are profound. Most adults know very little about the what happens during sleep. Sleep Medicine is one of the most recent additions to an ever-increasing range of medical specialties. It should NOT be viewed as esoteric and beyond understanding...in fact, some of the most recent science is available at newsstands, on-line and delivered to your home. In a recent "double issue" of TIME magazine (August 17/24th, 2020), the editors dedicated 14 pages of the issue to the topic "How to sleep better – the changing science, business and culture of a good night's rest". One subsection was entitled "What exactly is your brain doing while you sleep?" and was highlighted with the words: "New Research on its physiology shows why we need to take slumber seriously".

In the third paragraph they write, "In the past five years, brain researchers have begun to expose a hidden world of chemical reactions, fluid flowing into and out of the brain, and the busy work of neurons that reveal the sleeping brain is as industrious as the waking one. Without good-quality sleep, those critical activities don't take place, and as a consequence, we don't just feel tired and cranky, but the processes that lead to certain disease may even get seeded. One of the reasons we sleep, it now seems, might be to keep a range of illnesses – including cognitive disease like Alzheimer's and other dementias – at bay". They then described the association of "build-up" brain amyloid and another protein call "tau" associated with patients suffering from Alzheimer's disease. In mice, they confirmed those protein levels "dropped dramatically – especially during the deeper stages of non-REM sleep". In mice chronically deprived of non-REM sleep, more amyloid built up in their brains over time than in mice who got regular nightly rest. Similarly, (Holtzman, the researcher) saw similar changes when he compared amyloid in the spinal fluid of people who were well rested vs. sleep deprived. The article continues describing even more promising confirmatory data and ongoing longitudinal studies.

In that same TIME "sleep-focus" set of articles, another writer wrote: "There are many scientific reasons to desire good sleep. Poor sleep quality is associated with a whole host of unhealthy side effects. Getting bad sleep puts people at a higher risk for diabetes, cardiovascular disease, Alzheimer's, impaired memory, problem-solving issues, fatigue, anxiety, mood disturbances and poor performance at work."

Another comment included "The keys to good sleep, I'm told, are simple: exercise; eating well; not drinking too much; a dark, quiet space; creating a wind-down routine; no "screens" two hours before bed; and a comfortable bed. The greatest enemy of sleep is "stress." In my opinion, speaking to the last listed point, the presence of inescapable, non-ignorable large, intermittently rotating massive structures – creating noise while adversely affecting the environment and property values - creates a "lingering" stress that is consciously and unconsciously "recognized and felt". Humans are continually trying (often unsuccessfully), to "resolve or normalize" such intrusions. That strife resolution is ongoing and likely contributes to sleep disruption and annoyance suffering.

In another section, comments from Dr. Louis Ptacek, a neurology professor at the UCSF, commented "human sleep is largely a mystery; getting too little is linked to heightened risk for metabolic disorders,

Type 2 diabetes, psychiatric disorders, autoimmune disease, neurodegeneration and many types of cancer. It is probably true that bad sleep leads to increased risks of virtually every disorder".

I ask, "Why should we not protect ourselves (not only our health but also including our well-being, our families, our properties) through the active protection of our ability to have quality sleep?"

Appendix:

The following table appeared in the World Health Organization Executive summary in 2009 although it had also been published in 1999. Current experimental Sleep Research continues to support the listed sleep disturbance threshold values.

Effect		Indicator	Threshold, dB
Biological effects	Change in cardiovascular activity	*	*
	EEG awakening	$L_{Amax,inside}$	35
	Motility, onset of motility	$L_{Amax,inside}$	32
	Changes in duration of various stages of sleep, in sleep structure and fragmentation of sleep	$L_{Amax,inside}$	35
Sleep quality	Waking up in the night and/or too early in the morning	$L_{Amax,inside}$	42
	Prolongation of the sleep inception period, difficulty getting to sleep	*	*
	Sleep fragmentation, reduced sleeping time	*	*
Well-being	Increased average motility when sleeping	$L_{night,outside}$	42
	Self-reported sleep disturbance	$L_{night,outside}$	42
	Use of somnifacient drugs and sedatives	$L_{night,outside}$	40
Medical conditions	Environmental insomnia**	$L_{night,outside}$	42

Table 1
Summary of effects and threshold levels for effects where *sufficient* evidence is available

* *Although the effect has been shown to occur or a plausible biological pathway could be constructed, indicators or threshold levels could not be determined.*

***Note that "environmental insomnia" is the result of diagnosis by a medical professional whilst "self-reported sleep disturbance" is essentially the same, but reported in the context of a social survey. Number of questions and exact wording may differ.*

Taken from W.H.O. 2009 EXECUTIVE SUMMARY

Part – 3: Wind Noise "Basics"

Wind Turbine Noise:

Sound Spectrum Defined by Frequency

Audible noise 20-approx 15,000 Hz (adult)

Infrasound 0.1-20 Hz

Low-frequency sound 20 to 160-200 Hz

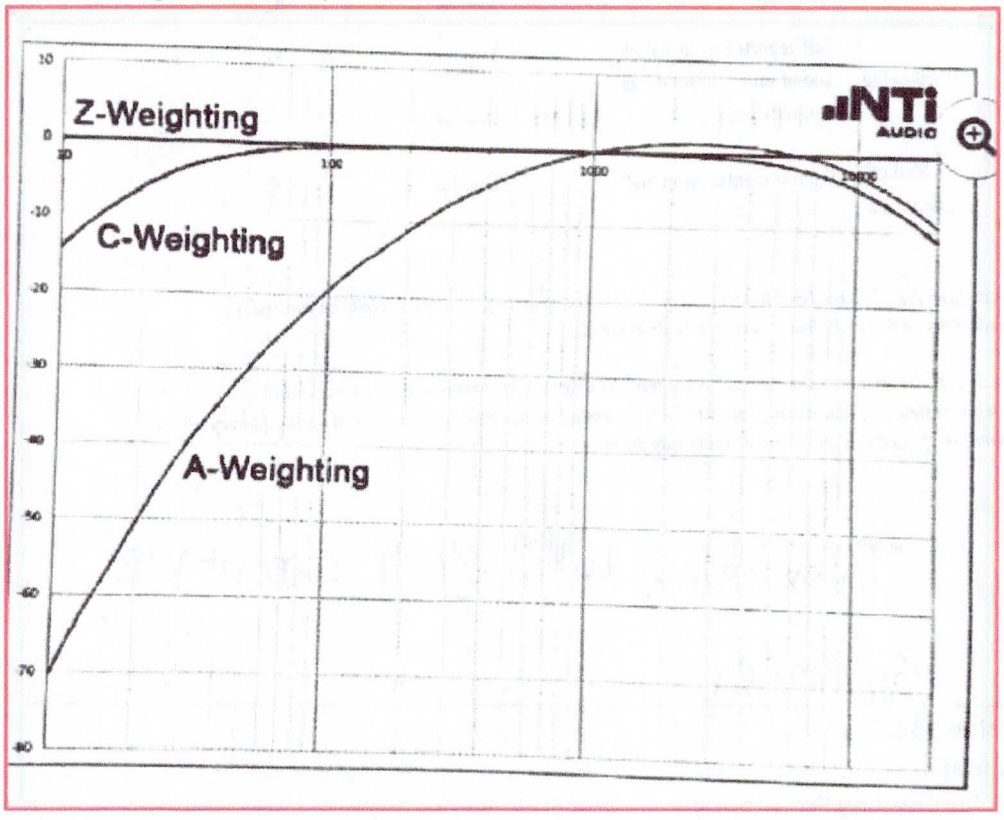
the term "ILFN" combines infrasound and low-frequency noise together.

Note: That "loudness" (or sound pressure) is measured in decibels (dB) and is quantified on a logarithmic scale meaning, e.g., that increasing the measured loudness of a sound from 30 dB to 40 dB (at 1000 Hz) is approximately 2 times louder (not 25%). The relationship of dB change to loudness varies with frequency where change occurs. (See below)

Sound Measurement and "Filter Effects" – Use with IWTs and What it Does and Doesn't Measure

Standards for describing sound levels or limits are set in decibels. Use of "dB(A)" with A, C, G, L, Z classification reflects the filter used during measurement. "A" has been used as the standard descriptor filter around the world but excludes accurate measurements of frequencies below 200 Hz, including both infrasound (0-20 Hz) and low frequency noise (20-200 Hz). This glaring "undermeasurement" of the true "quantity of infrasound using only "A weighting" to describe the whole noise spectrum was a product of the ETSU-R-97 wind turbine siting guideline by the BWEA and the British Department of Trade and Industry. This guideline was developed specifically to circumvent more science-based UK regulations that were more restrictive to IWT placement. As such, it is important to recognize that A-weighted loudness measurements will generally only reflect audible noise content which could also contain potentially harmful inaudible sound content - particularly when used with IWTs. National "standards" in Australia do not require infrasound (either within or outside homes) to be predicted in planning submissions nor to be measured in the required compliance testing to the planning permit noise conditions. Most jurisdictions do not require wind turbine-generated low frequency noise to be predicted or measured (unlike other sources of industrial noise). In fact, most noise measuring instruments and microphones are unable to measure accurately in the infrasound range, especially below 8 Hz., and some standards explicitly specify the use of equipment which cannot measure infrasound. Having said that, "C-weighting" is available on standard acoustical equipment and is clinically useful to measure environmental low-frequency noise sound pressure levels.

The image below shows the differences of Z- (unweighted) vs both A- and C-weighting. C-weighting will more accurately reflect intensities at various frequencies when applied in the low-frequency noise spectrum: The horizontal axis shows the log scale of frequencies while the vertical axis is in units of decibels.



Shadow Flicker

This is the effect of the sun (low on the horizon) shining through the rotating blades of a wind turbine casting a "recurrent/pulsing" moving shadow; it will be perceived as a "flicker" due to the rotating blades repeatedly casting the shadow.

Source of IWT Noise:

Machinery noise in the nacelle (horizontal containment for machinery - behind hub)

Rhythmic/pulsating, trailing-edge noise from the blades ("blade swish") as they slice through the air at up to 200 mph

Irregular, low frequency noise (LFN) and infrasound from the blades due to in-flow air turbulence

LFN and infrasound at the blade-tower-passage frequency and its harmonics.

Primer on Sound: What it is, Measurement (Adopted from Waubra foundation):
Operating turbines create electrical energy inside the nacelle through the rotation of a central axle that is turned by the force of wind pushing on large canted perpendicular blades connected to that axle.
Besides the desired generated electrical power, "waste energy" in the form of airborne pressure waves (sound) and ground-borne pressure waves (vibration) are released into the environment.
Noise is that part of the sound frequency spectrum which is audible or can be perceived. "Noise" is defined as unwanted sound.
The strength (sometimes expressed (vaguely similar) as "loudness" in the case of noise) of the sound is measure in decibels ("dB").
The wavelength of individual sound waves is a measure of the distance between the peaks of pressure waves. The speed of sound divided by the wavelength gives the frequency of the sound and is expressed in hertz (Hz)
Where the frequency of the sound waves is below 20 Hz, the distance between the waves becomes relatively longer, and the general term for this portion of the frequency spectrum is known as infrasound. Infrasound is only audible (heard) at sound high levels (dB). However, it can be "perceived" at lower sound levels and be damaging to the human body at levels well below audibility.
Impulsive infrasound from a variety of industrial sources (industrial turbines, HVAC installations) has long been known to have the potential to be harmful to humans, especially with chronic exposure.
Terrain and weather conditions influence noise. The wind speeds and directions upstream of a turbine vary due to:
Terrain effects, such as hilliness and ridge lines
Objects on the surface of the terrain, such as buildings and trees
Daytime thermal effects, temperature inversions
The following contribute to sound levels heard or perceived at residences:
meteorological conditions
wind turbine spacing and associated wake and turbulence effects
vortex effects
wind shear
turbine synchronicity (adjacent IWTs with blades turning with perceived passing of the tower at the same moment - generally is more intense with IWTs lined up parallel to wind direction
tower height, blade length turbine power settings
During daytime, as the 3-bladed rotor turns, it encounters air at various speeds and directions which produces a combination of sound effects, i.e. rhythmic/pulsing blade swish about 3 dBA above the steady aerodynamic noise and a steady rhythm of low frequency noise and infrasound. During nighttime, air speeds and directions, not influenced by daytime thermal effects, become more varied, the atmosphere becomes more stratified and background noise is less, causing the various sound effects (aerodynamic noise, rhythmic/pulsating noise, rhythmic LFN and infrasound) to be noticeably more intense than during the daytime. The daytime swish noise often becomes a night-time clapping, beating or thumping noise. (Wilhem Post (On Wind Turbine Noise and Air Pressure pulses))
The so-called upwind vs downwind design of wind turbines can definitely influence turbine sound production. "Upwind" (referring to turbine blade positioning into the wind with blade positioning in front of supporting tower) is almost exclusively used as it produces less turbulence and hence less noise.
This was first described in detail by N.D. Kelley in the late 1980s.
People who are not exposed to the sounds of a wind farm find it very difficult to understand the problems of people who do live near to wind farms. Some people who live near wind farms are disturbed by the sounds of the farms, while others are not. As the sound levels increase, a greater percentage of exposed people suffer annoyance. In some cases, adverse health effects are reported, in other cases, such effects do not appear evident. As sound levels increase, the reported incidence of health effects also increase and become increasingly severe. This lack of similar effects to every resident reflects individual noise sensitivities and complex effects on the physical health is confusing to outside observers (at first) but is well known in epidemiological data and normal variations of reactions at a given stimulus strength in populations.
Amplitude Modulation (Audible Blade Swish)

Although there remain differences in opinions about what causes the amplitude modulation of audible wind turbine noise most of the explanations involve air turbulence around the turbine blades. There are a number of explanations and more than one may apply at any specific wind farm site. For example, eddies in the wind, wind shear (different wind speeds at the higher reach of the blades compared to the lower reach), slightly different wind directions across the plane of the blades and interaction among turbines, have each been identified as causes of modulating wind turbine noise from modern upwind turbines.

The importance of the presence of audible amplitude modulation for wind turbines relates to the subjective annoyance of the audible signal that may warrant an adjustment for that subjective/annoying characteristic. In the frequency domain the fluctuation for a turbine occurs across the entire spectrum. At distances removed from the turbine, the high frequency components are reduced and can alter the audible fluctuations to more of a low frequency noise. At a given site of noise analysis within a field of emitting IWTs, a summation of noise described as "rumble to roar" is appreciated due to the collisions of sound waves - both amplifying and cancelling noise levels. These continuous "modulating noises" can be perceived as extremely annoying.

Variable Noise related to Blade Angle

The blade can be rotated at the point of attachment at the hub thus changing the canted blade angle with respect to inflow air. The steeper the angle, the more noise. Dr. Van den Berg summarized this in a table in his 2006 thesis. He described the increase of trailing edge sound level as a function of angle of attack. The most efficient power production is when the inflow air allows the turbine to reach full power with a blade angle of 1 degree or less. Thus, in real world operation where conditions are not so perfect, the sounds can exceed the "rated" sound power level used in a model by 11dBA or more (with the angle of attack at 9 degrees).

Wind Turbine Noise is "Distinctly Annoying"

Wind turbine noise has been described as having a character that makes it far more annoying and stressful than other sources of noise at the same A-weighted level, including airport, truck traffic, railroad or industrial noise. Thorne (acoustician) has pointed out that human perception of noise is based primarily on sound character rather than sound level, and that wind turbines are unique sound sources that exhibit special audible and inaudible modulated and tonal characteristics. He states that sound levels of 32 dBA Leq **OUTSIDE** a residence and/or above an individual's threshold of hearing inside the home are markers for serious AHEs, especially among susceptible individuals. Thorne described IWTs and wind farms as a unique source of sound and noise - like no other noise source. The sounds are often of low amplitude and shifting in character, making it difficult for people who have never been exposed to such sounds to understand the problems of those who complain about the sound. IWT noise is "distinct and annoying enough" to commonly be heard 10 dBA below background noise. It is this annoying property unique to IWT noise that likely causes more "stress" which can occur at "lower sound levels" than other environmental noise sources. This relative "more annoying effect" is reflected in the average Lden (sound level "average" over day-evening-night) ratings assigned by the WHO that are lower for IWT than rail or highway noise.

"Worst-Case Conditions" Sound Propagation Models

It is noted that consultants for wind utility developers often claim that wind turbine sound emissions inside and adjacent to the project footprint estimated by the sound propagation model's represent worst-case conditions. Models are representations and simplifications of complex interactions between noise emitters and their surrounding environment. For specific situations of modeling noise levels emitted by wind turbines, e.g. in complex terrain, such as sited along ridges and in valleys, understanding interacting factors and creating assumptions that will accurately allow predicted sound levels, can be quite challenging. The ability of the model to accurately replicate how the sounds are blocked by terrain or reflected by terrain is especially weak. **Errors in models of wind turbine noise propagation located on flat terrain have been shown to have errors of 5-10 dB or more** when studied by independent acoustical engineers.

However, it is only true that the input data (power sound level) used for the turbine's acoustic energy represents the turbine's sound emissions at or above its nominal operating wind speeds under standardized weather and wind conditions. That designated power sound level will then permit a prospective buyer of turbines to compare the sound emissions from various makes and models. **The IEC (International Electrotechnical Commission) test data does not account for the increased noise from turbulence or other weather conditions that may cause higher sound emissions.** Indeed, in the IEC test data, it specifically reports that it

is **not** "worst case" for real-world operations. Independent of the effect of weather and wind on the turbine's noise emissions, ANSI (American National Standards Institute) standards for outdoor noise caution that **turbulence in the air can increase the downwind sound levels by 6-7 dB or more.**

Impulsive sound was considered inherent only with older downwind turbine designs but was found only to be reduced with modern turbine upwind designs. In a landmark 2006 study by G.P. Van den Berg, it was shown that the impulsive swishing sound increases with size because larger modern turbines have blades located at higher elevations where they are subject to higher levels of "wind shear" during times of ground level "atmospheric instability". **This results in sound fluctuating 3-5 dBA between beats under-rate moderate conditions and vary up to 10 dBA or more during periods of higher turbulence**.

To compensate for the added annoyance of fluctuating or impulsive sound, the convention is to add a penalty of 5 dBA to computer model estimates of average sound levels to account for the increased annoyance from short term fluctuations in sound levels. In the Kamperman/James criteria, this penalty is already included in its recommendations for the maximum allowable sound level at the receiving property of 35 dBA.

The only information regarding sound levels to be expected during projected wind farm operation proposed for Madison County, Iowa Arbor Hills Project was "right at 45 dBA" as stated by Matt Ott given during the initial hearings for variance. I saw nothing in the application, that I as a citizen, was allowed to review that referred to produced sound levels.

Regardless of these complicated factors, objective noise limits, need to stand as the "limit" for any IWT noise production. IWT platting contractors must do their best (and likely remain conservative) as any emission levels about the limits are "not excusable" and should be consider as not being in compliance and thus requiring mitigation/correctional action.

Winds Speeds at Night: Contrary to Common Perception

Popular notion is that wind picks up (increases speed) after sunrise and abates after sundown. This is what is most often seen as experienced at ground level; the opposite occurs above 80 meters. After sunrise low altitude winds are coupled to high altitude winds due to the vertical air movements cause by the developing thermal turbulence. As a result, the low altitude winds are accelerated by the high winds, which through the air mass coupling, in turn slows the high-altitude winds. At sunset this process is reversed. As described by Rick James, "when ground-level wind speed calms after sunset, wind speed at typical hub height for large wind turbines commonly increases. As a result, turbines can be expected to operate, generating noise, while there is no masking effect from wind-related noise where people live (near the ground). The contrast between wind turbine and ambient sound levels is therefore at night more pronounced. As the turbine's blades sweep from top to bottom under such conditions, the blade encounters slightly different wind velocities creating unexpected turbulence that results in rhythmic swishing noise". Such calm or stable atmosphere at near-ground altitude accompanied by wind shear near turbine hub height occurred in the Van den Berg measurements **47% of the time** over the course of a year on average - and most often at night.

This is a key concept to understand when protecting the conditions for sleep during the night. This concept is the key "deception" propagated in the ETSUR- 97 guidelines pushed by the majority-authoring Wind Energy sympathetic factions in their attempts to evade more restrictive sound regulation based on sound annoyance/tolerance regulations present in the British Standard 4142 regulatory document. The resultant pseudoscience-based "high night-time" (and thus the short set-backs) permitted IWT-generated sound levels have been promulgated by both Wind Energy groups and turbine manufacturers in IWT adoption and spread throughout Europe, Australia, New Zealand and the United States. Wind Energy never talks about it.

Part – 4: IWT Sound Emissions - Types

As described in Part-3 "Wind Basics", sound emissions are first categorized by their frequencies.

Infrasound

Wind Turbines produce infrasound along with audible noise. The more powerful the wind turbine, the greater the proportion of infrasound and low frequency noise is emitted.

Sound with frequencies below 20 Hz is labeled as infrasound. It is usually cannot be heard, but actually can be heard at the higher end of the 20 Hz zone while "perceived" at the lower portions provided the sound pressure

level is sufficiently high. The sound is perceived with the ears usually giving a feeling of pressure at the eardrums. Infrasound at an audible level is usually found on the car deck of a ferry and when driving a car with an open window. Infrasound is most often associated with sound at other frequencies, so the experience of listening to "pure" infrasound is uncommon.

"Perception" Thresholds, Serious Consequences with Larger IWTs Power Generating Capacity The rapid introduction into rural residential locations at close siting from resident of increasingly larger IWT for the purposes of larger energy production per turbine has been without ANY efforts by Wind Energy to ensure public safety with the new levels of sound production profiles - particularly in the infrasound range. George Kamperman (Acoustician) believes that the amount of low-frequency noise generated by IWTs increases by 3-5 dB for every megawatt of electrical power generated. This is particularly important as MAE has recently placed (in adjacent counties) many 4.8 MW IWTs (nearly 2.5 times greater output then the 2 MW planned for Madison County). Wind Energy disputes that IWTs produce little, if any, infrasound. Furthermore, they believe that within the infrasound range, the sound levels produced are less than the human thresholds for perception. Those referenced thresholds, however, were derived from assessment of "pure tones" which are not type of sounds produced by IWTs. ILFN is more characterized as impulsive and varied. As the human ear "reaches" to embrace detection, when sound is not pure-tonal, noise recognition can extend another 10 to perhaps 15 dB lower (Swinbanks).

Many Acousticians have commented about an easily discernable difference among people to hear sound. The distinct range of hearing capabilities in normal people is the primary basis of the observation that only a smaller percentage of an affected population suffers with noise annoyance which then becomes a larger percentage as the IWT sound levels increase (get louder). It is true that some can hear "better" (quieter levels) than others. AT the "townhall" resident testimonies held throughout Madison County (leading up to the efforts to formulate a Wind Ordinance) approximately 25% of residents voiced a desire to allow IWTs into the county while a passionate 75% did not want them forced into their lives. Several "pro-Wind" comments were from farmers who stated they "could run their tractors all day long under the turbine and never notice them". Such individuals, if wearing hearing protection or riding in a protective enclosed tractor cab, would probably be protected against appreciable audible emissions being generated by the IWTs. If such individuals worked without sound protection, the immediate background noise levels, e.g. tractor engine (and the domination of the sound source in the immediate vicinity) from farm machinery, would normally be high enough to exclude a separate, recognizable IWT noise. Even if machinery was not immediately operating, human sound perception "adapts" to the usual background noise level - thus making their "unfocused" listening experience less aware of ongoing IWT sound. Such adaptation may take several days to recover in the absence of background noise associated with mechanized farming.

Clear Lessons from N.D. Kelley Pioneering Studies

Evidence that IWTs produce perceptible levels of infrasound in addition to audible low-frequency noise above 20 Hz has been available since the 1980s (Taken from Punch/James - 2016). Kelley, et al, in response to noise complaints, measured noise levels emitted by the Mod-1 IWT during their seminal multi-year evaluation concluded:

"... one of the major causal agents responsible for the annoyance of nearby residents by IWT noise is the excitation of highly resonant structural and air volume modes by the coherent, low frequency sound radiated by large wind turbines. Further, there is evidence that the strong resonances found in the acoustic pressure field within rooms actually measured indicates a coupling of subaudible energy to human body resonances at 5,12, and 17-25 Hz, resulting in a sensation of whole-body vibrations".

Most importantly, Kelley found that the turbines radiated their peak sound power (loudest in terms of decibels) in the infrasonic range - typically between 1 and 10 Hz. Annoyance was the result of coupling of the turbine's impulsive low-frequency acoustic energy into the structures of some of the surrounding home - frequently confined to within the home itself. Despite these early findings that IWTs generate infrasonic levels that produce acoustic energy, vibrations and resonances that affect people in their homes, the Wind Industry has chosen to regard them as insignificant...

Infrasound Emissions from IWTs DO exist

There has been an intense effort by Wind Energy to "downplay" the existence (if possible) and the potential adverse health effects of infrasound.

The overall mechanisms by which jet engines, aerodynamic structures and wind turbines generate sound was first placed on a rigorous mathematical foundation by M.J. Lighthill in 1952 - nearly 70 years ago. Swinbanks (Acoustician) noted that his analysis has since stood the test of time. The principal process which generates very low frequency infrasound is the effect of the aerodynamic lift force of the blade acting upon the air. Even if a steady, unchanging lift force rotates in a circle, the periodic changes in its position give rise to sound generation. For an ideal wind turbine blade generating power in a completely uniform, steady oncoming airflow, the resultant sound consists primarily of the lowest blade-rate harmonic, plus to a lesser extent the immediate second and third harmonics.

Swinbanks describes the infrasound-generating process as "unavoidable". (The following paragraphs are from his testimony at the Australian Select Committee on Wind Turbines - Submission 189). "If a wind turbine is to provide useful power, it must satisfy two requirements. First, it must slow down the oncoming wind in order to extract its energy. Secondly, it must convert this energy into a rotational torque to drive its generator. Thus, the blades of the turbine must exert a forward-acting force on the oncoming wind to slow it down, while exerting additional tangential forces in the circumferential direction to give the required torque. These simultaneous objectives are achieved by the twist and alignment of the blades relative to the oncoming wind, so that both components of force can be generated by the aerodynamic "lift" from the blades. For any wind turbine that is generating power, these two rotating force components have to be present. In turn, a specific amount of infrasound is inevitably generated, regardless of how precisely and accurately the blades are profiled, polished and streamlined".

These basic underlying effects were accurately modeled by NASA in their late 1980's investigation of upstream-rotor turbines (type in use today). However, real circumstances introduce additional effects. The existence of the support tower downstream of the blades still requires the airflow to separate around the tower, which gives rise to some degree of upstream modification of the flow directly in front of the tower. NASA initially modeled these effects using the assumptions of a comparatively smooth flow change, but in practice trailing vortices from the tips of the turbine blades can also impact the tower and lead to an increase in infrasonic noise generation. At the same time, slower moving air closer to the ground at the bottom of the blade rotation can give rise to additional recurring transient variation in lift force on the turbine blades. This effect becomes more significant as the diameters of wind turbine rotors increase in size, since the blades then rotate through a much greater vertical distance and the change in windspeed from the top to bottom of the rotation can then be much greater.

Finally, any large-scale turbulence present in the incident airflow results in additional fluctuating lift forces which can also interact with and modify the infrasound that is generated.

Long Range Propagation of Infrasound

Infrasound persists for much greater distances than audible sound and, unlike audible sound, penetrates well into insulated building structures with ease; and often increases the impact by resonating within the house, like a drum. This occurs, regardless of the source of sound and vibration energy.

Penetration of buildings and amplification via resonance can also occur from sound and vibration from natural sources such as earthquakes and thunder but is of such a temporal nature that, unlike wind turbines, produces no adverse health effects.

Sound propagation varies depending on the frequency of the sound being propagated. Audible sound attenuates (decays) at roughly 6 dB/distance doubling from the source. Infrasound attenuation is roughly half of that because of the longer wavelength being "absorbed and carried" in the "denser" medium of the ground. Infrasonic pulsations from a single 4 MW wind turbine were measured 10 km from their source in 1985 by NASA researcher William Willshire - the presence and recognition of associated adverse health consequences of this low frequency energy component of noise being noted

WELL BEFORE commercial IWTs were later pursued. Recent data collected by Acoustician Les Huson in Australia and the United Kingdom at onshore and offshore wind developments has shown that attenuation (reduction in sound level with increasing distance from the source) can be much less than the 3dB per doubling

distance found by Willshire in 1985. This means that infrasound noise, in certain situations, can even propagate further than what is commonly described.

Under normal atmospheric conditions, the temperature of the air progressively gets colder as altitude increases. Under such conditions, the propagation of both audible sound and infrasound spreads out and attenuates at a similar rate of -6dB per doubling of distance. There is also progressively greater attenuation of the higher audible frequencies, as a result of atmospheric sound absorption. Under certain atmospheric conditions, however. there may be a temperature "inversion". This can occur particularly at night or the early morning, when the ground and the air immediately above it lose heat faster than the air at higher altitude. Consequently, for several hundred feet or more, the air may actually get warmer with increasing altitude, before ultimately reverting, at higher altitude, to its more usual cooling profile. A similar situation can occur when the wind changes from a cold wind blowing over cold ground, to a warmer wind from a different direction blowing over the same initially colder ground. A well-known consequence of this inversion temperature profile is that low frequency sound can be trapped and reflected by the inversion layer, so that it spreads out more slowly. Its rate of attenuation then reduces to more typically -3 dB per doubling of distance, so that at large distances, although the higher frequencies may be imperceptible, the ILFN can still be clearly detected.

Radiation inversions are probably the most common type of temperature inversions. This forms near the earth's surface during the night. After sunset, especially on a clear night, the earth's surface cools because energy is radiated to space. The air which is just above the earth cools through contact with the cool surface. Many residents in Adair county became upset after the recently erected IWTs became operations with the thumping they experienced during the first winter. They were being kept awake by the readily perceptible modulated low frequency noise and infrasonic "silent thumps" of IWTs at a distance of even 3 miles.

In considering IWT distancing from property lines and resident homes, it is first important to protect humans with audible sound limits - particularly at night - to eliminate disruption of sleep and thereby mitigate that core determinant of AHEs from wind turbines. That established limit of audible sound (expressed in dBA) will have some influence on the omnipresent lower frequencies of IWT emissions, but NOT complete "control". One MUST recognize that infrasound causes health effects and that those effects extend a much greater distance than audible sound. This is a sad reality, if audible sound limits are set high - e.g. >40 dBA at night - there is a marked increase in ill-effects of infrasound at the receptor structure. Distancing is the only way to lessen the harmful adverse effects of IWT noise.

Initially defined are lower audible sound limits AND, ideally, secondly defined setback distances (to protect from longer-ranging infrasound) are needed to protect human health. The distance of 1.25-1.5 miles, as recommended by the Madison County Board of Health from their comprehensive review of available independent scientific information, would be appropriate for IWTs of 2 MW or less (although there would be some annoyance suffering, at times, even with that physical separation). Recently it has become apparently that separate ILFN noise regulation limits are needed – typically expressed with C-weighted values

IWT Separation and Infrasound

These following observations are particularly true of wind turbines which are positioned too closely together in a wind farm: The wakes from turbines positioned upstream are convected downstream by the wind and may compromise the lift forces generated by turbines located further downstream, with resultant adverse consequences for both the fatigue life of the blades and the generation of excess infrasound. The more the "wake deficit" that is brought about by the extraction of energy upstream, the more the reduction of the amount of power that the downstream turbine can generate in a given wind strength. This effect was first intentionally investigated in the design of the 1981 MOD-2 upwind rotor turbines. Yet despite this early research, more recent examples of wind farms have been constructed with separation in the downwind direction as little as 3 turbine blade-diameters, which not surprisingly have resulted in complaints from nearby residents of excessive noise and infrasound.

Historically it was accepted that wind turbines should be no less than 5-8 rotor diameters apart, depending on the direction and consistency of the prevailing wind, with the larger separation being for turbines in line with the major wind direction. This was accepted industry practice and, as an example, was explicitly specified in the 2002 NEW SEDA handbook. The purpose of this specification is to minimize turbulent air entering the blades on

an adjacent turbine. As noted, turbulent air is associated with increased sound levels and infrasonic pulsations.

If a significant proportion of the wind blows at a right angle (90 degrees) from the major direction used for turbine layout it follows that turbine spacing should be 7 or 8 rotor diameters in both directions. It should be noted that the 7-8 rotor diameters number is a compromise between ensuring smooth air inflow to all turbines (and hence less noise and vibration) and packing as many turbines as possible into the project area. Research conducted at John Hopkins University in 2012 showed that the best design for efficient energy extraction suggests wind turbines should be 15 rotor diameters apart. It is increasingly evident that some projects are not laid out in accordance with accepted specifications to reduce turbulence, which in turn significantly increases acoustic emissions including audible noise and infrasonic pressure pulses. It is very important that such "variations of aggressive IWT placements" be recognized as likely and that residence audible sound levels (expressed as Lmax) be clarified precisely such that sound limits enforcement can be made. Additionally, with MAE's practice of turbine "clumping" and close in-line spacing, listing a maximal permissible sound level within the infrasound spectrum would also be protective.

Sound Propagation Computer Modeling

As just noted, it is increasingly evident that some projects are not laid out in accordance with accepted specifications to reduce turbulence, which in turn significantly increases acoustic emissions including audible noise and infrasonic pressure pulses.

There are commercial quality wind turbine computer modeling programs available but are limited to only spherical but not line propagation that could grossly underestimate the true impact of the sounds on adjacent properties located along the rows. These programs also did not follow the advice of the NASA studies about propagation of the infra and low-frequency sounds. Rick James, (Acoustician) commented that it was not uncommon for acoustical consultants hired by property owners to measure sound levels on their properties frequently found levels that exceed the modeled sound levels by 5-8 dBA. He was concerned that models/designs did not reflect "worse case conditions", failed to fully disclose assumptions, limitations and tolerances. Finally, they need to consistently provide confidence limits to account for the inherent inaccuracies in any model representing a complex set of conditions.

Recent Mid-American Energy promotional ads have extolled the "advanced quality of the computers they use in siting turbines. Although I do not know exactly what capabilities they have, the pattern of IWT placement in "clumping/groups" and placed in "lines" often congruent with prevailing wind directions suggests computer modeling may not be ideal based on the physics of IWT sound propagation. I would suggest that industry's "dense siting" practice may likely be "inconsistent" with the paramount **primary health concern** of limiting sound exposure to residents.

For these reasons, among others, an independent sound impact assessment by a qualified member of INCE (Institute of Noise Control Engineering) acoustician is needed and such a requirement should be in the requirements of a County Wind Ordinance. Although there is time and cost required for such a review, future monies saved will be enormous compared to the monies spent (legal fees) over decades by individuals and groups to eliminate or mitigate IWT annoyance produced from a poorly designed, industry-submitted plan. This independent audit should be made available to anticipated residents impacted by IWT placements near their residences BEFORE construction. This essential Wind Ordinance component is mentioned in the recommendations part.

Low Frequency Sound

The range for this category of sound is usually defined as 20-200 Hz but has also been defined, by some acousticians as 10-160 Hz. Low-frequency wind turbine noise is usually described in its modulating state as a rumbling, as humming or as a roar. It may have a more or less "tonal" character – described as fluctuating and varying in level and/or pitch. It may also be described as having tone-like pulses excited with regular or random intervals. It is often reported as having a feeling of eardrum pressure.

It is characteristic that the noise varies a lot in time with varying wind and other atmospheric conditions.

A beautiful representation of "on-going" low-frequency noise modulation was presented at the 2017 ICBEN (International Commission of Biological Effects of Noise) by Dr. Steven Cooper, Acoustician, The one minute visual recording of vacillating low-frequency sound levels (seen as snap-shots of colored lines along with

summated averages along the recording duration represented in black) is available at https://1drv.ms/v/s!AjF3hssMsBNBg5Rs1lRebR87OkWyQQ?e=gDptEi

You will note that the displayed frequency range extends from 0 to 1000 Hz. "Rumble" characterizes the sound from 20 to 100 Hz, "roar" from 100 to 200 Hz and "whoosh from 200 Hz and higher. These varying peaks within the noise spectrum, (generally high enough in dBA loudness) will generate audible sound - from which people suffer annoyance.

What you see is a "real-time" FFT analysis (Fast Fourier Transform converts a signal from its original domain (often time or space) to a representation in the frequency domain or vice versa). The black trace is "time-averaged" to slow it down enough to make it easy to see. As "averaged", the true peaks are not seen. The range of peaks are shown as the colored lines. The "beat" is relatively steady but the amplitudes at any frequency change a bit from one time to the next. This is because there are multiple wind turbines contributing to the acoustic data used to do the FFT analysis. While all turbines may be spinning at the same rpm, they are not perfectly in sync with each other and the sound from each turbine take a slightly different amount of time to reach the microphone. Thus, the black line trace is showing the blending of these similar pulses and tones, sometime adding together to create a maximum, sometimes cancelling each other out creating a minimum.

Leventhal (primary Acoustician for Wind energy) has identified (in his more recent opinion) that infrasound is not an acoustic issue of annoyance associated with turbines, but the emphasis should be on low frequency noise. In Leventhall's DEFRA report, in 2004, he referenced work undertaken by Bradley in 1994 that changed the modulation rate of low frequency noise and obtained a subjective assessment of the annoyance factor for different rates of modulation. Bradley indicated for the critical region of between 2 and 4 Hz (being the rate of modulation of low-frequency noise) could require an adjustment for annoyance of up to 17 dB, due to the subjective assessment of the severity of the annoyance when compared to no modulation. Leventhall reportedly "left" this mainstream of thought in 2005 as he became the primary Wind Energy acoustical spokesman.

The level of annoyance suffering increases substantially for low frequency sound - once perceived – than the more readily audible mid-frequency sounds. Low-frequency is in the 20-200 Hz range and is more appropriately measured with dBC filtering.

Annoyance:

A complex consequence of IWT... will focus on "audible" sources. (Taken from Rick James, 2009)

It is not clear which of the following IWT noises generate "annoyance suffering" that is specified by the WHO as an "adverse health effect". It could be:

1) the distinctive rhythmic, impulsive or modulating character of wind turbine noise (synonyms for "thump", "swoosh" or "beating" sounds.

2) its characteristic low frequency energy (both audible and inaudible and also impulsive),

3) health effects of chronic exposure to wind turbine noise (especially at night),

4) in-phase modulation among several turbines in a wind farm (this can triple the impulse sound level when impulses of three or more turbines become synchronized) or some combination of all these factors best explains the annoyance. One or more of these characteristics are likely present depending on atmospheric and topographic conditions, (especially at night) as is the individual susceptibility of each person to them.

Nevertheless, reports based on surveys of those living near wind farms consistently find that, compared to surveys of those living near other sources of industrial noise, annoyance (suffering) is significantly higher for comparable sound levels among wind utility footprint residents. In most cases, where relationships between sound level and annoyance have been determined, annoyance starts at sound levels **10 dBA or more below the sound level** that would cause equivalent annoyance from the other common community noise sources. Whereas one would expect that people would be annoyed by 45 dBA nighttime sound levels outside their homes in an urban area, rural residents are equally annoyed by wind turbines when the sound levels are 35 dBA independent of the time of day.

Annoyance is discussed later to a greater extent in the discussion of adverse health effects.

Appendix

(Taken from the "Wind farm Noise" textbook during the author's description of Outer Hair Cell Responses, Hearing Thresholds in the Infrasound and Lower-Frequency Sound Spectrums) Note significantly lower recognition of infrasound emissions as perceived by the "outer hair cell response".

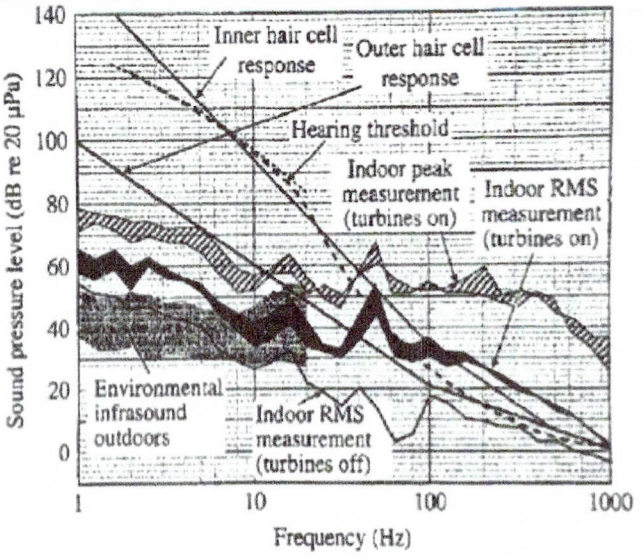


Figure 7.7 Inner and outer hair cell responses, hearing thresholds, environmental infrasound and wind farm infrasound.

Part – 5: History

Wind Energy's Wind Ordinance preferences: Where did they come from and will they protect human health?

In this section I will review first the early understanding of lower frequency noise and its impacts on humans and then focus on the development by Wind Energy of the ETSU-R-97 guideline document that has come to be the "basis and explanation" of current siting of IWTs at a typical distance of 1500 feet from residences despite a tremendous amount of recent science saying that adverse health effects are seen at that distance.

Early ILFN recognition in Industrial gas turbines and HVAC systems.

(Taken from Richard James review article: "Wind Turbine and Low-Frequency Sound: Warning Signs That Were Not Heart) - Bulletin of Science, Technology and Society 32(2) 108-127, 2012)

In the 1970s through the 1990s, acoustical consulting was often associated with occupational and community noise in the audible frequency range. Several projects involved industrial processes where high levels of infrasound were a significant factor contributing to an occupational hazard. Examples of locations where workers reported adverse audible and ILFN included foundries operations and combustion burners. In the early 1990s, there were concerns about pregnant women being exposed to noisy occupational environments. James, in his article, pointed out that the ILFN was not the focus of the study but did prompt changes to the noise processes to allow greater worker safety and tolerance. This author importantly makes the distinction that unlike those industry responses, Wind Energy has not pursued any investigation of the sound types nor impacts of the noise made by IWTs. While some IWT design changes were made (use of up-wind design, blade shape/wind loading considerations, and blade edge "feathering" - that mostly affect audible noise emissions), ILFN cannot be appreciably lessened **except by** reduction in the sound power level ratings of the turbines and/or by increasing distancing to the receptor (resident).

By the early-mid 2000's, increasing numbers of reports of resident AHEs living near wind turbine utilities were appearing, which this author believes was related to:

1) intense ramp-up of on-shore IWT farms in this country - moving from remote locations into rural residential areas.

2) a substantial increase in the power generation capacity of individual turbines (correlated with "blade swept area" made possible by added turbine hub height to permit longer blade arm lengths and technologic improvements in turbine design and building materials, (all done without ANY acknowledgement nor study of potential subsequent heightened AHEs to humans).

3) implementation of turbine-siting guidance with "Outside U.S."- developed "turbine siting guidance" (mostly through the ETSU-R-97 document developed by Wind Energy interest in the United Kingdom in the absence federal oversight/verification in this country).

Over those early years, a number of acoustical engineer researchers collected an increasing body of knowledge focused on the similarity of machinery - produced and IWT - associated worker/resident complaints. James mentioned Charles Ebbing - head of Carrier Corp Acoustical Labs who investigated HVAC noise affecting some occupants of high-rise office buildings. Dr. Malcolm Swinbanks, who had many years of experience with machines that produce ILFN, was an early investigator. He also had personal experience with inaudible levels of modulated ILFN causing the type of symptoms associated with IWTs. Dr. Swinbanks became a major scientist raising the concern of AHEs caused by IWT noise emissions.

Of particular historical clarification, is that Dr. Swinbanks worked from 1975 to 1978 and then again from 1985 to 1989 with Dr. Geoff Leventhall on these investigations of noise production by gas turbines and industrial wind turbines. Indeed, clarification of the ILFN emissions from IWTs was made by Kelley, et al in the 1980s, with a decade-later reaffirmation of the relevance of that work in the understanding of adverse health effects from those lower frequency noises.

It is of absolute importance was that Dr. Geoff Leventhall did much of the research needed to resolve the problem. A report published in 1997 by some of the same researchers who have since published articles on wind turbine noise and other effects (Persson Waye, Rylander, Benton, and Leventhall) highlight some of the compelling parallels:

1) (From the background): Some of the symptoms that are related to exposure to low frequency noise such as mental tiredness, lack of concentration and headache related symptoms, could be associated with a reduced performance and work satisfaction.

2) (From the Conclusion): The results showed that low frequency noise was estimated to interfere more strongly with performance. The results also gave some indications that cognitive demands were less well coped with under the low frequency noise condition. .... The relation between reduced activity and response time, which was especially pronounced in the low frequency noise condition, may also indicate that increased fatigue was of importance for the results.

The adverse health effects reported by workers occurred with short-duration exposure (e.g. 8 hours a day or less). This is a much lower "dose" than what people living near IWTs experience. That 1997 study found that some of the symptoms related to exposure to modulated very low-frequency sound are similar to those reported by people experiencing exposure to IWTs.

Rick James went on to highlight other, earlier parallels in scientific evaluations of "noise-Induced sick building syndrome. This referred to buildings erected during the 1970s and 1980s that used large fans, centrally located, often on the top floor, to provide heating and air-conditioning for the building. In the affected buildings, complaints arose that people did not want to live or work there. Complaints of physical discomfort, productivity loss, effects on mood, lower social orientation, cognitive dysfunction, headaches were voiced by many (but not all). In these buildings, it was found that the HVAC system was the primary source of recorded infrasound and very low-frequency sound. Not all workers in the building complained of audible rumbles. When the problem was audible, one or more workers might hear a rumble or roar from the ventilation ducts. In those cases, there was little question about the problem. People who could hear it, demanded that it be fixed. But, if it was inaudible, people did not associate their symptoms with the sounds that made them less productive. It required special studies and tests developed by Dr. Leventhal and others to identify that the workers' sense of being uncomfortable or having other symptoms while in their offices was associated with the modulated ILFN. These investigators convincingly showed that pulsations in the HVAC systems corresponded to times when the workers reported symptoms of mental tiredness, lack of concentration, headaches and reduced performance and work satisfaction. Rick James carefully and fairly clarified that many of those symptoms from the studied "sick buildings" were "couched" in the language of productivity and work performance. However, subsequent research revealed a host of closely-matched symptoms that are reported by those experiencing adverse health effects from IWTs.

Apparently, Dr. Leventhall, despite his early research and clarification of ILFN being responsible for symptoms closely mirroring those from IWTs, in the years to follow, uniquely and inexplicably chose to develop and

support Wind Energy's stance on the "benign" character of ILFN produced by wind turbines. He became a champion and referenced leader in Wind Energy's promulgation of IWTs around the world.

Hearing vs Perceiving - Both can produce AHEs

Continued research supported the link between the complaints and aspects of wind turbine ILFN.

People who worked or lived near large rotating machines found that they felt uncomfortable or had symptoms that were not related to any known illness or pathology. A common denominator of all those machines is that they produce sounds in the ILFN range. A review of some studies conducted to determine why people reacted negatively to working near these machines revealed a "common thread" - inaudible ILFN was present and was associated with the physical symptoms reported by some of the workers.

Previous research had shown that at AUDIBLE levels, ILFN were able to produce physical responses. However, many scientist and engineers assumed that inaudible levels could not cause any problems.

Indeed, Mid-American Energy (MAE) representatives in our Winterset Courthouse during the 2018 permitting process, repeated the saying "what you can't hear, can't hurt you". Many acoustical engineers were taught this as a part of their academic training regarding the perception of ILFN.

Subsequent studies by researchers such as Swinbanks, Ebbing and Ebbing's colleague Blazier, an independent acoustical consultant who worked in the HVAC industry, found evidence that SOME people responded to INAUDIBLE levels of ILFN produced by the machines.

Further, relevant comments by Swinbanks (2010) include "as a result of spending long hours working on sites in the presence of significant levels of very low frequency noise, I acquired considerable familiarity with its effects and consequences." In addition, and not unique to just Dr. Swinbanks, he became sensitized to ILFN his early work with those noise exposures, noting he could perceive or "feel" inaudible ILFN. This author has, as well, appreciated that ineffable sensation (best described as an extremely fine skin tingling) when emerging from a car in the setting of densely and closely sited large IWTs surround a home in central Adair County operating during "heavy winds," to attend a meeting.

Typically, when a resident complains of "perceiving" these "inaudible pulsations", an industry-paid acoustician may come to measure nearby IWT emissions. Their reports state that the levels of infrasound are below the threshold of perception for steady pure tones. Swinbanks (2010) stated "care must be taken when comparing broad-band measurements, having noise simultaneously present at all frequencies, against a threshold defined by individual, stand-alone pure tones". He offered a neuro-processing basis observation: When an ear is subjected to a steady pure tone in a laboratory environment, it will be less sensitive to low-frequency sound than when presented with sound consisting of a complex mix of tones (neither steady nor pure) in the same frequency range. They are a complex mix of tones whose summed amplitude modulates in short, rapid bursts, sometimes lasting 10 milliseconds or less. These modulations, or pulsations have high crest factors and large dynamic ranges.

The peaks can be 30 to 40 dB higher than the SPL (sound pressure level) in the valleys between them". Dr. Malcolm A. Swinbanks produced a nice review of this topic when presenting to the Australian Senate Select Committee on Wind Turbines on March 20, 2015. Part 2 describes "The Perception of Low Frequency Sound and Infrasound". As noted in the previous paragraph, it is important to see IWT noise as "impulsive and complex".... meaning levels of sound fail to take into account either of the character of the sound or the relationship between adjacent frequency bands. He also referenced a number of reported cases in the literature where ILFN was clearly being perceived at significantly lower levels than would be assessed by such basic comparisons with the hearing threshold.

He summarized that "conventional hearing perception is considered to take place via response of the inner hair cells of the cochlea (the sensing structure of the inner ear), but it has been shown that the cochlea outer hair cells respond with greater sensitivity at very low frequency, and induce additional neurological signals. Hitherto, these outer hair cells have been considered to perform only the task of controlling the overall sensitivity of the hearing process, but it is possible that they can also contribute directly to very low frequency perception". He continued with "a further mechanism has been proposed, whereby sound pressures acting through the lymphatic fluid directly on the otolith components of the vestibular (balance) organs have been calculated to exert comparable forces to those induced by motion and acceleration. Any non-uniformity in the compliance of the structures supporting these otolith sensors may then result in a response which that of

physical motion. Indeed, it has been argued that the correlation between persons who suffer from motion sickness and those who report adverse effects from wind turbines is sufficient to be more than a result of mere chance".

Of note is that a resident from NW Madison County, who turned west onto I-80 was faced by a horizon of revolving turbine blades. She soon thereafter felt sick, nauseated and vertiginous enough to be forced to stop her car on the side, attempted to recover, fortunately later then proceeded off the next exit.... eventually recovering upon exiting the turbine field. That same sensation has been noted by others.

Wind Energy Concedes "Annoyance" Exists but Offers Other Excuses

Over the past twenty years, the wind industry has presented "their" evidence implying that IWTs are "safe" near people's home. Yet the reports of nearby residents suffering annoyance, sleep disturbance and the consequences of chronic non-restorative sleep and body/vestibular responses have been received from people living within 2 or more kilometers of IWTs not only located in this country but in countries around the world (Hanning & Nissenbaum, 2011; Harry, 2007; Krogh, Gillis & Kouwen, 2011; Nissenbaum, 2009; Phipps, Amati, McCoard and Fisher, 2007; Shepherd, McBride, Welch, Dirks & Hill, 2011).

Some of the research has focused on the annoyance potential from audible sound produced by wind turbines. Wind Energy agrees that annoyance does exist but stops there to accept the impact of that adverse consequence. Annoyance suffering is real and is an adverse health effect in and of itself – as was recognized and stated clearly by the WHO in 2009. Symptoms of depression, anxiety, confusion, vertigo (among many, many others) are real spin-off manifestations of being in close proximity to these turbine towers. They are NOT reflective of psychosomatic or psychological illness of residents. The "nocebo effect" may have some minor role but as months to years of exposure pass, the symptoms frequently persist and may become debilitating making a psychosomatic etiology highly unlikely. I would point out that the 2015 peer-reviewed publication by the Council of Canadian Academies that was given to the Madison County Board of Health by the Iowa Environmental Council (local representation of the Wind Energy faction) lists that current evidence is sufficient to establish a causal relationship between a person's exposure to wind turbine noise and feelings (suffering) of annoyance.

Beyond the audible and visible "triggers" of annoyance suffering there are less obvious causes of the adverse health effects from IWTs. While Wind Energy has repeatedly downplayed the concern of infrasound and that humans are biologically incapable of "hearing" infrasound so that it should represent no concern to human health, there is ample evidence that this is **not** the case.

1) There are examples of adverse health responses mediated through the vestibular system's response to modulated infra and low-frequency noise.

2) Salt and Lichtenhan (2011) and Salt and Kaltenback (2011) have confirmed that there is a physiologic response to modulated infrasound at levels below the threshold of perception (defined in laboratories using "pure tones" that may start at amplitudes as low as 60 dBG).

3) Swinbanks (2011) demonstrated that as a direct consequence of the dynamic time domain stimulation of the auditory system by the modulating wind turbine infrasound, the "typical IWT infrasonic and low-frequency noise can be readily perceptible and audible at very much lower levels than had been previously recognized" (noted above).

4) Even much more recently, (Max Planck Institute) data using f-MRI (functional magnetic resonance imaging of the brain), found that "subaudible" noise in the infrasound range directly "activates" specific brain centers or "nuclei" which are known to directly influence body autonomic responses. In my opinion, this may be the link with automobile and air traffic noise where autonomic stimulation is thought to trigger the development of cardiovascular disease. This is very likely the case with IWT noise but, because IWT noise is more "annoying", this autonomic triggering is likely beginning at lower sound thresholds (less loud) than the other studied environmental noises. These threshold comparisons are shown in the 2018 WHO report.

Despite these findings and clear impacts of adverse health effects on humans by IWTs, the Wind Energy Industry, through its experts and trade associations, has denied that IWTs can cause such AHEs.

Highly recognized experts, some well- known in the field of acoustics, have defended the wind industry position through white papers, reports and testimony in hearing and through committees that establish guidelines for siting industrial-scale wind turbines. That viewpoint has not been accepted by other experts.

NASA and Department of Energy Funded Research from the early 1980s to about 1991

The U.S. government has known about health effects of infrasound and low frequency noise from IWTs since 1987. It was concerned (then) enough to commission a study. The study was a research project funded by the U.S. Department of Health, Contract No. DE-AC02-83CH10093. Among many impressive scientific papers, was the following: Dr. N.D. Kelley, Solar Energy Research Institute, Golden, Colorado:

"A proposed Metric for Assessing the Potential of Community Annoyance from Wind Turbine Low- Frequency Noise Emissions" Note: "Community Annoyance" is now called Wind Turbine Syndrome; "Low Frequency" includes infrasound; "Emissions" includes noise and vibrations.

It should be noted that the Wind Energy faction still does not (implied refuses) to consider to measure ILFN exposure levels inside the home.

Between 1982 and 1988, Kelley and his colleagues published five important papers:

1. N. D. Kelley, R. R. Hemphill, M. E. McKenna. "A Methodology for Assessment of Wind Turbine Noise Generation", 1982. (First published in J. Solar Engineering, Vol. 21 (1981), pp.341-356).
2. E. W. Jacobs, N. D. Kelley, H. E. McKenna, N. J. Birkenheuer. "Wake Characteristics of the MOD-2 Wind Turbine at Medicine Bow, Wyoming". November 1984.
3. N. D. Kelley, H. E. McKenna, R. R. Hemphill, C. l. Etter, R. l. Garrelts, N. C. Linn. "Acoustic Noise Associated with the MOD-1 Wind Turbine: Its Source, Impact, and Control". February 1985. (First published by the Solar Energy Research Institute, February 1985). (262 pages)
4. N.D. Kelley. "A Proposed Metric for Assessing the Potential of Community Annoyance from Wind Turbine Low-Frequency Noise Emissions", November 1987.
5. N. D. Kelley, H. E. McKenna, E. W. Jacobs, R. R. Hemphill, J. Birkenheuer. "The MOD-2 Wind Turbine: Aeroacoustical Noise Sources, Emissions, and Potential Impact". Solar Energy Research Institute. Prepared for the U.S. Department of Energy, January 1988. His work was published in peer reviewed journals. He presented his paper "Acoustic Noise Associated with the MOD-1 Wind Turbine: Its Source, Impact, and Control" at the Fourth ASME (American Society of Mechanical Engineers) Wind Energy Symposium held in Dallas, Texas on 18-20 February 1985. In 1987 he presented his paper "A Proposed Metric for Assessing the **Potential of Community Annoyance from Wind Turbine Low-Frequency Noise Emissions", at the American Wind Energy Association "Windpower '87 Conference and Exposition", October 5-8, 1987 in San Francisco, California.**

Kelley et al, concluded: "...one of major causal agents responsible for the annoyance of nearby residents by wind turbine noise is the excitation of highly resonant structural and air volume modes by the coherent, low frequency sound radiated by large wind turbines. Further, there is evidence that the strong resonances found in the acoustic pressure field within rooms actually measured indicates a coupling of subaudible energy to human body resonances at 5,12 and 17-25 Hz, resulting in a sensation of whole-body vibration." A page from that publication graphically shows the display of measured frequencies and their sound pressures.

3) Additional investigation by Kelley, found that turbines radiated their **peak** sound power in the infrasound range, typically between 1 and 10 Hz (that is STILL the case as can be seen on Wind Industry produced displays of IWT-produced sound intensities along the entire noise spectrum). Annoyance was the result of a coupling of the turbine's impulsive low-frequency acoustic energy into the structures of the home and that the annoyance was frequently confined to "within the home itself". In Kelley's and in three other investigator's work, the studies report similar findings, namely that perception, generally is non-auditory in character, begins when the rms ("average") SPLs (loudness) of the modulating tones that are as low as 35 dB rms with increasing impacts as the rms levels rise to 50, 60 and to 70 dB and higher. In all these studies the dynamic modulation of the blade-pass tones produces pressure peaks that are often 10 dB or more greater sometimes much more, than the rms values.

The following link tracks the work of Dr. Kelley and his findings which remain relevant for IWTs currently being placed for energy generation.

http://docs.wind-watch.org/Infrasound-wind-turbines-4-August-2015.pdf

I would strongly recommend that this link be opened and the history of the recognition of infrasound and its potential for adverse health effects was first described by N.D. Kelley and how it was "forgotten or intentionally overlooked". Despite the recognition of potential human harm, this information was discarded by Wind Energy

and specifically by the turbine manufacturer, Vestas, the manufacturer of turbines proposed for installation in Madison County.

Two primary researchers, Hubbard and Shepherd (1990) **(30 years ago)**, reported the following:

1) Wind turbines primarily produce infrasound and low-frequency sound.
2) Sound propagates from IWTs at a decay rate half that of common (audible) "point" sources
3) IWT noise travels farther than other sounds.
4) IWT noise will be a significant indoor noise problem due to room resonance and a dominance of ILFN acoustic energy.

1500 Setback recommended by MAE:

Fifteen hundred (1500) feet was the distance (in the original Mid-American Energy (MAE) request for siting of IWT) from rural residences for the proposed Arbor Hills Wind Farm. At none of those initial and none of the subsequent follow-up meetings at any level was there a description of how that distance was proposed, how long it had been in use nor ANY description about the human health implications of that distance. In the written proposal, there was no listing of the anticipated noise exposure level to residents. Some of the presenting MAE representatives were not clear as to which model of IWT was planned for Arbor Hills. The only mention of noise levels incurred by the IWTs was the verbal (never written) comment (during the meeting) by Matt Ott (MAE) was that he anticipated no more than 45 decibels at the front door of an occupied residence. He claimed that it was a safe level.

Fifteen hundred feet setback was the only specification in not only Madison County's proposals but also that of Adair County and any proposal IWTs that I have seen for Iowa. So where did it come from?

The Origen of the 1500 Foot Setback

Industrial Wind Turbines function through transferring wind energy onto large rotating blades that turn a shaft that operates a generator that creates electrical energy. That entire string of energy transfer creates sound which is characterized as "noise" when it is characterized as disagreeable. Noise regulation from any source in the United Kingdom was via the British Standard BS4142 (described as method for rating industrial noise affecting mixed residential and industrial areas). A document described as the Planning Policy Guidance 24 (PPG24) was generated in the UK that outlines some of the main considerations which local planning authorities should take into account in drawing up development plan policies and when determining planning applications. PPG24 provides advice on how the planning system can be used to minimize the adverse impact of noise without placing unreasonable restrictions on development or adding unduly to the costs and administrative burdens of business. The document introduced the concept of noise exposure categories (NECs) ranging from A-D for residential development and recommends appropriate levels for exposure to different sources of noise. A proposal for residential development needed a determination of which NEC categories would be operative also taking into account both day and night-time noise levels. The PPG24 takes into account the recommendations of the Noise Review Working Party which reported in October 1990. PPG24 - 1994 recommended using the British Standard BS4142. This regulation was formulated to assess facility external noise (outside at a property) **based on the likelihood of complaints**.

Background noise levels (LA90) should be measured. Source-specific noise levels (rating level) are then obtained from manufacturer's data or measured in situ. The background noise level is then subtracted from the Rating Level. If there is likely to be a tonal content or "specific character" to the building services plant noise then a +5 dBA correction is applied to the Rating Level. This assessment method is only applicable to external areas. Assessment of excess value:

1) A difference of around +10 dBA or more indicates that complaints are likely
2) A difference of around +5 dBA indicates a marginal significance of complaint.

This is the same (but not for IWTs) formulation as used in the United States ... as in the ISO TC/43. ((ISO is the registered trademark for the International Organization for Standardization. TC/43 deals with acoustics under which there are three subcategories - noise, building acoustics and underwater acoustics. Under the "noise" category, there are many further subcategories including ISO 1996-1:2016 which describes measurement and assessment of environmental noise. In the overview of subcategory, ISO 1996-1:2016 defines the basic quantities to be used for the description of noise in community environments and describes basic assessment procedures. It also specifies methods to assess environmental noise and gives guidance on predicting the

potential annoyance response of a community to long-term exposure from various types of environmental noises. ISO 2016 is currently in the third edition, is 47 pages long, and can be purchased from the ISO website)). In general, the LA90 (background) noise is going to be in the mid-upper 20s dBA range in the rural residential areas of Madison County.

This BS4142 regulatory limit is based on reasonable likelihood of complaint generations and was too restrictive for IWTs **as wind turbine have no noise control options except greater distancing**. Other industrial facilities don't have this problem, because they can enclose machinery in buildings, use mufflers, duct wrapping, etc. Thus, the Wind Industry had to come up with a "guideline" that raised background noise levels with the definition of 'LA90 -10 min' and convince U.K. regulators to use that guideline instead of BS4142. (Unfortunately, the LA90-10min measurement is effective for broadband noise such as traffic noise but not when measuring intermittent noise as produced by wind turbines).

That is exactly what they did as they developed ETSU-97. BS4142 continues to be used for industrial permitting and apparently remains a thorn in the side of consultants working to permit wind turbines and promote more noise in rural areas.

ETSU-R-97

ETSU-97 is a guideline and not a set of regulations. The acronym stands for "Energy Technology Support Unit". The ETSU working group was formed by the British Wind Energy Association for the purpose of preparing wind energy friendly guidelines and research. In that capacity, it worked on behalf of the Department of Trade and Industry (DTI); generally, with no independent oversight and no transparency. "The Assessment and Rating of Noise from Wind Farms" was published in 1997 and became and remains the UK government's preferred method of assessing wind farm noise for planning purposes. Rick James (in his article, Wind Turbine Infra and Low-Frequency Sound: Warning Signs that were not Heard) went on to describe the "inadequate" design of the ETSU-R-97 which was a "guideline only" for the UK that was developed specifically to circumvent more science-based UK regulations that were more restrictive to IWT placement. The guideline was developed by the Working Group on Noise from Wind Turbines which consisted of several acoustical consultants with ties to the wind industry in the UK, representative of companies or their attorneys involved in or with the wind industry, and several representatives of local governments and the chairman, who represented the government's Department of Trade and Industry (DTI).

The introductory comments about ETSU's purpose to "offer a reasonable degree of protection to wind farm neighbors without unreasonable restriction on wind farm development" has been met with near universal contempt (as also occurred in Madison County during a joint writing session with the Supervisors) as the guidelines should not provide the justification to impose greater levels of wind turbine noise intrusion than would be permitted by other forms of industrial development.

ETSU-97 compares the turbine noise with a level 5dB above background noise, but when background noise levels are low (particularly in rural areas), it sets a higher lower limit. The day time lower limit can be anywhere between 35 and 40 dBA and the night time lower limit is 43dBA. The most bizarre result is that night time background noise level can be "assigned" up to 8dBA more than the day time noise. No other standard anywhere in the world has a nighttime limit higher than a day time limit.

The ETSU-R-97 was specifically designed that way to harvest the greater wind resources that occur at night. It appears that the ETSU-R-97 was produced to permit introduction of wind farms into inappropriate low background noise locations where they and other comparable industrial installations could not meet planning conditions derived from the long established BS4142. It could be reasonably supported that the Department of Trade and Industry (DTI) worked with the British Wind Energy Association that formed the ETSU to develop "fuzzy-science" based guidelines. I would view this as "pseudo-science to support policy, NOT policy to support science".

Further concerns:- ETSU-97 is a document that has remained unchanged over 23 years. Over the same period most everything else has changed:

1) The understanding into the effects of noise on people has advanced - particularly regarding adverse effects of noise on sleep and potential for cardiovascular disease promotion from environmental noise. The World Health Organization has weighed in with guidelines concerning not only other forms of environmental noise but also IWT noise. Sleep studies and actigraphy (movement) monitoring have now clarified sound pressure levels

where there is 1) no sleep disturbance, 2) non-conscious recognition of noise with subsequent disturbance of healthy sleep stage architecture and 3) awakening from sleep due to the uniquely disruptive quality of IWT noise.
2) The maximum size of IWTs has increased. With that, adverse health effects from sound emissions in the infrasound-low frequency noise (ILFN) range are now recognized in turbines >.5 MW thus creating new health considerations of turbine siting (that were not considered with the initial guideline).
3) The maximum size of wind farms has increased.
4) The possibility for closer adjacencies between neighboring wind farms has increased, leading to the need for greater consideration of cumulative noise effects.
5) The approach to wind turbine control has evolved from previously dominant 'stall regulated' technology to the now dominant 'variable speed' technology, thereby enabling much more control flexibility over the noise output characteristics of wind turbines.
6) Acoustic standards which were present in the early 1990s (which then formed the basis of discussions for ETSU-97) have been updated. This includes increased awareness of factors affecting 'derived prevailing background noise levels'.
Despite all these technologic and scientific advances in our understanding of IWT noise and its effects on human, the ETSU-97 has not changed since it has been accepted as non-regulatory guidance.
1) They initiated the "practice" of unreasonably "treading" inside the property rather than sticking to the property line.
2) ETSU-97 avoids "sound limits", rather, they set up the device of "relative to background noise: with which they were able to ramp the limit up assuming a low wind shear (gradient of wind speeds over the vertical height of the rotor sweep) factor. Noise intrusion is most likely during high wind shear conditions so mainly during the night time and evening when wind speeds at ground level are likely to be low but turbine noise at or close to maximum. Noise assessments by wind farm developers have either failed to consider wind shear or applied very low levels of corrections so underestimating the likely noise impact on nearby residents.
3) Additionally, when ETSU-97 was written, the tallest IWT was 32 meters to the hub, at which height wind shear effects could only lend to relatively small errors. Now total heights of tower/blade are >200 meters bring even greater adverse wind shear associated noise production. On average, high wind shear occurs at night about one-third of the time.
4) ETSU-R-97 allows night-time IWT levels to >20dBA above actual background noise in many quiet rural locations. (Greater than 10 dBA over background levels is associated with noise levels where complaints are likely. The additional 10 dBA represents noise levels that are 4 times louder and 100 times more intense)
5) They used a L90 (average over 90% of time tested) for the wind turbine noise, which is approximately 7-13 dB lower than the Lmax. Sleep disturbance, being biologic in origin is best characterized at given decibel threshold levels. ETSU-97, by characterizing noise essentially as an average (Leq), eliminated any possibility of assessing for sleep disturbance which is the most important of the many adverse health effects produced by IWTs. The "Leq" noise level designation of the IWT noise level (rather than Lmax) continues today and is present in the Wind Ordinance draft given (directly or indirectly) to county supervisors by industry.
6) There is no recognition of infrasound, low frequency (ILFN) or tonal noise character (see below).
7) Amplitude modulation is the most important noise characteristic of wind turbines. All comments about this are excluded in ETSU-R-97. Wind turbine excess amplitude modulation (EAM) is generally recognized as when the turbine blade 'swish' changes to thumping or banging. EAM is highly intrusive event at >1.5 km. The attenuation afforded by a closed window can be highly variable depending on the type of glazing system and frequency of the noise. In the event of low frequency noise as occurs with EAM, no window type, whether open or closed is effective at attenuating the noise. EAM is similar to helicopter "blade slap" - itself the result of blade vortex interaction. This aerodynamic interaction noise consequence has been well understood for decades...
Why is a wind turbine's EAM
such a technical mystery for Wind Energy? Simple: Wind Energy (including Mid-American Energy – as overtly stated by Matt Ott - one of their apparent technical experts) denies that ILFN can be perceived in any way by humans and therefore could not cause no adverse health effects. Vestas, the manufacturer of IWTs used by MAE in this region, formally requested and received permission from New South Wales, Australia 2012 to longer

consider ILFN a relevant consideration in IWT siting. It appears that Wind energy has continued the same stance to completely ignore ILFN as a concern in this county (in the absence of federal/state oversight). A complete copy of that letter is in this part's appendix.

This description is NOT to suggest that the labeled ETSU guidelines are the ones specifically given to the Supervisors nor were incorporated into the initial MAE request for variance. The distance "1500 feet" is used throughout Iowa and the only precedence for this "extremely close setback and consequential excessive resident noise level exposures came with the development and initial acceptance by the UK government. The "forced acceptance" by residents outside the U.S. has appeared to have worked well enough that WE development in this country has simply retained those original poorly conceived and now further outdated "guidelines". Peak noise levels appear arbitrary as well. At every location within the UK or where ETSU principles have been used internationally there has been resistance and public outcry in not all but among a significant proportion of affected residents.

Subsequent Adoption Worldwide

After being adopted (but not approved as regulation) by the British government, British Acousticians Hayes and later Leventhall were pivotal in the adoption of the ETSU-R-97 tenets - particularly to former British colonies (Australia, New Zealand) - with these Acousticians being presumably sent to establish control of the narrative and establish a template that the local firms could subsequently use for other wind energy projects. Leventhall formally started his pro-Wind energy work when he became a spokesperson for the British Wind Energy Association in the mid 2000's after Dr. Van den Berg published his thesis "The Sound of High Winds" and two other papers that observed wind turbine blades create pressure pulses as the blade passes the tower. For the next 15 years, reportedly at the request of industry trade groups, Leventhall and others organized "international" wind turbine noise conferences where research was promoted and reviewed that reflected the Wind Energy vision. Hayes (British Acoustician) apparently consulted on a project in New York state in the mid-late 2000's where working with US consultants reportedly "borrowed ETSU concepts" to get their projects approved in later projects. Those "templates" reportedly initiated by Hayes were "used around the world" being changed to accommodate regulations. It is highly likely that such "original" language perpetuates to this day; with the various "Wind Energy Associations" sharing the recipe to Wind Energy Industry (contractors)- a great many of whom sit at the Wind Energy boards. (Do a search for the Australian senate's hearings on wind turbine noise. Start at "Stopthesethings.com" and "the Waubra Foundation" searching for the names Hayes, Leventhal, Swinbanks, Thorne, Cooper to locate their work in Australia and New Zealand).

So Where is the Federal-Level Oversight to Protect the American People from IWT Adverse Health Effects?

Aaron Price (Madison County Supervisor – resigned as of early July, 2020) stated in a prior county meeting something to the effect that the Federal government would not have allowed IWTs to become so "widespread" if there was some inherent risk to human health. The unspoken fact is: There is **NO** regulation of IWT by the U.S. Federal government. This fact, in the course of my reading, remains completely unaddressed by Wind Energy; they get to define if IWTs are safe (seemingly in an arbitrary and capricious manner) or not and convince local counties in Iowa that they are OK. They have found that financial incentives seem to facilitate adoption of IWT placement - both for the landowners and the county tax rolls.

The U.S. Environmental Protection Agency (EPA) created the Office of Noise Abatement and Control (ONAC) following enactment of the Noise Control Act of 1972. In 1981 Congress agreed to the Reagan Administration's proposal to cease funding for ONAC. Congress, however, did not repeal the Noise Control Act when it eliminated ONAC's funding.

Before its elimination, ONAC engaged in a wide variety of activities to abate noise pollution under authority of the Noise Control Act and, after 1978, the Quiet Communities Act.

The Quiet Communities Act of 1978 amended portions of the 1972 Noise Control Act to require coordination between federal agencies on noise control. It was intended to speed up FAA response to noise regulations proposed by the EPA and requires the FAA to provide the public with a detailed analysis of EPA proposals. These included identifying sources of noise for regulation, promulgating noise emission standards, coordinating federal noise research and noise abatement, working with industry and international, state and local regulators to develop consensus standards, disseminating information and educational materials and sponsoring

research concerning the effects of noise and the methods by which it can be abated. It also authorized the EPA to provide grants to state and local governments for noise abatement.
The EPA ceased most noise abatement activities after ONAC's funding was eliminated. There is still some minimal enforcement in the area of airport noise. Responsibility for the enforcement of EPA's railroad and motor carrier emission standards was shifted to the Department of Transportation.
Since defunding ONAC, federal noise emission and labeling standards have not been subjected (best I can find in the internet literature) to critical evaluations despite the evolution of relevant science and technology and a better understanding of the effects of noise on people. The EPA has been unable to provide technical assistance to state and local governments or to participate in private standard-setting efforts. State and local governments have been preempted from adopting their own noise emission and labeling standards that differ from EPA standards for sources or products that EPA has regulated.
Apparently, there were **never** any EPA standards or regulations for industrial wind turbines. State and local governance has had to pick up that protective effort... but as said many times... without funding or other vital resources to do that. Specifically lacking are technical resources and highly trained engineering specialists to understand the science of industrial wind turbine sound emissions and interpret and stay current with the rapid explosion of our understanding of those sound emissions causing adverse health effects. Unfortunately, relying on Wind Energy and the Wind industry for objective knowledge and guidance in protecting human health has never happened. In my opinion, executing their agenda has, by necessity, eliminated their concerns of protecting human health.

Part 6: Adverse Health Effects from IWTs

A great review (essentially a textbook - 2014) was done by Bob Thorne, PhD (PhD in Public Health and Acoustician specializing in infra- and low frequency sound) - 158 pages "Wind Farm Noise and Human Perception - A Review". (May google the title; the entire text comes up). It starts with the Preamble: "There is a significant body of peer-reviewed research readily available in public forum to substantiate the potential for serious to moderate adverse health effects to individuals due to wind farm activity noise while living in their residencies and while working on their farms near large-scale wind farms or large turbines. Adverse health effects can arise from extreme psychological stress from environmental noise, particularly low frequency noise with symptoms of sleep disturbance, headache, tinnitus, ear pressure, dizziness, vertigo, nausea, visual blurring, tachycardia, irritability, problems with concentration and memory, and panic attack episodes associated with such sensations when awake or asleep".
The hypothesis from this Review is that serious harm to health occurs when a susceptible individual is so beset by the noise in question that he or she suffers recurring sleep disturbance, anxiety and stress.
Research for the Review suggests that 5% to 10% of the individuals living in the vicinity of a large wind farm will experience serious harm to their health. The observed markers for serious health effects are:
(a) wind farm noise levels of LAeq 32 dB or more **OUTSIDE** the residence and
(b) wind farm noise if heard or is perceptible (felt) at levels above the individual's threshold of hearing **inside the home**.
Previously, a study took place in Victoria, Australia (2012) that was led by Bob Thorne that was published and presented to the Australian Senate Hearing on 'Excessive Noise from Wind Farms'. The residents interviewed lived between 700 and 3500 meters with an average distance of 1400 meters. (This is almost three times farther than the distance proposed by Mr. Clifton in his Wind Ordinance draft submitted to the Board of Zoning for review and judgement). The study design is exploratory and observational, establishing the research required for the development of hypotheses. It is a scientific method- driven determination of health-related, perceptual and environmental variables, i.e. health related quality of life and noise exposure in a sample of adults exposed to wind farm generated noise.
The study used convenience sampling to obtain completed questionnaires. The survey included self report assessments on exposure to community noise and perceived intrusiveness of noise; annoyance and sleep interference due to noise exposure; psychological wellbeing, quality of life and general health; noise sensitivity and personality traits; attitudes to noise sources; and demographic information.
Questions were guided by pre-existing studies in the literature or by the use of pre-existing validated inventories, including:

- WHO Quality of Life ScaleQ
- Questions from Dr. Thorne on annoyance
- Noise Sensitivity Questionaire
- SF-36v2 Health Survey
- Sleep Disturbance from Epworth Sleepiness Scale, Pittsburgh Sleep Quality Index

Questions from Dr. Nissenbaum on Turbines and Health

The study sampled sound levels from wind farm locales and non-affected locales with full monitoring for low frequency sound and infrasound. The 23 residents sampled lived within 5 km of two wind farms while 2 were from locales without wind turbine activity.

In this comprehensive study, results of all the six categories were evaluated. As I have done in my research, the World Health Organization's Health and Noise criteria were central to the descriptions of harm. "Health" was defined as a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity. Quality of life is a multifaceted concept: "An individual's perception of their position in life in the context of the culture and value systems in which they live and in relation to their goals, expectations, standards and concerns. It is a broad ranging concept affected in a complex way by the person's physical health, psychological state, personal beliefs, social relationships and their relationship to salient features of their environment".

Further, the WHO Report of "burden of disease from environmental noise" - from 2011 and 2018 is a scientific evidence supported "exposure-response relationships" and case studies in calculating burden of disease. The report concludes ".... environmental noise should be considered not only as a cause for nuisance but also a concern for public health and environmental health". In the 2018 WHO report on environmental noise, beside automobile traffic, railway noise and aircraft noise, evaluations were done on industrial wind turbines and leisure noise.

The WHO report considers sleep disturbance and its potential for adverse health effects. I would agree that sleep disturbance is the MOST significant concern and is the pathway to a full range of serious adverse health effects.

Concordance that sleep disturbance produces major health endpoints accompanies most review of AHEs from IWTs. Most significant to myself, as a practicing Cardiologist for 30 years, is closed-linked data of sleep duration and serious cardiovascular outcomes (reviewed in Part - 2). Inherent with that association are important autonomically-mediated association with "chronic inflammation" that may trigger/promote the development of asymptomatic measurable (developing atherosclerotic obstructive vascular disease) and observable clinical cardiovascular endpoints such as hypertension and fatal and non-fatal heart attacks. ANYTHING a society can do to lessen cardiovascular disease development and its progression - including minimizing suffering annoyance from industrial wind turbines - should be considered paramount. This is particularly relevant when lease lengths of 58 years are being granted for projected continual operation of IWTs.

Comments on the Thorne's study results included:

1) The data suggests that the sample of individuals exposed to turbine noise, have, on average, substantially lower health-related quality of life compared to the community and clinical samples.

2) When exposed to wind farm noise and wind turbine generated air pressure variations, some will more likely than not to be so affected that there is serious harm (also termed 'significant adverse effect') to health.

3) 91% of the respondents stated that turbines annoyed them inside the home while 9% said no. For turbine noise heard outside the home 95% of the respondents said yes and 5% said no. All report that wind turbines affect sleep and the ability to work is dramatically affected.

4) Families have moved away to sleep, (but) must still work the land and will not sell.

5) Headaches, although not serious adverse health effects, clearly effects quality of life. In response to the question: "What health effects such as headaches have you experienced since the turbines went online that did not exist previously", 24% responded with daily or constant headaches, 56 % experienced headaches 2-4 times a week, 64% experienced a tight scalp or band-effect around the head, 52% experienced blurred vision, 40% stated dizziness was experienced, 4% experienced chest pains, 52% experienced nausea, 76% state ear-ringing was experienced, 12 % experienced pressure in the ears and 60% experienced vertigo/balance

problems. Of the persons who responded citing headaches as a problem, 80% observe that headaches only occur when the turbines are operating. Most of the
respondents noted that these effects are not experienced all the time but often enough to be debilitating.
6) In response to the question: 'How long did it take after the turbines started before you felt unwell', 35% of the respondents said fairly quickly (a month or less) and 56% said 6-8 months. Of those who responded "fairly quickly", there were some who became unwell almost immediately. These respondents now find it very difficult to return to the locale to work when the turbines are operating as they suffer from headaches and/or nausea almost immediately. In 56% of the responses the symptoms improve/abate fairly quickly when the person leaves the locality.
7) Dr. Thorne provided some insights into experiencing IWT noise. "Wind turbine sound has a unique nature that is variable over time and highly dependent on wind speed and directions, as well as locale. Some standards refer to "audible characteristics" such as amplitude modulation, tonality, impulsiveness and so on. Observations at the different locations near the wind farms under different weather conditions and measurement distances indicate the sound of turbines are individually observable (swish, rumbles, clunks, whines) at distances of 200-500 meters. (500 meters is the setback distance proposed by Mr. Clifton in his Wind Ordinance draft). At around 900 meters only clearly distinctive turbines are identifiable (swish, rumbles) and by 2000 to 3000 meters, the sound of turbines is "cumulative" and is heard as a general source of noise. At each wind farm, turbines could be "clearly " heard at dwellings approximately 2000 meters from the nearest turbine. The sound of turbines can be heard 2000 meters both upwind and 2000 meters downwind as well at an angle to the turbines. The sound, with turbines operating, can be described as a steady rumble with a mixture of rumble-thumps. The general character over a long time period of an hour or so is of a steady rumble".
8) In this study, at 2000 meters, IWT sound is perceptible outside or inside a dwelling. The sound of turbines is often "clearer" inside as higher frequencies are reduced through the building fabric.
In his "Discussion Summary" section from his 2012 study he commented that:
1) By necessity, the investigation was applied to residents who claim they are adversely affected
2) All those studied WERE adversely affected by wind farm activity, ...and there was evidence of serious harm to health.
3) The subjective experience of annoyance is a common reaction to noise. Different individuals can exhibit different annoyance reactions to the same noise, and these individual differences can be ascribed partly to differences in noise sensitivity.
4) The finding suggested that the individuals living near the wind farms of this study have a degraded Health-Related Quality of Life through annoyance and sleep disruption and that their health is significantly and seriously adversely affected (harmed) by noise.
5) Serious harm means more than "mere" annoyance and that it can be quantified in terms of reported illness, sleep disturbance or other physical effects.
6) Definitions of 'serious harm' were postulated:
a) an exposed individual is adversely affected to the extent that he or she is obliged to remove himself or herself from the exposure in order to mitigate the harm; and/or
b) if three or more serious adverse health effects are recorded for an individual. Three serious adverse health effects are established from this study as being:
i) Sleep disturbance with a global PSQI >5 (validated sleep study)
ii) a state of constant anxiety, anger and helplessness
iii) an SF36v2 mental health value of <40 (validated health survey)
I have researched and asked experts in IWT-related matters, what Wind Energy thought of this study and the conclusions Dr. Thorne produced that show "conclusively" that IWTs can cause serious AHEs.
Those experts reported: little, if any response was generated by Wind Energy. This appears to have become their "normal response" of Wind Energy, i.e. unless it can support their narrative, they don't talk about it.... hoping, like this study and the proceeding long list of studies and data and basic science supporting that IWTs do cause adverse health effects, will simply "go away".
Included in this manual is a fascinating sequence of verbatim comments made by residents who were severely harmed by IWT Noise and, as a result, felt to consider or proceed to achieve evacuation of their homes. We, as

the public (unless we are close acquaintances with affected residents) do not directly hear these comments of distress. I am sure that participating resident granting easement have the same "scale of distressed comments, but are forbidden by contract to express those reactions. Please read the 6/28/2020 article included in this Part's Appendix, by Carmen Krough, et al, "Wind Turbines: Why Some Families Living in Proximity to Wind Energy Facilities Contemplate Vacating Their Homes: An Overview of Findings". The intensity and depth of their reactions is quite personal and revealing.

Later, Dr. Thorne in his 2014 textbook, reviewed "Wind Farms and Health Effects". In his chapter, he provided a very brief introduction to a small sample of experts who have published evidence of the topic of wind farm activity and its potential effect on human health. Up front, he highlighted **the ultimate connection: "If there were no ill effects before the wind farm started operating, and there are a lot of complaints about adverse health effects now that it is operating, what has changed"?**

1) Dr. Eja Pedersen in Human Response to Wind Turbine Noise: Perception, annoyance and moderating factors" present an understanding of how people who live in the vicinity of wind turbines are affected by wind turbine noise and how individual, situational and visual factors, as well as sound properties, moderate the response. She has written other works on IWT health effects.

2) Dr. Nina Pierpont, MD, PhD (Academic Pediatrician) presents work relating health effects of wind farm activity. Her work presents an important body of knowledge that has been extensively peer-reviewed. She states the following symptoms: "... sleep disturbance, headache, tinnitus, ear pressure, dizziness, vertigo, nausea, visual blurring, tachycardia, irritability, problems with concentration and memory and panic attack episodes associated with sensations of internal pulsation or quivering when awake or asleep". Insight into the understanding and threshold of defining adverse health effects by Wind Energy were exampled by their "acoustical science leader", Dr. G. H. Leventhall as he critiqued Dr. Pierpont's work. (As one reads the following quote in his review paper, keep in mind Dr. Leventhall's absolute rejection that wind turbine ILFN contributes to adverse health effects). "I am happy to accept these symptoms, as they have been known to me for many years **as symptoms of extreme psychological stress** from environmental noise, particular low frequency noise. The symptoms have been published before. The so called **"wind turbine syndrome" cannot be distinguished from the stress effects from a persistent and unwanted sound.** These are experienced by a small proportion of the population and have been well known for some time". In later correspondence, Dr. Leventhall confirms his belief that there is no such thing as wind turbine syndrome. This writer/reviewer believed Dr. Leventhall acknowledged (in his first comment) that the psychological and associated physical stress originated from industrial wind turbine noise. Symptoms reflect the underlying adverse health effects. Moreover, when IWTs are "forced onto an otherwise unaffected population" some of whom then develop these symptoms, it highlights the immoral and unethical behavior of the Wind Industry contractor who "causes" those adverse health effects. It is NOT the resident's fault that he and many of his neighbors develop "ill-health consequences" that can go on to precipitate other health effects.

3) This central concept of Wind Energy's actions to deprive a resident of his health also extends to his well-being, quality of life, and amenity. Dr. Daniel Shepherd specializes in public health and psychoacoustical studies. He sees "primary health" as embracing the concept of health in all policies (e.g. labor, environment, education) and so includes not only the treatment of disease but its prevention. At the community level, good health can be facilitated not only by the pursuit of healthy lifestyles but also with the provision of restful and restorative living environments. A prominent factor determining the restfulness of a living space is the level of privacy and intrusion by community pollutants, including smell, air quality and noise. He finds that "there exists compelling evidence attesting to the impact that community noise can have on health. A number of interacting factors combine to determine an individual's response to noise. As such, noise level should not be used as the sole metric with which to judge the potential health effects of noise. Annoyance can lead to degraded health, quality of life and impaired sleep, while disrupted sleep can lead directly to severe health deficits. Noise sensitive individuals are more susceptible to the negative effects of community noise. Turbine noise is a type of community noise and likewise has the potential to impact health and wellbeing. Evidence to this effect now exists in the peer-reviewed literature. Dr. Shepherd has proposed a simple model demonstrating (in the rural context) feasible mechanisms exist by which wind turbine exposure can degrade health and wellbeing: turbine noise can lead directly to annoyance and sleep disturbance (i.e. primary health effects) or can induce

annoyance (suffering) by degrading amenity. Additionally, the trait of noise sensitivity constitutes a major risk factor, with annoyance and sleep disturbance the likely mediators between noise sensitivity and health. In relation to secondary health effects, it would be expected that quality of life will be affected immediately, while stress-related disease emerges from chronic annoyance and sleep disturbance over time.

4) Clarifying the central risk of sleep disturbance (which I too, have seen in patients presenting with heart arrhythmias and obstructive sleep apnea), Physician Dr. Hanning, reports that "inadequate sleep has been associated not just with fatigue, sleepiness and cognitive impairment but also with an increased risk of obesity, impaired glucose tolerance, high blood pressure, heart disease, cancer and depression". Sleepy people have a substantially increased risk of traffic accidents.

5) Michael Nissenbaum, M.D., has conducted a study of the health effects of persons living within the Mars Hill Wind Turbine Project in Maine. He declared a "high probability" of significant AHEs for residents living within 1100 meters and a significant risk of AHEs in a significant subset of people living out to 2000 meters from an IWT. He listed:

1) Sleep disturbances/sleep deprivation and the multiple illnesses that cascade from chronic sleep disturbance

2) Psychological stress which can result in additional effects including cardiovascular disease, chronic depression, anger and other psychiatric symptomatology.

3) Increased headaches

4) Unintended adverse changes in weight

5) Auditory and vestibular system disturbances

6) Increased requirements for and use of prescription medications.

5) Dr. C. V. Phillips reviewed some epidemiologic principles in his testimony before the Wisconsin Public Services Commission. Based on his knowledge of epidemiology and scientific methods and his readings of the available studies, he summarized that:

1) **There is ample scientific evidence to conclude that wind turbines cause serious health problems** for some people living nearby. In addition, he commented on the observation of people vacating their home being an exposure-disease combination.

2) **Reported health effects, including insomnia, loss of concentration, anxiety and general psychological distress are as real as physical ailments, and are part of accepted modern definitions of individual and public health. While more difficult to study (less objective, presenting in "gradation"), they probably account for more of**
the total burden of morbidity in Western countries than do strictly physical diseases. It is relevant and important to take the less intense versions of the problems more seriously in making policy decisions, while not ignoring the serious diseases.

3) **The reports that claim that there is no evidence of health effects (Writer's comment: commonly seen on Wind Energy websites and their "peer reviewed" papers) are based on a very simplistic understanding of epidemiology and self-serving definitions of what does not count as evidence. Though those reports probably seem convincing (on first appearances), they do not represent proper scientific reasoning, and in some cases the conclusions of those reports do not even match their own analysis.**

"Effects of Wind Farm Noise and Vibration on People" in the 39-page chapter of the "Wind Farm Noise" Textbook. They authors summarized: There are many well-documented cases of adverse health effects resulting from both short- and long-term exposure to wind turbine noise. These symptoms include nausea, dizziness, pressure (or fullness) in the ears and recurring sleep disturbance; in most cases medical professionals are unable to otherwise explain them. There are also a significant number of people who are so badly affected that they have had to leave their homes or have had to undergo medical treatment to address their (unexplained) symptoms. Sleep disturbance experienced by people
living in the vicinity of wind farms manifests as prevention of the onset of sleep (insomnia) or the prevention of a return to sleep after being awakened. (Writer's comment: Sleep disturbance as either shortened time in sleep due to insomnia or recurrent awakening **or** normal-sleep stage progression disruption due to "brief, non-awakening" events that results in delay or prevention of reaching deep slow wave or REM sleep have also been shown in formal sleep study evaluation with EEG (brain wave) monitoring. This sleep architecture fragmentation

has been known for more than 20 years and is recognized by the World Health Organization. The 1999 WHO statements list 32 dBA as the audible threshold for sleep disruption.)

Continuing from "Wind Farm Noise": Ten to twenty percent of the population are easily disturbed from their sleep and a higher percentage can be expected to be found in rural areas (Hanning and Nissenbaum, 2011). Of course, a smaller percentage of the population (generally 5-10%, according to Thorne, (2013)), report serious health effects, although a considerably greater percentage suffer from annoyance and recurring sleep disturbance. In some cases, some members of the same family suffer terrible effects while others suffer no ill effects at all. The actual percentages depend on how far the residents are from the nearest turbine. In cases where they are **within 500 meters of the nearest turbine** (MAE's request as pursued by Phil Clifton (Supervisor) for the Madison County Wind Ordinance), **up to 30% of people may be highly annoyed and suffer some form of adverse health effect in addition to sleep deprivation**. As distance from the nearest turbine increases, the percentages of affected people decrease. Thorne (2012, 2014 - from the literature mentioned at this part's beginning), found that adverse health effects occur in some people when wind farm noise levels exceed LAeq,10min levels of either:

32 dBA OUTSIDE the residence

22 dBA INDOORS, if wind farm noise is at a level that is perceptible inside the home.

Thorne also concluded that noise that exhibited excessive levels of "fluctuation" that could contribute to adverse effects. He defined fluctuation in terms of LAeq and LZeq levels in 1/3-octave bands averaged over 0.1-0.125 msec. The LZeq metric is used to determine if amplitude modulation (AM) exists for low frequency noise or infrasound, where LAeq metric is more likely to identify AM in the mid-frequency range. A difference of 2 dB or less between the peak and trough of the 1/3-octave band sound level was considered to acceptable, 4 dB was considered to be unreasonable and 6 dB or more was considered to be excessive.

In a recent study, McBride et al. (2014) found that some people living near wind farms had a lower quality of life than others due to increased levels of stress and poorer sleep. It also became apparent that the 'objective manifestations of health effects associated with noise-related annoyance may emerge after some years of exposure'.

The Cape Bridgewater wind farm has been the subject of studies by Thorne (2012) and Cooper (2015), who both found poor sleep quality and adverse health effects in residents. Cooper surveyed six occupants of three houses located between 650 and 1600 m from the nearest turbine. He found that these residents suffered from sleep disturbance, headache, ear pressure, tinnitus and an elevated pulse rate (an indirect finding associated with autonomic shifting toward more dominant sympathetic tone).

The onset of these later four 'sensations' was found to be well correlated with changes in the turbine output power, caused by the following operating scenarios: turbines starting up increase in power of 20% or more decrease in power of 20% or more turbines operating at maximum power and wind increased above 12 m/s

Cooper also found that the infrasound environment with the wind farm operation was characterized by a mix of tonal noise and random noise and was very different to the natural environments, which is characterized by random noise only. He found that the total sound pressure level (denoted WTS - 'wind turbine signature') of the first 11 harmonics of the blade-passing frequency of the wind turbines was correlated with **unacceptable sensation perceived within infrasound spectrum**, such as those listed above. With (specific measuring tools), he recorded the peak levels of the first 11 harmonics. He then added them logarithmically to obtain what he referred to as the WTS (dB). He found that if the WTS (dB) exceeded 51 dB, an unacceptable sensation level would exist. He pointed out that all of the residents involved in his study have been exposed to wind farm noise for at least six years and had a heightened sensitivity to it. (Writer's comment: The WTS stands for "wind turbine signature" which is a characteristic "equally separated" discrete spikes (from 5-20 dB in size) above the time-based infrasound sound pressure recording. These spikes, consistent with the associated transient "strained" blade acoustic response thought to be due to blade stalling/bending during rapid load fluctuations).

Leventhall, (the principal and historical "managing" Acoustician for Wind Energy), in his submission to the Australian Senate Inquiry, pointed out that the large changes in wind farm output power would produce a noticeable change in audible noise produced by the wind farm and this change would draw people's attention to it and attract the recorded responses. He also pointed out that people in the Cooper study recorded increases in audible noise at the same time as they recorded increases in sensations, leading Leventhall to

conclude that the adverse health effects experienced by residences were a result of audible noise, not inaudible infrasound, and that 'residents are reacting in the typical manner of highly stressed persons who are affected by a noise which they do not wish to hear'. (Writer's comment: To my knowledge, actual audible-zone sound recordings (actual A-weighted rises in mean sound levels) correspond with the subjects' recognition of the 'increase in audible noise'. Why is this phenomenon only recognized after a considerable period of 'conditioning time' (years?). Why does this infrasound perception occur at long distances from the IWT - much farther than audible sound would travel? Has wind industry done anything to actively prove or disprove that speculation made by Leventhall? How would he explain the extremely discrete infrasound-origin spikes that correlated with the subjects' recognition? Has Wind Energy, in an effort to bring data supporting Dr. Leventhall's hypothesis, reproduced these findings themselves, then taken the recording of an infrasound-only spectrum that contained those "inaudible spikes" without accompanying audible sound content (filtered out) and verified that they were not the source of the reported sensation. Other Acousticians, report sensitized subjects when "coming into the visualized OR NON-VISUALIZED proximity of the windfarm (miles away), but too far away to "hear" (audible) but close enough to perceive more distantly-projected infrasound) report perceiving the disagreeable/disrupting sensations, and that they can recognize those tones during "heavy" wind farm operation. Residents frequently lament that they, as the suffering residents, "don't know why THEY have to prove these noise perceptions. They ask why the makers of the wind farm or the turbines themselves are not required to show they are safe and "free from harm"?

Separately, if wind turbine noise doesn't produce adverse health effects as Leventhall wishes people to accept as true, then why would wind turbine exposure cause high stress in individuals and why would they recognize the noise (coming from the turbine) as disagreeable? In my opinion, Levanthall needs to 1) take professional responsibility for that statement and 2) prove his statement and produce data that is accepted by an independent (not from Wind Energy chosen reviewers) medical and acoustical sciences peer review.)

Doolan (2013) reviewed literature concerning wind turbine noise perception, annoyance and low frequency emission. He concluded the following:

1) There is a similarity between findings of studies on low-frequency noise annoyance and wind farm noise annoyance.

2) There may be a link between personal and social moderating factors and annoyance.

3) Noise levels that satisfy acceptable A-weighted criteria can still cause annoyance, suggesting that the A-weighted noise level is an inappropriate criterion for specifying allowable wind farm noise levels. (Writer comment: This is particularly a concern with IWTs> 2 MW which have the capability to radiate perceptible ILFN much farther than less powerful IWT models. A-weighting is mostly used to judge audible sound levels. This observation gives STRONG SUPPORT to require regulation of IWT ILFN emissions by an objective limit, e.g. "shall-not-exceed 55 or 60 dBC Lmax (fast)

4) Spectral balance and temporal qualities of the noise should be included in any criteria of acceptability.

5) It is possible that a person's susceptibility to wind farm noise may change as the length of exposure increases.

6) (Greater clarification of particular IWT noise features causing annoyance is needed).

There were many other studies listed and described to the extent reported above. Some were questionnaire driven, all reported symptoms in varying and usually distance-dependent fashion. Association with IWT noise exposure and disturbance of sleep, psychological effects and "distress" in humans were noted. Exact association of which type (frequency range) noise is responsible is not clear.

Of particular note was the comment semantics in the Schmidt (2014) study that summarized the findings: ...At present, it seems reasonable to conclude that noise from wind turbines increases the risk of annoyance and disturbed sleep in exposed subjects in a dose-response relationship. There seems to be a tolerable limit of around LAeq of 35 dB. This would equate up to 46 dBA Lmax. (Writer comment: Why is the resident required to "tolerate" a detectable noise level? Toleration implies ongoing annoyance which, in itself, is an adverse health effect). Audible noise thresholds avoid sleep disturbance is 30 dBA; 32 dBA and above disturbs sleep which cause adverse health effects).

Annoyance:

In 1999, the WHO defined annoyance as "a feeling of displeasure associated with any agent or condition known or believed by an individual or a group to be adversely affecting them". Later, the WHO in 2011 declared that "high levels of annoyance caused by environmental noise should be considered as one of the environmental health burdens". Annoyance is considered to be an adverse health effect (AHE) by the WHO's definition of health.

Noise sensitivity is considered to be a stable, partly heritable personality trait. Noise sensitive individuals are more likely to have stress related disorders, anxiety, HAs and poorer sleep than the average. Several studies have concluded that **individuals do not "get used" to annoyance over time... they may become indifferent but not unaffected.** There is no dispute that psychological factors play a part in any reaction to turbine noise, to suggest that they are the sole explanation is contrary to evidence.

Annoyance "burden" varies directly with the sound levels. The "extent" of annoyance varies from study to study and among differing standards and statements from health organizations.

The 2016 Health Canada Study found that 13.7% of residents reported a high (very or extreme) level of annoyance above 40dBA.

A noise criteria reference chart for rural areas compared EPA community reactions from 1974 case studies to normalize community reaction to intrusive noise in rural areas:

Sporadic resident complaints begin at 30 dBA (Ldn) (level combined with day-night differences)

Widespread complaints at 34 dBA

Strong appeals to stop at 44 dBA

Vigorous community action at 50 dBA

(The latter two sound levels represented 10 and 13% of the population as being very annoyed)

Noise in rural areas above 35 dBA are considered as "incompatible" by the American National Standards Institute

Above 40 dBA, the WHO has issued statements of concern (based on scientific sleep data that noise will produce sleep impacts - motility, sleep architecture disruption, arousals, chronic sleep deprivation).

Dr. Malcolm Swinbanks had a few comments about "annoyance"

1) Residents should not be described as "annoyed" by IWTs but rather "suffer annoyance". It is important to distinguish between an effect that has been externally imposed, rather than self-induced.

2) It has been suggested that blame lies with specific types of personality, implying that people are at fault who have sought a rural lifestyle because they value quiet and tranquility in preference to an urban environment. It is unlikely that many of those living in rural areas will have preselected personalities enabling them to be tolerant of unwelcome, external adverse intrusion.

3) Recently the argument has been advanced (please see Vestas request to the government of New South Wales, Australia to eliminate ILFN as a relevant consideration in placing IWTs) that "problems are created by activists raising alarm in advance of windfarm consent and installation and that the subsequent number of complaints can be directly correlated with the prior presence of such activists".

This argument is meaningless if it fails to take account of the actual sound levels, setbacks and geography of individual windfarms, or the fact that there are reportedly many more complaints in the USA than in Europe, given that the **permitted sound levels in the USA are clearly significantly higher than elsewhere.**

Landowners or neighbors may not respond with complaints as they have entered into agreements with Wind Energy to not complain in exchange for cash payments. Also, a very significant number of landowners who have signed the 58-year term property easement, no longer live (or ever lived) on the property. It is my opinion that it is unethical to prohibit, by contract and implied penalty, that residents relinquish their right to voice concerns about potential or real adverse health effects that they are experiencing or will experience as a result of accepting financial return in exchange for placement of an IWT on their property. Such "gag-rule" contracts have been described as to be severely deficient in informed consent (particularly since wind industry refuses to acknowledge the potential health impacts of infrasound). Resolution of such resident/patient health concerns (though requests for medical services are likely not prohibited) will occur but, in an era of exploding health costs, will lead to a "potentially preventable" economic burden to our strained healthcare system.

Annoyance is a health issue for many people living near IWTs. It is considered to be an adverse health effect (AHE) by the WHO's definition of health.

There is no dispute that psychological factors play a part in any reaction to turbine noise, to suggest that they are the sole explanation is contrary to evidence. Those "psychological factors" are far more likely to produce immediate complaints that frequently dissipate within weeks to months. Complaints that develop early and persist or develop more slowly (usually within 6 months) are most likely unrelated to any "negative emotional" response.

Low Frequency Noise

The WHO, in 1999 stated, "It should be noted that low frequency noise, for example from ventilation systems, can disturb rest and sleep even at low sound levels. In that same publication, the WHO identified the importance of measuring low-frequency components. "It should be noted that a large proportion of low-frequency components in a noise may increase considerably the adverse effects on health" and that "the evidence on low frequency noise is sufficiently strong to warrant immediate concern". This was stated over 2 decades ago without substantial recognition or response by protective governmental agencies. Apparently that information is not provided to County Supervisors.

Leventhall was one of the first Acousticians to describe how low-frequency noise is a special noise problem - particularly to sensitive people in their homes. He indicated that annoyance to lowfrequency noise increases rapidly with noise levels often starting just above the threshold of audibility.

He also noted that the WHO places a special emphasis on low-frequency noise as an environmental problem and source of sleep disturbance, even at low levels. (Leventhall, as noted elsewhere, since has become the principle "Acoustician mouthpiece" of Wind Energy mostly through his denial of IWT produced infrasound). The WHO acknowledges that a noise consisting of a large proportion of low frequency components may considerably increase AHEs and should be limited to <40 dBA. Cummings, another Acoustician, notes that sound levels of 40 dBA trigger high levels of community pushback.

Amplitude modulation (AM) of infrasound and low frequency noise has adverse effects on the body. It is a term often used to describe wind turbine noise - usually referring to low-frequency noise, it can include infrasound. It refers to a sound that varies in intensity over either a short or long time period - generally on the order of seconds or fractions of a second. Nearby residents to IWTs find measurable AM sounds as highly disturbing with symptoms varying person to person and in a significant portion of such residents. These symptoms include sleep disturbance, annoyance, headaches, ear pressure or pain, dizziness, nausea, anxiety and a general feeling of distress or discomfort. Some of the rarer symptoms are blurred vision and memory loss.

There is extraordinarily strong evidence that other forms of less "annoying" environmental noise can cause cardiovascular disease (hypertension, atherosclerotic vascular disease and fatal and non-fatal myocardial infarctions) as described elsewhere in this submission to the Madison County Board of Zoning. This is well documented in the 2018 WHO report on Environmental Noise. I have also made reference to two articles published in 2019 that appeared in world cardiovascular meetings and highly respected cardiovascular journals which link "impaired sleep (duration) to objective measures of vascular atherosclerosis and heightened rates of clinical events.

Nina Pierpont, M.D. (Pediatrician), PhD (Population biology) coined the term "Wind Turbine Syndrome" to describe a range of symptoms reported for 38 family members of 10 families who lived near IWTs.

Her work has been very extensively peer-reviewed. More recent laboratory research, suggest that a variety of health symptoms may be due to ILFN stimulation of both vestibular and cochlear components of the inner ear.

Infrasound Recognition and AHEs.

With most of the newer wind turbines (now 3 MW to 3.5 MW)- (as described in Australia)-increasing numbers of residents living within 10 km (6.2 miles) have suffered and are still suffering severe health impacts since the wind turbines started operating. Many have left their homes repeatedly and eventually permanently, to live in greatly diminished financial circumstances, as their homes are no longer habitable or saleable. Some resident become too "unwell" to work. Wind turbines are not the only source of impulsive infrasound and low frequency noise causing severe health damage. The same pattern of identical serious adverse health effects, sleep deprivation and home abandonments, sometimes out to similar distances are being report by neighbors to other known sources of infrasound and low frequency noise - at open cut coal mining, underground mines with large extractor fans, gas turbine power stations and other sites.

Berger (2015) noted three important aspects of wind turbine infrasound:

1) The sound is regular and pulsating in amplitude. The rhythmic thumping stimulates the inner ear sensory functions, causing a host of symptoms (nausea, chest pain, etc.)
2) Measurements of environmental infrasound are typically reported as average or RMS values. However, the peak values of the signal are what are likely to determine the detection threshold. The peak to RMS ratio for wind turbine infrasound is greater than the peak-to-RMS ratio for tonal sound used in infrasound thresholds testing, so the RMS amplitude of wind turbine sound underestimates its ability to be detected. (This is visually displayed on Fig. 7.7 from "Wind Farm Noise" which was placed in the appendix of Part 4),
3) Some people may be far more sensitive that others due to differences in physiology: some may not be bothered at all but some may suffer severe symptoms when exposed to the same infrasound levels.
Inaudible sound pulsations occurring at infrasonic frequencies emitted by wind turbines have been shown to cause perceptible sensations in a laboratory experiment by research Steve Cooper, an acoustician from Australia. The results were presented at the December 2017 Acoustical Society of America Conference in New Orleans. There he showed that:
1) He can reproduce in his laboratory the acoustic characteristics of IWT sound pressure pulsations occurring at infrasonic rates found in homes of people living near utility scale wind turbines who have filed complaints of adverse sensation and health effects.
2) These inaudible acoustic conditions reliably trigger, in self-identified "sensitive people", sensations and adverse effects associated with the complaints by people who live in or near the footprint of utility scale wind turbines.
Conclusions included that:
1) Wind turbine sound emissions consisting of dynamically modulated pressure pulsations at infrasonic frequencies synchronized to the Blade Pass Frequency have been shown to cause sensations and other adverse effects under controlled laboratory conditions.
2) Alternative explanations, frequently offered by Wind Energy as the Nocebo Effect, are NO LONGER acceptable arguments, since direct cause and effect has been established.

Perception of Infrasound by a Deaf Woman

Separately, another "experiment" was done by Dr. Steven Cooper involving a functionally deaf woman with auditory nerve damage. She claimed (and constantly suffered annoyance from) she could perceive (inaudible to her and to others) "when the IWTs were turned on or off or when they gearedup".
During this witnessed demonstration (in the basement away from any visual clues of IWT operation, the utility operator agreed to (through phone interaction with Dr. Cooper) turn on/off and "gear-up" as Dr. Cooper requested. The deaf resident correctly (very shortly after initiation) recognized all the "test states" that were otherwise consider "inaudible" sound emissions. She explained the perceived signal as a sensation of pressure or movement in the air or structure of her home. She demonstrated this to Dr. Cooper by having him remove his shoes and socks and stand on a part of the floor of her home where the vibrations were most prominent for her. He was able to feel it. Dr. Cooper said that thresholds of sensation were experienced at narrow band sound pressure levels of 4-5 Hz at >50dB. Prior nominal (tonal) audible threshold for frequencies of 4-5 Hz is >100dB. He also did tests of ground vibration and structure response that showed the movement he felt was not from ground borne energy, but was from the home responding ("breathing") to the pulse pressure.
When that pulse goes through a structure (home or one's body) small resonance are evoked that can be felt as pressure changes or if affecting the vestibular sensory organs, as motion.
Finally, in Appendix 3 of the July 25, 2011 "Noise-Con 2011" submission by Bray and James, they included comments from Alex Salt, PhD (14 December 2010) as below:

Infrasound Perception from Wind Turbines and the Inner Ear? Dr. Salt's view:

There is controversy whether prolonged exposure to the sounds generated by wind turbines adversely affects human health. The unweighted spectrum of wind turbine noise slowly rises with decreasing frequency, with the greatest output in the 1-2 Hz range. As "conventionally understood" human hearing is insensitive to infrasound (needing over 120 dB SPL to detect 2 Hz), it is claimed that infrasound generated by wind turbines is below threshold and therefore cannot affect people. The inner hair cells (IHC) of the cochlea, through which hearing is mediated, are velocity-sensitive and insensitive to low frequency sounds. The outer hair cells (OHC), in contrast, are displacement sensitive and respond to infrasonic frequencies at levels up to **40 dB below those**

that are heard. A review found the G-weighted (filter that will actually measure infrasound while A-weighting does not) noise levels generated by IWTs with upwind rotors to be approximately 70 dBG. This is substantially below the (tonal) threshold for hearing ultrasound which is 95 dBG but is above the calculated level for OHC stimulation of 60 dBG. This suggests that most wind turbines will be producing an unheard stimulation of the OHCs. Whether this is conveyed to the brain by type II (incoming, sensory) fibers or influences other aspects of sound perception is not known. Listeners find the so-called amplitude modulation of higher frequency sounds (described as "blade swish" or "thump") highly annoying. This could represent either a modulation of audible sounds (as detected by a sound level meter) or a biological modulation caused by variation of OHC gain as operating point is biased by the infrasound. Cochlear responses to infrasound also depend on audible input, with audible tones suppressing cochlear microphonic responses to infrasound in animals. These findings demonstrate that the response of the inner ear to infrasound is complex and needs to be understood in more detail **before** it can be concluded that the ear **cannot** be affected by wind turbine noise.

Measuring Infrasound

To fully assess all potential annoying or health-damaging sound components being emitted from IWTs, methods of measuring sound must:

1) utilize instruments able to monitor the whole spectrum of sound
2) be conducted inside as well as outside homes or at property lines if sound is regulated there.
3) produce results in narrow bands **not** one-third octaves or dB(A) as is currently standard
4) must continue over sufficient periods of time, to cover most if not all environmental conditions (wind speed and direction, etc.)

The Concern that IWTs Can Facilitate Development of Cardiovascular Disease:

The WHO data review boards (Principally Measuring **Environmental** Noise Data) measured 3 critical health outcomes: **(Taken directly from 2018 WHO statement)**

1) Cardiovascular Disease: ischemic heart disease (angina, myocardial infarction (heart attack), hypertension. **Noted that cardiovascular disease has important health consequences and can lead to more severe disease and/or mortality.**
2) Effects on sleep: Percentage who were highly sleep-disturbed (via data from):
A) self-reported and assessed with standardized scale
B) Formal sleep studies (PSGs) - probability of additional awakenings
C) Cardiac and BP measures during sleep
D) Motility measures of sleep outcomes in adults
E) Sleep disturbance in children

Noted that effects on **sleep may be in the causal pathway to cardiovascular disease.**

3) Annoyance: reflected by the percentage of the population that is highly annoyed assess with standardized scale

Noted that large proportions of the population are affected by noise annoyance, even at relatively low exposure levels. **Annoyance may be in the causal pathway to cardiovascular disease.**

***** Again, the three links (or causal pathways) to cardiovascular disease are from environmental noise (directly measured increased incidence, due to effects from sleep disruption and annoyance)**

****

The data directly from available IWT exposure studies is considered "conditional" with available studies not being of sufficient "power" to currently be consider the evidence to be "strong enough" to include IWT noise. NONE of the available data suggested otherwise. Notable is that wind turbine noise has been described as having a character that makes it far more annoying and stressful than other sources of noise at the same A-weighted level, including traffic and industrial noise. Additionally, Thorne, has pointed out that human perception of noise is based primarily on sound character rather than sound level, and that wind turbines are unique sound sources that exhibit special audible and inaudible modulated and tonal characteristics.

(Writer's comment: Like many "triggers or responses" in biological systems, thresholds for presumed autonomic shifting to heightened reactionary sympathetic tone is likely NOT a single feature...such as a

discrete noise level...but include other features such as quality of the annoying stimulus or unique factors present in "vulnerable populations").

Particularly noteworthy are the WHO recommendations to policy-makers to reduce exposure from wind turbines in the population exposed to levels of 45 db Lden. Other forms of environmental noise which also had recommended noise levels were:

Aircraft: 45 dB Lden, 40 dB Lnight

Railway: 54 dB Lden, 44 dB Lnight

Road Traffic: 53 dB Lden, 45 dB Lnight

Industrial Wind Turbines: 45 dB Lden - nothing specified for night given inadequate data to allow a recommendation. The review data committee conditionally recommended that policy-makers implement suitable measure to reduce exposure from wind turbines in the population exposed to levels above the guideline values.

The reported guidelines were published BY the WHO Regional Office for Europe. In terms of their health implications, the recommended exposure levels can be considered applicable in other regions and suitable for a global audience, as a large body of the evidence underpinning the recommendations was derived not only for European noise effect studies but also from research in other parts of the world - mainly America, Asia and Australia.

What is Going On: Deep Dive into a Much Deeper Pond

The human organism is thought to have evolved in a "natural" environment where survival was dependent upon unique capabilities of hearing and vision among other senses that were selected and honed over millions of years. The brain became the "central processor" of information from all the traditional senses and also received and responded through the peripheral nervous system. Within the peripheral nervous system, there is the autonomic nervous system that influences the function of internal organs. Simplistically, it is a "control system" that acts largely unconsciously and regulates bodily functions such as heart rate, digestion, respiratory and many others. Within the autonomic nervous system, there are two major branches - the sympathetic and parasympathetic nervous systems.

The sympathetic nervous system is often considered the "fight or flight" system using "activating" chemicals such as norepinephrine as a neurotransmitter with epinephrine (adrenaline) being produced by the adrenal glands. The parasympathetic system is often considered the "sleep and eat" system and chiefly uses acetylcholine to act on two different receptors. In many cases, both of these systems have "opposite" actions where one system activates a physiologic response and the other inhibits it. In practicality, there is an "undulating balance" - or responsive "rheostat" that can both momentarily change an ongoing balance or can more persistently change (slightly) toward one side or the other depending on environmental or individual "body-regulating needs."

As a heart rhythm specialist, I am referred patients having the consequences of heart attacks presenting as palpitations representing "PVCs" or "non-sustained lower heart chamber (ventricular) abnormal rhythms" or, more serious, aborted sudden cardiac death. Genetics combined with environmental/behavioral factors can produce atherosclerosis which is a complex disease process facilitated by high cholesterol, hypertension, smoking, glucose intolerance among others. The development of the atherosclerotic "plaque" has been worked out showing a very complex genesis.

An over-riding factor in the disease background is our controlling nervous system. One system – the autonomic nervous system - plays a both protective and facilitative role for our body's survival and functioning in responding to the "outside environment" or regulation of normal day/night activities.

As just mentioned, this is achieved by both hormonal and neurotransmitter actions. It is truly remarkable how a perceived threat can almost instantly change the ease of individual atoms transferring through a single cell membrane on specific portions of our heart's "wiring system" or can subtly shift membrane thresholds that trigger contraction of individual heart cells. Long-term or "tonic" activation of the "fight-or-flight" limb of the autonomic system (sympathetic system) can have the effect of disrupting a "normal balance or "homeostasis" that has the potential consequence of causing "more rapid aging" - this being associated with body adaptation processes that turn out to be "destabilizing and disease producing".

Listed on a NIH (National Institutes of Health) web site (C Ayada, U Toru, Y Korkut: Hippokratia, 2015 Apr-June, 19(2):99-108 The Relationship of Stress and Blood pressure Effectors), the authors describe long-term stress physiological adaptation as different from acute stress and lay-out the chain of responses that are believed to occur. "Daily events cause chronic stress and have detrimental effects on the body (allostatic load) beyond the creation of "fight or flight" response to acute stress. In general, chronic stress has various effects, such as increased risk of cardiovascular disease, decreased baroreceptor reflex response, increased blood pressure and neuroendocrine response to new acute stress, decreased blood pressure and neuroendocrine response to repeated stress and increased basal blood pressure. These mechanisms work together harmoniously to help an organism survive under acute stress conditions and to prepare it for future threats. However, long-term activation of the stress circuit can cause many different health problems, including the increase of risk factors for cardiovascular disease. Although cardiovascular diseases progress in stress, especially in depression, the role of the RAAS (renin angiotensin aldosterone system) in the stress response is generally neglected. Indeed, the RAAS is one of the most important systems in the development of the pathogenesis of cardiovascular diseases." The authors describe the known effects of elevated norepinephrine from chronic stress that lead to increased hypoxia, cAMP levels, catecholamine metabolites and intracellular calcium. Through elevated renin from chronic stress, angiotensin II becomes elevated that leads to increased superoxide anions, ACTH levels, adrenal glucocorticoids, aldosterone and catecholamines. Together these two consequences may affect excitation-contraction matching, activated apoptotic ways, pathological hypertrophy, weakening of ventricular plasticity and left the ventricular ejection fraction, cardiovascular damage related to oxidative stress, increased ventricular hypertrophy, vasoconstriction, sodium retention, the development of myocardial fibrosis and facilitated cardiovascular remodeling. All these may promote the development of chronic heart failure.
They also describe the relationship of chronic stress and Endothelin-1. " ET-1 is found in most endothelial cells, and is the strongest vasoconstrictor agent (of ET-1,2 and 3). It is produced in the heart, kidneys, central nervous system and posterior lobe of the pituitary gland. ET-1 production is increased by many factors....and there is evidence that ET-1 production is increased in hypertension models". They continue with ET-1 effects on ET-A and ET-B receptors and resultant cardiovascular effects. Importantly, " in addition to its vasoactive characteristics, ET-1 stimulates smooth muscle cell proliferation through the same receptors. Thus, it contributes to vascular restructuring and leukocyte adhesion. ET-1 generally tends to increase blood pressure and venous tone. Additionally, it is reported that the mitogenic effect of ET-1 contributes to the development of atherosclerosis... it is likely to be a component in the pathogenesis of cardiovascular diseases. ET-1 causes an increase in human vascular smooth cells which occur through platelet-derived growth factor, fibroblast growth factor and epidermal growth factor as a result of the response to ET-A receptor. That is why anti-endothelin treatment may not be only anti-hypertensive but also anti-atherosclerotic."
This above excerpt is not meant to confuse or overwhelm but to demonstrate that basic bench research and clinical trials leading to RAAS inhibitors and beta blockers have become quite sophisticated and that through this research, models of adverse health effects from chronic stress (producing sympathetic activation) are quite plausible and could be considered "causal".

Other Real-time Medical Examples of likely Autonomically-Mediated Cardiovascular Disease Obstructive Sleep Apnea - A Disease Model to Consider for IWT Health Effects

In my work I deal with arrhythmias - heart rates that are too fast, too slow or not "normal". Atrial fibrillation is fast becoming one of the abnormal rhythms that is consuming most of a "heart electrician's" time and an increasing amount of this country's medical resources. Atrial fibrillation likely has always been a part of the human condition but in the last 40 years - particularly after linking atrial fibrillation to embolic stroke - it has become a major health concern and threat. In this country, roughly half of the patients with atrial fibrillation have a disorder sleep - the majority of that labelled as obstructive sleep apnea (OSA). Briefly, it is the intermittent complete or partial interruption of airflow into or out of the lungs occurring as the patient transitions into deeper sleep with relaxing tonsillar soft tissue or the tongue creating obstruction to that airflow. Patients with OSA are commonly overweight being frequently obese to morbidly obese. Their nights of sleep are characterized by multiple arousals triggered by intermittent surging adrenergic tone due to low oxygen in the blood caused by airway obstruction and resultant marked interruption of oxygen delivery to the lungs. They frequently snore loudly and characterize their nights of "sleep" as nonquenching and "never enough" They wake

up tired and start the day exhausted and find themselves struggling at times with otherwise simple acts or mental calculations. They reluctantly admit and are told by others, that they "seem to be in a cloud". Treatment begins with confirming the diagnosis with a sleep study and usually the prescribing of a CPAP (continuous positive airway pressure) mask. These same patients often also have type II diabetes, and hypertension (often quite labile (varying)), and hyperlipidemias. There is also evidence of endothelial (lining of blood vessels) dysfunction and hypercoagulability. As mentioned, they are frequently obese.

How did this all start? An unhealthy lifestyle is, of course, the superficial answer. More likely it started with our stressful lives (vaguely stated because it is) and living in the "passing lane" where sleep is considered a more optional need or where for some, obtaining quality, restorative sleep is compromised by where we live. Unfortunately, disordered sleep creates the metabolic condition where sympathetic tone and stress hormones are higher thus affecting glucose metabolism and the triggers of hunger and satiety (1) which leads to obesity, insulin resistance, hypertension among many other things. Clearly, our genetics also have a role. Importantly, not everybody will react to "stress" the same, and, as a result, not everyone displays these later stages where discrete disease states are attained and then labeled.

From various cardiovascular studies some findings were presented: Patients suffering from OSA have >2.8 times increased likelihood of fatal cardiovascular (CV) events and nearly 3.2 times likelihood of nonfatal CV events. In a study of 182 men, ages 30-69 years followed for 7 years, 122 did not have OSA noting that their developed incidence of CVD as 6.6%. The remaining 60 with OSA had a CVD incidence of 36.7% - 5 times higher. Although long suspected, the incidence of heart failure (both with impaired and preserved systolic (contractile) function) has been correlated with sleep disturbance. In the Heart Health Study, mild-moderate OSA (AHI>10) was independently associated with a 2.38-times increased odds of having heart failure.

Hypertension - however defined - is quite common in our industrialized society. Extensive reviews by multiple investigators show that 50% of OSA patients have hypertension and 30% of hypertensive patient have OSA. Indeed, OSA - one form of a sleep disorder, is strongly associated with the development of hypertension which then can progress into a myriad of various endorgan diseases (strokes, heart disease, vascular disease, kidney disease, etc.).

As seen with industrial wind turbines, suffering annoyance and tinnitus and sleep disturbance are adverse health effects that effect quality of life associated with dBAs of <40... but does not constitute the harder endpoints of cardiovascular disease which, when you look at the additional disease burden as a function of increasing sound levels, starts around 40 dBA. I would hypothesize that the transition from 30 to 40 dBA reflects autonomic shifting from likely intermittent to a more consistent "active/dominant" sympathetic tone that initiates the cascade of inflammatory response and adverse renin-angiotensin/aldosterone system (RAAS) activation that, over time, plays out the development of hypertension and atherosclerotic vascular disease leading to both subclinical and clinical ischemic (adverse organ blood flow) consequences.

WHO Comments about Environmental Noise Health Effects

With the escalating threat over climate change triggering rapid industrialization of wind energy generation, both factions: pro- or anti- wind are now coming to grips with realities of what these massive machines and their visual impacts, sound emissions and effects on property values and wildlife, etc., **NOW** mean to their future energy security balanced against quality of life. The visual impacts are complex as individuals and communities try to adapt to its alien presence. The effects of wind turbines on man are relatively new with one of the earliest papers in 1987 (Kelley) surprisingly identified what is likely the most important consideration of chronic exposure to IWTs - infrasound and low frequent noise
(16). It has only been in the last 15-20 years where we have seriously pursued defining IWT exposure and health impacts. Intensive discussion and data collection leading to publishing that generate acknowledged "experts" that are pulled to friendly factions into unfriendly judicial interactions continues for one reason – the entirety of the health impact from IWTs - psychologic and physical - remains incompletely described.

The "conflict" of the siting of these turbines is driven by financial rewards on one side and on the other side an imposition of enduring unnatural background noise and an honest concern for potential serious adverse health effects that most likely worsen through subliminally to significantly heightened stress.

Effects are hard to measure and they are seemingly wide-ranging in scope and variable among people. In the long-term manner in which residents are exposed living close to IWTs, to clarify and quantify "the full extent" of their long-term health effects will take a long time with carefully designed studies with enough people in both the exposed and "control" groups where confounding variables are recognized and accounted for that will quantifiable and statistically validated conclusions that then can best forge public policy. Such a complete and long-term study will likely NOT be done. Having said that, there currently is an enormous amount of information about AHEs from IWT exposure – enough to implement protective "siting regulations".

In the 2018 WHO report, under the area of "additional contextual factors", they again state that "very little evidence is available about the adverse health effects of continuous exposure to wind turbine noise". They did comment that proper public involvement, communication and consultation of affected citizens living in the vicinity of wind turbines during the PLANNING state of future installations is expected to be beneficial as part of health and environmental impact assessments. That said, it should be noted that MAE's first notification to residents living in the targeted turbine zone (except for those approached up to two years earlier to obtain easements) was not done until a few weeks before the first of three public hearings - essentially not allowing any education or research on the potential impact on targeted residents of a decision which did not request/involve their input. That report also states that residents living in the potential areas selected for IWTs may have greater expectations of the quietness of their surrounds and therefore be more aware of the noise disturbances. They also pointed out, unlike for traffic, railways or aircraft noise that with wind turbines, noise reduction interventions are more complicated than for other noise sources due to the height of the source and because outdoor disturbance is a particularly large factor.

Furthermore, they comment that noise "emitted from wind turbines has other characteristics, including the repetitive nature of the sound of the rotating blades and atmospheric influence leading to a variability of amplitude modulation, which can be a source of above average annoyance. This differentiates it from noise from other sources and has not always been properly characterized". They acknowledge (which pro-wind factions refuse) that "standard methods of measuring sound, most commonly including A-weighting, may not capture the low-frequency sound and amplitude modulation characteristic of wind turbine noise". These last three points are central considerations to the production of disordered sleep and subsequently in the production of pleomorphic (many faceted) adverse health effects.

In a 2019 German medical publications, Mathias Basner, Associate Professor of Sleep and Chronobiology at the University of Pennsylvania wrote an editorial entitled "Noise: What is to be done?" Dr. Basner also was a lead writer of the 2018 WHO publication on the "Burden of Disease from Environmental Noise". He pointed out that "health effects of noise go far beyond hearing". The so-called nonauditory effects of noise include annoyance reaction of the exposed population, sleep disturbance, school children's learning impairment and cardiovascular disease" (increased risk for hypertension and myocardial infarction). He continued by clarifying that "noise is defined as unwanted sound" and that the circumstances of the noise exposure play a crucial role for the non-auditory noise effects. Sound is often perceived as noise if one has little control over it and feels at somebody else's mercy. He stated that the "number of studies on the health effects of noise has increased considerably over the past few years. Even if high-quality studies are still missing for many noise sources and disease endpoints, there is little doubt among researchers that noise is an important risk factor for cardiovascular disease. He commented that we habituate (get used to) to many things - including noise. However, the habituation is rarely complete - **that is that the adverse health effects are still at work even if we no longer perceive noise as such.** Health impairments from noise exposure is the result of cumulative processes, i.e. health impairment is the result of relevant exposure over long periods of time.

Appendix:

Beyond the physics and physical harm, there is an undercurrent of mental anguish and reaction that leads to AHEs. Open link below for 17-page June, 2020 article overviewing reasons why some residents are forced to vacate their homes.

- **Wind Turbine Incident/Complaint Reports in Ontario, Canada: A Review—Why Are They Important?** Carmen M. Krogh, E. Jane Wilson, Mary E. Harrington *Open Access Library Journal* Vol.6 No.2, February 18, 2019 DOI: 10.4236/oalib.1105200 582 Downloads 2,331 Views Citations

- **Human Health, Rights and Wind Turbine Deployment in Canada** . Carmen Krogh, Brett Horner *Open Journal of Social Sciences* Vol.5 No.5, May 17, 2017 DOI: 10.4236/jss.2017.55012 1,805 Downloads 3,509 Views Citations This article belongs to the Special Issue on **Human Rights and Social Justice**
- **Preliminary Results: Exploring Why Some Families Living in Proximity to Wind Turbine Facilities Contemplate Vacating Their Homes—A Community-Based Study** . Carmen M. Krogh, Robert Y. McMurtry, Anne Dumbrille, Debra Hughes, Lorrie Gillis . *Open Access Library Journal* Vol.7 No.2, February 21, 2020 DOI: 10.4236/oalib.1106118 404 Downloads 1,265 Views Citations
- **Déja vu and Wind Turbines: A Review of Lived Experiences after Appeals of Ontario Industrial-Scale Wind Power Facilities** . Jane Wilson, Carmen Krogh, Paula C. Peel *Open Access Library Journal* Vol.7 No.5, May 15, 2020 DOI: 10.4236/oalib.1106276 775 Downloads 3,207 Views Citations
- **Health Canada's Wind Turbine Noise and Health Study—A Review Exploring Research Challenges, Methods, Limitations and Uncertainties of Some of the Findings** . Carmen M. Krogh, Anne Dumbrille, Robert Y. McMurtry, Richard James, Robert W. Rand, Michael A. Nissenbaum, Jeffery J. Aramini, Stephen E. Ambrose *Open Access Library Journal* Vol.5 No.12, December 20, 2018 .DOI: 10.4236/oalib.1105046 677 Downloads 2,745 Views Citations
- **Wind Turbines: Why Some Families Living in Proximity to Wind Energy Facilities Contemplate Vacating Their Homes: An Overview of Findings** . Carmen M. Krogh, Robert Y. McMurtry, W. Ben Johnson, Anne Dumbrille, Mariana Alves-Pereira, Jerry L. Punch, Debra Hughes, Linda Rogers, Robert W. Rand, Richard James, Stephen E. Ambrose, Lorrie Gillis *Open Access Library Journal* Vol.7 No.6, June 28, 2020 DOI: 10.4236/oalib.1106443 814 Downloads 3,220 Views Citations
- **Grounded Theory as an Analytical Tool to Explore Housing Decisions Related to Living in the Vicinity of Industrial Wind Turbines .** Carmen M. Krogh, Robert Y. McMurtry, W. B. Johnson, Anne Dumbrille, Mariana Alves-Pereira, Jerry L. Punch, Debra Hughes, Linda Rogers, Robert W. Rand, Richard James, Stephen E. Ambrose, Lorrie Gillis *Open Access Library Journal* Vol.8 No.3, March 26, 2021 DOI: 10.4236/oalib.1107233 411 Downloads 2,516 Views Citations
- **Wind Turbines: An Exploration of Research Participants' Living Experiences as a Consequence of Ontario's Green Energy Act** . Carmen M. Krogh, Robert Y. McMurtry, William Ben Johnson, Jerry L. Punch, Anne Dumbrille, Mariana Alves-Pereira, Debra Hughes, Linda Rogers, Robert W. Rand, Richard James, Stephen E. Ambrose, Lorrie Gillis . *Open Access Library Journal* Vol.10 No.6, June 29, 2023 DOI: 10.4236/oalib.1110043 112 Downloads 1,161 Views Citations

Nocebo Effect

This concept is a central piece of quoted evidence by Wind Energy to explain the origins of "annoyance" as being a psychological response, or an "attitudinal defect" of residents. This was directly mentioned by a physician (neurologist/sleep specialist) who was a paid consultant for Mid- American Energy when he provided oral testimony at the original Madison County Board of Adjustments and by Peter S. Thorne, PhD - Toxicology, in his comments to the Madison County Board of Health.

The "Nocebo Effect" has been used to explain the development of "annoyance to IWTs" based on resident's generalized subjective impression of the turbine impact on their senses. This has been popularized (essentially only) by the Wind Energy faction. The WHO has completely rejected any relevance of the nocebo effect. Frankly, a person's reaction in having to acknowledge, accept and then daily endure an object constantly viewed as "negative" in the presence of their home environment – is "what it is". The first recorded "annoyance response" toward IWTs was observed during the first U.S. operation of a large wind turbine during initial prototype turbine operations (ND Kelley) in North Carolina in the 1980's. The usual symptoms of sleep disturbance, headache, tinnitus, irritability, problems with concentration and memory developed in a significant proportion of nearby residents – it is likely NONE of them had any pre-exposure negative opinions about the turbines.... it was after all, one of the very first times that an IWT had ever been operated.

In the textbook: Wind Farm Noise, the authors include this in their section on "The Nocebo Effect":

There are a few pro-wind-farm advocates who claim, via various web sites, that any adverse health effects due to wind farms are imagined, that wind farms do not make any audible noise and that complaints only began after anti-wind-farm activists began their campaigns to stop the construction of future wind farms. They

attribute reported adverse health effects to mass hysteria and use pseudoscientific terms such as 'mass psychogenic illness' or 'psychogenic nocebo phenomenon'. Others (for example, Knopper et al. (2013) agree that wind farms produce sufficient noise to annoy some people, but suggest that the only adverse effect of wind farm noise is annoyance, which can manifest as physical symptoms in some people. Whether this is the case or whether low-frequency noise and infrasound generated by wind farms have a direct adverse physiological effect, as suggested by Salt and Lichtenhan (2014) is still unproven. However, all of the literature claiming to prove that all adverse health effects are a result of a nocebo effect is based on suspect data, such as records of complaints produced by the wind farm industry, with no acknowledgement that over the past few years, wind turbines and the number of them in a wind farm have become much greater and that it takes time for people to realize what is causing their symptoms. Literature in favor of a nocebo-effect explanation universally fail to acknowledge work published by research in the U.S.A., New Zealand and Canada (Krogh, et al., 2011; Moller and Pedersen, 2011, Shepherd et al., 2011), who found that many wind farm neighbors who were in favor of wind farm operations prior to their construction, changed their view after the turbines began operating and adverse health effects became noticeable.

In support of the argument denying the nocebo effect, there are at least two instances of acoustic engineering professionals succumbing to illness during and soon after undertaking measurements in homes of people complaining of wind farm noise (Ambrose et al., 2012; Swinbanks, 2015). These symptoms came on entirely unexpectedly and the professionals involved did not have any prior expectations that they would suffer any effects. It is interesting to note that in the Swinbanks case, periodic infrasound was measured, with the highest peak level of 55 dB in the narrowband frequency spectrum and the cumulative effects of all the harmonics raising the peak level in the time domain to between 69 and 72 dB, indicating that spectral analysis can considerably underestimate the true peak of a noise. However, even this level is below what would normally be detected by a human subject, indicating that infrasound levels below the normal detection threshold may have ill effects on some people.

In the Punch and James article, the authors thoroughly review the reported "nocebo effect".

In the textbook "Wind Farm Noise" the authors wrote "Much more extensive testing has to be done to determine a dose-response relationship that reflects real-world wind farm noise exposure and this will take a long time, even if funding becomes available to undertake the work. Before this work is completed, we must make do with case studies and self reporting incidents. These latter have now become so numerous that the construction of future wind farms should only proceed with care, ensuring that resulting low-frequency noise levels and infrasound at residences is below the thresholds (discussed in section 1.6 in their textbook). There should also be a commitment by a wind farm developer to pay appropriate compensation to, or purchase residential property from, anyone suffering adverse effects within the first six months of turbines beginning to operate.

A Need to Site IWT at Distances that Reasonably Achieve "Sound Safety" - Best Described as "Near" Background Levels; Is it 'fair' to Annoy /Harm a Sensitive Minority?

The key to more healthy (mental and physical) coexistence is siting of IWTs far enough away from ordinary human interaction that annoyance is rare. How far away does it need to be - from not visible (to avoid any visible annoyance) to something closer which may always invoke some degree of annoyance in some people. People are "biologically designed" and thus generally behave in their responses in a "normally distributed fashion. There are some individuals will always recognize (and react "briskly") and some (at the other end of the curve) who will never respond. The majority in the middle will have "some recognition with an average response". At greater, and toward higher, physiologically-damaging levels of noise exposure, this normal distribution is no longer relevant with the "center" of the distribution shift rightward reflecting a high percentage of highly annoyed individuals.

Wind turbine sound is perceived to be more annoying than other equally loud sources (Pedersen, Bakker, Bourma & Van den Berg, 2009). Higher levels of annoyance may be partly explained by wind turbine noise amplitude modulation, lack of night-time abatement and visual impacts. Wind turbine tonal and audible low-frequency sound are also plausible causes of wind turbine noise annoyance (Moller & Pedersen, 2011) and reported health effects (Minnesota Department of Health, 2009) and, may play an important part in the cause for adverse community reaction to large IWTs installed close to residences in quiet areas. Wind turbine low-

frequency energy presents a recurring and/or unpredictable pressure signature, with audibility requiring forced judgement occurring over a much longer period of time than other environmental sources of low-frequency energy.

Sound Perception

Harrison concluded that "IWTs caused annoyance in about 20% of residents living within a distance considered acceptable by most regulatory authorities and that for many of the 20%, the annoyance and sleep disturbance lead to adverse health effects (AHEs)". Thorne noted that human perception of noise is based primarily on sound character rather than sounds level, and that wind turbines are unique sound sources that exhibit special audible and inaudible modulated and tonal characteristics. He stated that sound levels of 32dB (A) Leq outside a residence and/or above an individual's threshold of hearing inside the home are markers for serious AHEs - especially among susceptible individuals.

In New Zealand (another country that has been seen as a huge proponent of alternative forms of energy), studies have concluded that people who live within 2 Km of IWTs have been found to have a lower quality of life, lower physical quality of life and lower environmental quality of life. Such victims also report experiencing a significant lower quality of sleep. There is a rapidly growing amount of literature by acousticians, academics and health professionals that focus on the adverse health effects of being in the vicinity of IWTs (Dr. Donald Deever, 6/13/2018 - Public Comment: Opposition to a Proposed Wind Turbine Project).

A 2011 Ontario Review Tribunal Decision found that wind turbines can cause harm if placed too close to residents stating: "This case has successfully shown that the debate should not be simplified to one about whether wind turbines can cause harm to humans. The evidence presented to the Tribunal demonstrates that they can, if facilities are placed too close to residents. The debate has now evolved to one of degree. (Erickson v. Director, 2011).

Human Rights and Social Justice

What allows a Wind Energy company to decide they can study a wind map and begin planning a wind farm without the acceptance of all parties who might be involved? Was it the transition from small early farms turbines that were of essentially no consequence to health or scenery considerations to a slightly larger (but still not obtrusive and annoying) but more sophisticated models of the early 1970s that suddenly (because of a natural progression - "alway bigger") produced the current, massive scale turbines that we see today? Have we lost sight of the consequences of that transition...in terms of annoyance, sound generation and being unconcerned about unknown biophysical ramifications?

What was initially an image of closely-spaced turbines clustered along a remote canyon ridge in California became a sudden, uninvited, and "unstudied for safety ramifications" rush literally into our backyards. What may have been an easily accepted small structure a century ago became a forced placement of "dominating eyesore" with potentially seriously harmful health consequences and otherwise, completely unwanted. When did we stop considering the impact of these massive structures; when did we stop being considerate and respectful of our neighbors?

Canada has ratified an "international convention" which recognize the individual's right to the enjoyment of the highest attainable standard of health. The deployment of IWTs in Canada presents a contemporary example of the individual's right to health in conflict with competing interests as described in a May, 2017 article by Krogh and Horner. Through the review of government publications, documents and websites they confirmed the following health principles that have been adopted and supported by Canada.

1) Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity.

2) Individuals have a fundamental human right to the highest attainable standard of health.

3) Governments have a shared-right responsibility to help Canadians maintain and improve their health, while respecting individual choices and circumstances.

4) A primary role and responsibility of government is to generate effective responses for the prevention and control of non-communicable diseases.

5) No one shall be subjected without their free consent to medical or scientific experimentation.

They quoted Health Canada's "broad mandate to protect and maintain the health of Canadians - including protecting people from risks in the environment where they work, live and play...." and the "...public expects

government to mitigate those risks...." The main health risks of noise identified by the WHO were listed and exposure to IWTs were described as a plausible cause of reported health effects. Among many, the important ones identified were annoyance, sleep disturbances and all its consequences on a long and short- term basis, cardiovascular effects, hormonal responses and the possible consequences on human metabolism and the immune system. Despite these risks, the Canadian government has approved deployment of IWTs despite municipal governments having declared their jurisdictions to be unwilling hosts of wind energy projects.
The authors concluded, through review of government documents, peer reviewed literature and other references, "that Wind Energy deployment in Canada can be expected to result in harm to human health. The resulting harm is deemed avoidable and conflicts with the individual's fundamental human to the highest attainable standard of health". Furthermore, they stated that "governments have a responsibility to help Canadians maintain and improve their health by generating effective responses for the prevention of avoidable harm. Individuals have a right to make informed decisions about their health. IWT knowledge gaps and potential risks to health should be fully disclosed". Individuals should not be exposed to IWTs without their informed consent.
The same set of protections should apply to residents of this county. The owners of the wind turbine and/or local government do NOT fully know the full extent of adverse health consequences of chronic exposure to wind turbines. Industrial Wind Turbines have NOT been shown to free of adverse health consequences. If, upon completing informed consent of the unknown risks, the resident decides not to accept the risks, then it should not be permissible that wind turbines be placed within a distance where AHEs are potentially deemed possible given our current understanding (approximately 1.25 miles to avoid sleep disturbance due to ILFN - see below in Table where various investigators have submitted their recommendations).
The real question: Why is it the responsibility of the potential sufferer (some would say likely) to prove the proposed adverse health effects rather than the initiator (Wind Energy proponents) of the risk to adequately demonstrate the absence of health consequences prior to initiating the risk.
If IWTs are used, they should be sited such that their potential negative impacts are profoundly curtailed and that nearby resident's rights to live in a healthy environment are honored - especially their right to live and raise their children and grow old - both children and the elderly being considered more vulnerable to wind turbine noises.
Shain (2011) point out that wind farms represent a trade-off of adverse health effect of a few to beneficial health effects of many in the form of reduced carbon emissions. (That argument was voiced by a number of citizens at various County hearings). There is also an inherent argument that the government can interfere with the rights of a few for the benefit of many. However, in many other cases, the few disadvantaged people are usually fairly well compensated by the corporation causing the disadvantage. Unfortunately, the same is not true for people adversely affected by wind farms. **The rapid multiplication of wind farms in recent times seems to be in conflict with the precautionary principle, that would require that a particularly industrial activity not be undertaken unless there is no doubt that such an activity will not harm any people.** In many countries there is also a common law requirement that there is a duty to ensure that one does not cause predictable harm to their neighbor's interests.

Vulnerable Populations

The United States accepted the WHO's constitution in 1948: Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity.
In 1989, the "Rights of the Child" was unanimously adopted by the UN General Assembly with 193 countries ratifying - the most widely ratified human rights treaty.
The proclamation state that "childhood is entitled to special care and assistance".
WHO - defines vulnerable groups of children as:
The fetus and babies
Preterm, low birth weight and small for gestational age babies
Children with dyslexia and hyperactivity
Children on "ototoxic medications"
Who is most affected?
Children require more sleep than adults

Sleep disturbance at night can lead to an increase in medical visits, spending on medications... affects families' budgets and countries' health expenditures
Autism: in a survey of 17,000 children with autism spectrum disorders, over 40% were hypersensitive to sounds.
Concern over shadow flicker - noting shadow-processing mechanism are abnormal in autism (cast shadows interfere rather than help object recognition)
Autistic children and adolescents suffer from sleep problems, particularly insomnia 40-80% higher than normal developing children
Children's learning is affected by noise - both at home and at school
Pierpont: Case Study: 7 out of 10 school-age children and teens did worse in school during exposure to turbines, compared to before or after, including unexpected problems in reading, math, concentration and test performance - noted by both parent and teachers. Teachers sent notes home asking what was wrong with children.
Over 90% of Pierpont sample of affected people - both adults and children, "had cognitive difficulties during wind turbine exposure - problems that linger and resolve slowly after exposure ended.
These included difficulties with reading, math, spelling, writing, multitasking in kitchen and home, remembering a series of errands, maintaining a train of thought in a telephone conversation, following the plot of a TV show, following recipes and following directions to put together furniture."
Impairment of early childhood development and education caused by noise may have lifelong effects on academic achievement and health. Noise is an underestimated threat that can cause a number of short- and long-term health problems, e.g. sleep disturbance, cardiovascular effects, poorer work and school performance, hearing impairment, etc.
It is likely that children represent a group which is particularly vulnerable to the non-auditory health effects of noise. They have less cognitive capacity to understand and anticipate stressors and lack well-developed coping strategies. Moreover, in view of the fact that children are still developing both physically and cognitively, there is a possible risk that exposure to an environmental stressor such as noise may have irreversible negative consequences for this group.
Bronzaft (2011) pointed out the adverse effects of train noise on students in a classroom and showed that high achievers more often came from families that respect quiet and provided quiet areas for their children to study and sleep. In addition, he asserted that if parents are stressed by wind farm noise to the extent that they are suffering sleep deprivation, then their children are likely to suffer from poorer parenting.

Potential Concerns of IWTs in Proximity to Schools

Schools are places of learning where speaking and listening are the primary communications modes. It has only been in the last approximately 20 years, that school planners and the general public became aware of the significant negative effect of noise and excessive reverberation in the learning process.
Studies have shown that students learn faster, and comprehend and retain more in proper acoustic environments and this is even more critical for the youngest students who are still learning how to pronounce words. The hearing impaired also require good acoustics. Studies demonstrate that children need the following:
1) An acoustic signal (e.g. speaking teacher) that is at least 15 dBA more intense than the level of the background noise.
2) Overall sound levels (e.g. speaking voice plus noise) that are no greater than 70 dBA throughout the room.
3) Background noise that is less than 35 dBA throughout the unoccupied room.
4) Sound absorbing materials such as acoustic tiles that minimize reverberation, resulting in reverberation times of less than 0.6 seconds in unoccupied rooms.
Children need these conditions because:
1) Young children are ineffective listeners for speech in noise until they reach adolescence, when they achieve levels of speech understanding similar to those of adults.
2) Young children do not effectively listen and understand speech in reverberant conditions.
3) Children are especially susceptible to ear infections that can impair hearing for weeks to months.

4) Many children (up to 20%) have permanent hearing loss as a result of congenital, genetic and environmental causes. All people with hearing loss are adversely affected by both background noise and reverberation.
5) Significant numbers of children are learning in a language not spoken in their homes. All people listening in a non-native language are susceptible to interference from background noise.
6) Many children have difficulty focusing their attention on speech in background noise, even though they have normal hearing sensitivity and are learning in their native language. These students have auditory attention and learning problems and make up an estimated 10-15% of the student body.
Evidence also shows that noisy classrooms require teacher to speak at vocal levels that cause stress and fatigue to their voices. Many teachers complain of tired voices, vocal strain and health concerns because of their need to speak at such high vocal levels. In quieter classrooms, teachers can speak at more comfortable levels and their voices can still be heard throughout the room. When classrooms meet the ANSI S12.60 standard criteria, communication will occur at a clear signal-to-noise ratio of +15 dB (i.e. speech signal is 15 dB louder than the background noise).
To restate: For full-sentence intelligibility in listeners with normal hearing, the signal-to-noise ratio (i.e. the difference between speech level and the sound level of the interfering noise) should be at least 15 dBA. Since the sound pressure level of normal speech is about 50 dBA, noise with sound levels of 35 dBA or more interferes with the intelligibility of speech in smaller rooms (taken from "Guidelines for Community Noise" from the WHO expert task force held in London, 1999)
Low-frequency noise, and even at low levels has unusual annoyance properties related to other frequency content or its absence. Situations of isolated low-frequency noise without other noise or with other noise of very low level may be more annoying than when other noise is present with the same or louder noise level. Consider that turbines near schools and residential neighborhoods will impact people - both inside and outside. Inside, the ILFN will be perceived as "rumble" outside. Outside, the turbine noise will increase the background sound levels thus reducing the listening radius. Listening radius is our auditory perception of how quiet a community is based on how far away we can hear distant sounds. In a quiet rural community with quiet nights (30dBA or less at night), this distance can be a mile or more. With wind turbines, even those designed for 40 dBA at the homes, the listening radius will be a few hundred feet.
It should be clearly recognized that "learning" goes on at home as well as in schools. In addition, high quality, restorative sleep - a critical part of healthy brain development - is needed when children return home. Both audible (at sound levels of >30dBA) as well as perceived (not necessarily "heard") infrasound, low-frequency noise emitted from nearby wind turbines has been shown to disrupt normal sleep processes. Those disruptions have been described as producing "neuro-cognitive" developmental deficits. Several sound experts, particularly concerned about ILFN, suggest separations of >1-2 miles from IWT to home to minimize but not eliminate the health risks. This is particularly relevant for the community of Earlham, which, if the Arbor Hills windfarm extension into Madison County occurs, will bring a very large contiguous collection of large-scale IWTs located to the south and west of the town's perimeter. Minimal setbacks of only two miles may affect the learning environment of its schools, but also its citizen's health and dramatically discourage town growth. It is a completely avoidable likely problem. Placing IWTs as proposed in close proximity of the outskirts of any town is a virtual "death knell" for a small town's future - principally through the addition of a closely-created harmful environment and a lack of potential growth at the edge of town. I would suggest at least a 5- mile setback from current housing on the edge of town to the closest placed IWT.
Increased Cardiovascular Disease associated with Life in Rural Areas
Although advances in health care have brought improvements in cardiovascular outcomes, cardiovascular disease remains the leading cause of death in the United States. Unfortunately, in recent years, declines in cardiovascular mortality have stalled with some conditions such as stroke and heart failure are showing increasing death rates - these trends have been worse for people living in rural counties in the United States. Madison County, Iowa is considered a rural county without an urban core. In the U.S., health outcomes have widened markedly between rural and urban areas over the past 3 decades and health outcomes are now significantly worse in rural than in urban areas. There is
now at least a 20% disparity with rural counties having worse death rate as measured by "excess death rate" per 100,000. Life expectancy gaps continue to separate over time - being >3 years shorter in rural counties as

measured in 2014. Similar patterns have been seen for cardiovascular disease. Data from the 2017 Center for Disease Control and Prevention showed a 40% higher prevalence of heart disease among rural residents - a gap that has grown over the past decade. Rural areas have higher death rates for cardiovascular disease and stroke than urban areas and gaps are widening. Coronary heart disease death rates were significantly higher as compared with urban areas with rural residents having a 30% increased risk for stroke mortality. Rural women face higher maternal mortality rates
with that mortality growth being driven largely by an increase in cardiovascular deaths.
Rural areas have significantly higher rates of uncontrolled traditional cardiovascular risk factors compared with urban areas. Rural populations are significantly older and have higher rates of diabetes mellitus, obesity and hypertension. Tobacco use is higher in rural areas than urban areas. Data from the Behavioral Risk Factor Surveillance System suggest that roughly 25% of adults in rural counties report active tobacco abuse compared with 16% in metropolitan centers. Rural smokeless tobacco use was 8.5% versus 3% in metropolitan areas.
Rural areas have a higher prevalence of obesity, diabetes, elevated lipid levels and hypertension. In addition to less favorable physical health, rural areas experience less favorable mental and behavioral health, which has been tied to cardiovascular disease incidence, prevalence and mortality in both adults and children. Rates of depression and suicide are higher in rural areas. Among children, suicide rates are nearly twice as high in rural as in urban locations and these differences are increasing over time. This does not appear to be related to social isolation and loneliness.

Recent U.S. Upward Trending Death Rates from Hypertension - Over 3 X Higher in Rural Areas

In data just presented in the last 6 weeks, the U.S. death rates from hypertension related cardiovascular disease rose from 2007 to 2017. This trend was noted to accelerate starting in 2012 while the rate of decline from cardiovascular deaths started to slow down since 2011; the two endpoints are felt related.
Age-adjusted death rates rose from 18.3 per 100,000 to 23 per 100,000 people (probability for trend was <.001). The age-adjusted death rates rose 72% in rural areas and was 20% in urban areas (p<.001 for both trends). Rates rose about the same for men and women. The authors of the report felt the rise to be due to many factors - including the rise in obesity and diabetes as well as disparities in the social determinants of health as well as disparities in health care access and delivery to these areas.

Electricity Costs:

MidAmerican Energy keeps emphasizing how Wind Energy will keep power costs low. My MidAmerican electric energy costs went up 20% last year. Having said that, the price of residential electricity has risen lockstep with growth in renewable capacity in Europe but not in the U.S., and because of these European residential rates are now roughly twice U.S. rates. (Energy, Environment and Policy - posted April 31, 2018 by Roger Andrews). The reasons for the difference are
a) that renewables surcharges are added to residential electricity bills in Europe but not in the U.S. and
b) that residential electricity bills in Europe have increased roughly in proportion to the amount of money spent on renewable growth. Residential rates in U.S. states are set by state Public Utility Commissions that are legally obligated to set prices at levels that are fair to both consumer and providers. As a result, the European bill payer pays for new wind, solar, etc. while U.S. renewables expenditures are offset by adjustments to the federal budget that are not itemized but which ultimately get paid by the U.S. taxpayer. I have included a graph (2014 data) that correlates residential electricity prices in various European countries as a function of installed wind + solar capacity (Watts) per capita. (See graphs at end of this Part) The more installed renewables, the higher the residential electricity price. Denmark, the home of the IWT-manufacturing company that sells their turbines to MAE, has the greatest percentage
of their power production from wind energy and also the highest cost per energy unit. In the U.S., a lot of the increased cost is absorbed by into the federal budget destined to be eventually paid by the taxpayer. Make no mistake, renewables are more expensive than existing methods of energy production.
But even more important, it is about the goal of less carbon production to achieve electricity. The total CO2 production ("cost consequence") of IWTs facility manufacturing, erection, raw materials
extraction/refining/transport and ongoing maintenance costs are all considerable. Every turbine has a magnet made of neodymium that comes almost exclusively from China that requires an extremely toxic mining and

refining process that involves repeated boiling in acid with radioactive thorium as a waste product that has leached into the soil and is threatening ground water supplies in Inner Mongolia.
One must include the accompanying expenses of fossil fuel fired co-generation capabilities into the final comparison equation - that data is extremely hard to clarify. I also found another set of graphs that describe the obligate need of a co-generation plant working "with renewables" in order to provide continuous power 24/7 that can adapt to momentary changing of wind and solar energy resources.
This was shown in the April, 2020 National Geographic Magazine in an Earth Day, 50th Anniversary Special Issue. It appears that by 2045, the total generation of renewable power in the U.S with be nearly equal to the power generation produced through natural gas - and that at a level equal to "peak coal" in 2007. Currently, wind energy makes up a larger part of renewable than solar but "not for long". Solar is projected to triple its share by 2050 to become the leading renewable. This is in large part due to the herein-evidenced rejection by landowners of having IWTs "placed harmfully close" to their residences. Add the energy for constructing power lines and major transformer stations, erection costs and dirt moving among others. In that same issue was the picture of steel rebar - soon to be encased in CO2-producing concrete for one of the bases of 120 future IWTs in Texas to produce 338 MW of electricity to power more fracking for oil and gas. The magazine briefly touched the issue of nuclear power in the U.S. commenting about the closure of several nuclear reactors, ... finishing their comments with "much of their carbon-free electricity will be replaced by emissions-rich natural gas". The debate about the future of nuclear is complex and increasingly ideological". Nowhere is there a complete discussion in this article about regenerative agriculture but instead unsubstantiated dreams of greater yields (with more chemicals, more genetics and the attendant need for energy to produce these "additives") on soils driven to "extinction".
Also, as equally concerning is the evolving reality of the under-realized functional lifespan of IWTs in comparison to conventional energy production modes and the costs of decommissioning turbines faced with shorter functional service lifespans. When you see where a lot of the energy produced by Wind Energy is being used, it appears to be heading out of state. The calls by Wind Energy to achieve 100% of our energy sources will never be possible. Such "rally-cries" are delusional and serve as grossly inaccurate promotional misinformation for a failed concept to "save the planet". Robert Bryce's recent investigative journalism book "A Question of Power" clearly reviewed the financial and logistical impossibility of achieving 80% (let alone 100%) "renewable" electrical energy production in this country (mostly through analysis of the California effort, lithium-based battery technology, land-availability limitations and extraordinary costs. He also reviewed the merits of nuclear power as a much more viable source of "clean energy". One really needs to think about the misleading statements being made about the value of renewables. Instead, we need to focus on the real needs to change current patterns of energy consumption and dramatically increase carbon sequestration and perhaps reconsider looking in nuclear energy production options. In the final analysis, "it" will have to come to embracing future commerce with carbon credits. We need clear-thinking, realistic leadership with responsible allocation of our country's increasingly limited financial resources.

Decommissioning Implications - Costs: Unknown and Skyrocketing?

Comments from Isaac Orr - in Energy, Environment Sept 9, 2019 - while interviewing various wind energy experts....
Concerns for implications of relatively short useable lifetime of IWTs: Past turbines with 12-20-year lifespan based on experiences from Europe. Current U.S. experience with >10-year-old IWTs show significant needs to replace "blades and cells" despite the current IWT generation with reported 20-25 year expected lifespan. In comparison, coal-fired plants have 50-60-year functional life. Stated estimated total cost to taxpayers of the wind production tax credit between 2016-2020 will be $23.7 billion.
Estimates for "tear-down" cost for a single IWT is $200,000. Given roughly 50,000 wind turbines spinning in the U.S., decommissioning costs are estimated at $10 billion. In Texas, this could mean a potential current expense of $2.3 billion. This potentially would have to borne by landowners and counties pending financial viability and guaranteed protected funds for such actions. Options for upgrading with new models pending continuation of federal wind subsidies could be pursued but is not assured. There is significant disagreement about "set aside decommissioning funds."

Concerns: 1) extracting valuable materials from the turbines is not easy. Removal of copper from insulation would likely require significant labor costs,
2) Reducing the steel casings enormous sizes would require specialized cutting tools,
3) blades are high-tech wonders of composite materials which experts agree cannot be separated into its component materials and is thus worthless for recycling,
4) with turbine removal, the company is committed to restoring the site to its previous state.
In another story relating costs of decommissioning, it was reported that Germany is finding that disposing of their aging wind turbines could cost hundreds of millions of Euros **more** than previously planned and overwhelm Germany's capacity to dispose of non-recyclable wind turbine blades. Locally, the removal of 18 wind turbines in Chippewa County, Minnesota would cost, in 2019 dollars an estimated $632,000 each. It would make sense to ensure that decommissioning costs are completely covered **at whatever time** (likely requiring periodic reassessment of cost with contractual obligations to increase "bond coverage") in their life cycle as clearly stated in permitting requirements. If they refuse to cover that anticipated decommissioning cost with "irrevocable" availability of funds for some future need, that should be seen as their "commitment" to civic responsibility and "partnering" with the county and its residents. Things, people and times change; get all the decommissioning cost coverage confirmed in writing and keep that amount current with real-time costs. I would also suggest that all litigation costs regarding this specific item (in the event of MAE/current owner's unwillingness/inability to perform) "shall be borne" by MAE. MAE should not be allowed to "off-load" this responsibility to an insolvent "shell" corporation. IMPORTANTLY, MAE/current easement owner should not be able to assume/acquire ownership of the entire easement property to produce equity for decommissioning costs.
Smaller wind farm companies, with fewer financial resources may be tempted to just "walk away" when aging turbines no longer spin a profit. Some experts suggest that this may occur even before wind turbines outlive their useful life as manufacturing warranties on the big turbines expire. What is unknown is "at what point does the cost of maintenance tip over to the point it's not worth maintaining a turbine?'
They note that as wind turbine manufacturing has improved, the length of warranties on these products has decreased dramatically and today the terms cover between 5 and 10 years. Despite the obvious paradox of improved manufacturing with advertised longer functional service periods **and** shorter warranties, many turbine manufacturers have found a valuable revenue stream in selling extended warranties. It "could get ugly" when we see turbines needing work, and are no longer under warranty and not generating enough electricity to keep running them". Such scenarios should be specifically addressed in Wind Ordinance language. (This will be another cost eventually passed down to the consumer).

Litigation: A Replacement of Science and Failure of Leadership

Australian Senate Select committee on Wind Turbines held June 29, 2015 established that there is a **direct** pathway to disease resulting from wind turbine noise.
Since 2015, 248 government entities from Maine to California have restricted or rejected wind projects.
The following educational links were provided on a "gofundme" site to assist with grass-roots efforts by citizens affect by IWT threats to their health and way of life. The individual, Hamish Cummings has been working hard for years trying to expose the truth about wind farms, the approval process and ramifications of ill-sited wind turbines.
This is an example of what has been happening across the entire planet in response to "IWT forced community intrusions". It's NOT "NIMBY - (not in my backyard), it is NOT in anybody's backyard!
Wind Energy works from the same "playbook".
LINKS
Human Impacts: http://windvictimsontario.com/; http://globalwindenergyimpact.com/; http://mothersagainstwindturbines.com/; http://waubrafoundation.org.au/; http://www.windturbinesyndrome.com/; Recording Impacts: http://www.illwind.org/ Property Loss: http://windturbinepropertyloss.org/site/; Fire: http://turbinesonfire.org/; Informative sites: http://www.wind-watch.org/; http://stopthesethings.com/; http://quixoteslaststand.com/; http://www.windwiseradio.org/; http://www.friends-against-wind.org/; Wind Energy Performance: http://energy.anero.id.au/wind-energy Links to over 2000 international anti-wind groups:

http://quixoteslaststand.com/worldwide-anti-wind-groups/; http://ontario-wind-resistance.org/; http://epaw.org/; http://na-paw.org/; http://www.windaction.org/;

In another, more local case in Wisconsin that has been contested for over a decade in a state where turbine regulations exist at the state level:

The Brown County Town Health Board in Wisconsin recently declared Duke Energy's Shirley Industrial Wind Turbine Development to be a Human Health Hazard. The precise wording of the declaration follows: "To declare the Industrial Wind Turbines in the Town of Glenmore, Brown county, Wisconsin, a Human Health Hazard for all people (residents, workers, visitors, and sensitive passerby) who are exposed to Infrasound/Low Frequency Noise and other emissions potentially harmful to human health"

Human Health Hazard has been defined as a "substance, activity or condition that is known to have the potential to cause acute or chronic illness or death if exposure to the substance, activity or condition is not abated" (definition used in Brown County, Wisconsin Ordinance).

In the last 20 years, it has been estimated that over 5000 separate "anti-wind" coalition groups have formed in their desperate attempt to protect **their** life's work in their created homes, **their** view of land aesthetics and the importance of safe natural environments, **their** health - individual, family, community because **we** (wind energy victims and their representative leaders) don't listen and seek out safe compromise for **our** world. Again, lofty ideals.... but unique to this issue of "forced, unproven in safety, non-integrated to community wholeness" essentially unregulated and unsupervised placement of IWTs by Wind Energy industry primarily motivated by profits assured by non-consenting taxpayers. I recognize that industry incentives were approved by Congress, but **I would bet that Congress was never told the full story about potential health effects involving IWTs. If they had, they would've requested oversight and safe health standards.**

It is not clear whether affirming votes made by County Board of Adjustment or Supervisors to permit IWTs could create individual Supervisor or Madison County liability - having had specifically been presented with compelling data about IWT's inherent health risks and collateral negative impacts as projected with MAE's proposed plan. MAE has provided no facts nor supportive data to eliminate those potential "loss of quality of life or health" let alone "life and death" concerns. Again, Wind Energy has never been proven to be safe. This is even more concerning in that a supermajority of citizens polled within the footprint of the proposed Arbor Hills project have specifically stated that they did NOT want the turbines because of their concerns over health risks and violation of property rights.

Indeed, MAE (through the comments made by their industry-supported speakers at the Board of Health hearings) has acknowledged that "annoyance" is a health risk **and** that it is possible/feasible/plausible that IWTs could cause sleep disturbance that has been associated with cardiovascular disease as seen with other environmental noise sources. Finally, Dr. Thorne, a spokesman for MidAmerican Energy who spoke at that hearing agreed with me (personally, in a private conversation) that Wind Energy has never proven their turbines to be safe (in terms of health).

SCADA and NRO

Supervisory control and data acquisition are a control system architecture comprising computers, networked data communications and graphical use interfaces for high-level process supervisory management, while also comprising other peripheral device like programmable logic controllers and discrete proportional-integral-derivative controllers to interface with process plant or machinery. The SCADA concept was developed to be a universal means of remote-access to a variety of local control modules, which could be from different manufacturers and allowing access through standard automation protocols. It is one of the most commonly-used types of industrial control systems, in spite of concerns about SCADA systems being vulnerable to cyberwarfare attacks.

The Human-Machine Interface (HMI) is the operator wind of the supervisory system. It presents plant information to the operating personnel graphically in the form of mimic diagrams, which are a schematic representation of the plant being controlled, and alarm and event logging pages. The HMI is linked to the SCADA supervisory computer to provide live data to drive the mimic diagrams, alarm displays and trending graphs. In many installations the HMI is the graphical user interface for the operator, collects all data from external devices, creates reports, performs alarming, send notifications, etc. (Wikipedia)

Noise Reduction Operating Modes (NRO modes) are roughly considered to be a "throttle" option (as directed through SCADA) to control noise production and maximally achieve power production within the regulatory parameters. There is Mode 0 which is "pedal to the metal; noise be damned". Then there is NRO mode 1 which drops the energy output by 10% for a 1 dBA noise reduction. Each successive NRO mode, 2, 3 ,4 and 5 each reduce the noise another 10% and in NRO mode 5 the noise reduced about 5 dBA. This is not economical for the operator, which is why they are better off selecting one of the new quiet blade design options which can reduce the noise about 5 dBA from the older style and less expensive blades rather than buying "cheap" and then being forced by complaints to run their equipment at 50% energy output at night in NRO Mode 5 to meet a penalty for violating the regulatory limits.

Blade Throw

During the Joint Supervisor/Public Wind Ordinance Writing Workshop, there was some discussion about the setback distance between the IWT and the residence. Mr. Clifton decided that 1500 feet was the distance he wanted. Concern over the distance from the tower to the property line was discussed with again, preference for MAE standard language usage of 1.1 times the total tower (including to the top of blade) height. There continues to be no guidance from the manufacturer about a safety zone **specific** to the **physical size of a given model**. As happened many times as the public tries to secure the physical safety of its property, again, the public was told that the same safety zone was recommended for the V-110 2MW IWT as was recommended for the less powerful and shorter V-90. Concern from the public (attending) of potential tower toppling/blade throwing/nacelle fire with ember showering were again mentioned and completely ignored by Mr. Clifton. One would think that a given product (in this case a turbine model, e.g. Vestas Model 110, 2 MW) - is perhaps slightly different than a previous generation product (e.g. Vestas Model V-90, 1.8 MW) and that new written, model-specific recommendations should be mandated. Perhaps the materials and their sourcing/purity/manufacturing/testing of raw materials and finished products would need to be done to assure maximal safety. As such, specific safety specifications need to be stated on product documentation that is made available to the consumer (MAE) but also should be made available to the county where the product is installed. Such important information would be a record of the testing specific to assessing component failures should be made available to the County Supervisors, the County Engineer, the EMS infrastructure and, MOST importantly, to the resident whose property is in potential risk-proximity to the erected IWT. That information is not on the website (for the V-110) NOR has been disclosed by MAE despite multiple requests and has been ignored/not pursued by Supervisors or zoning administrators. The Zoning Administrator says it has been "addressed"... but short of actual model-specific paperwork and the manufacturer's appraisal and transparency of potential risk, I would safely state that this request has not been addressed. Once addressed, the public should be able to review the contents of that court-admissible document.

An early 2018 article appeared in the journal, Wind Energy (2018:1-9) co-authored by Scott Larwood from the Mechanical Engineering Department at the University of the Pacific and David Simms from the National Wind Technology Center (NWTC). The authors described concerns about past modeling of blade fragment risk and appropriate setbacks. The purpose of the study was to analyze the risk posed by rotor fragments from wind turbines to roads and buildings as studied at the NWTC. Contemporary sized IWTs from 0.6 to 3 MW capacities were studied. The analysis used a previously developed model for the blade fragment trajectory and the associated probability of impact around the turbines. This study, from a university engineering department in conjunction with a Wind Energy consultant at a national IWT testing center made the following conclusions and recommendations.

1) a setback of 2 times the overall turbine height (hub height plus rotor radius) to a **property line** resulted in a "routine risk", which would "probably be adequate" for public safety.

2) a setback of 3 times the overall turbine height resulted in a **probability of impact with a dwelling that would increase the risk "above routine**". Therefore, a setback of 3.5 times the overall turbine height is proposed to lower the risk.

It would seem appropriate to incorporate both of these setback recommendations that were formulated with engineering principles and a goal to achieve more optimal public safety. The modeling they used reflected current technology "standards" of constructing/erecting and maintaining IWTs and reflect needed and appropriate risk vs benefit analysis to best promote citizen safety.

Mr. Clifton's current recommendation of 1.1 times height to the property line and 3 times height to a residence ignores non-participating property rights of the adjacent property owner and is inadequate to protect human safety and land use operations. In addition, it violates the intrinsic value of the property to future development or sale by the owner. This author sees the recent erection of several IWTs "nearly immediately" adjacent to (on the south side of) I-80 (inside of Adair county), between Earlham and Stewart, as also creating great potential risk to the public in the event of a turbine failure. I have also seen many other IWTs placed with inappropriately (my appraisal) close approximation to active roadways around the State of Iowa. I have also seen "still" turbines with a missing blade "broken off near the hub" as well as pictures of nacelles/blade components on fire.
Apparently, it is acceptable to ignore science when it might impact Wind Energy Industry/Contractors' financial gain. I can see no other reasoning that would allow/incentivize such "reckless" turbine placement. The public expects and deserves protection from massive towers associated with largescale kinetics that they literally know nothing about. IWT deployment should reflect best current science and highest safety concerns. Because we have failed to protect the public in the past does not mean we should continue those potentially unsafe practices.

Appendix – Part 7: Other Selected Topic

Note European "equalized" relative energy pricing for combined solar and wind renewable sources from 2014. Highest penetration of renewable energies is in Denmark and Germany. The relative positioning of the U.S. is located along the lower left portion of the "line". The correlation of this association is remarkably "robust" with a R-squared value of 0.85. The current subsidies for renewable resources have, so far, protected the cost of electricity in the U.S. Future "plans" are for disappearance of subsidies that will likely dramatically raise energy prices and push U.S. prices toward eventual price tripling if Renewables become more prevalent.

Part – 8: Peer Review

It is amazing that this impasse of strongly conflicting opinions about the safety of IWT exposure has lasted so long. Truly amazing. Especially when: Wind Energy denies the relevance... essentially the existence of ILFN
They produce "peer reviewed" papers that are somehow a reflection of our country's greatest wisdom.
Those papers do cite papers that were peer reviewed - all 4 or 5 - but the MAE paper provided (as reflected by the copy I was given) was never published nor presented in a major meeting or congress where it was judged for its merit and never exhaustively contrasted both sides of the argument. There was no mention specifically in the "paper" of the exact process of the purported "peer review".
Indeed, there was no medical review of the contents.
I have included a considerable amount of information in the "conclusion" part that highlights the lack of supportive scientific principles that pervade the comments and quality of Wind Energy's arguments.

The Investigative Review Board (IRB) Process to Prove "Safety"

I believe it is the Duty and Obligation of Wind Industry/Turbine Manufacturers to prove the safety of their products. This information should be made available to the public with safety setbacks based on medical and engineering research. They have never done that and the potential for human harm continues to increase.
Industrial Wind Turbines have never been shown to be safe for people or animals/natural environments.
There have never been in-depth clinical trials examining populations of exposed humans with repeated biometric evaluations and comparing those findings with matched controls.
An IRB (Investigative Review Board) is a type of committee that reviews the methods proposed for research to ensure that they are ethical. Industrial wind turbine placements into potentially harmful proximity to humans has never had a formal IRB-approved research protocol with monitored research of these turbine. IRBs often conduct some form of risk-benefit analysis in an attempt to determine whether or not research should be conducted. The purpose of the IRB is to assure that appropriate steps are taken to protect the rights and welfare of humans participating as subjects in a research study.
Although IWTs have been "around" for 20+ years, they have never, to my knowledge, been "proven/shown/intensively evaluated for safety" in other countries such that those prior "studies" could be reviewed for the methodology, statistical analysis, quality of data and that they adequately support the conclusions.

Having personally been a past member and Chair of the Des Moines Area Hospitals Investigative Review Board for 15 years, I have seen the process unfold innumerable times where a study is presented by the principal investigator for his personal project or by the primary investigator for a regional or national study. The study design and endpoints as well as detail descriptions of the methods are presented.
Included also are past relevant research and findings that form the basis of the submitted research request. Board members (physicians, nurses, pharmacists, administrators, at-large community members, clergy and others have had time to review the submitted documents, highlighting areas of needed discussion and who have felt that the trial design is ethical, come to a meeting where the investigator verbally presents the study and then responds to questions from the Board. Particular focus on the completeness of the process/documentation of informed consent is done at that time. If reasonable, the study is approved and implementation of protection of human subjects is carried out by the IRB for the duration of the study.
In some studies, a data monitoring committee is available (particularly with large studies and where unknowns exist or where potentially serious adverse effects may come to light). This DSMB (Data Safety Monitoring Board) is an independent group of experts who monitor patient safety and treatment efficacy data while the trial is ongoing. Should concerns be raised through evaluation of requested review of singular "adverse events" or at pre-specified periodic data review points, the DSMB has the obligation to stop the trial and request further data or initiate further adverse event reviews before the trial is restarted.
It is remarkable that (to my knowledge) no IRB oversight has ever been done given the concerns about potential adverse health effects to humans. It is likely to never be done in a complete and formal way.
The least that should be done is that there is an "independent" (free of pro-/anti- wind bias) board that should be in charge of soliciting and recording events. If such events appear to be "anomalous" (deviating from what is standard, normal or expected), then formal evaluations to explain those observation should be mandated. Such evaluations should be well funded and able to have access to whatever scientific scrutiny is warranted. Metrics for assessment of AHEs would need to be clarified, be acknowledged as "scientific", be funded by the manufacturer among other significant considerations.
Yes, there is cost and bureaucracy involved but discovery, clarity and truth determination can be hopefully achieved. It is my opinion that the federal government continuation to subsidize these "unknown risk entities" puts America on an unknown course for climate security, resident health, safety and welfare security and delays safer, more reliable and sustainable energy production.

Causality

Although Wind Energy has never, nor ever attempted, to prove that industrial wind turbines are "safe", they continue to rebut increasing amounts evidence that IWTs pose a risk to human health. They commonly use the phrase "there is no credible evidence" as a means to "sanctify" their statement with an implied absolute certainty that IWTs are, in fact, safe. Instead, their statements fail to acknowledge that "causality" in epidemiology can never be completely proven. Causality is a "gradual term" for which evidence is
1) increasing with increasing number of facts
2) supported by the magnitude of effect
3) supported by a dose-response relationship
4) consistent with other studies in different populations
5) consistent with different study methodology
6) supported by biological plausibility
Indeed, the data that IWTs actually cause adverse health effects exists and lends support to all these tenets.
Sir Austin Bradford Hill, Univ of London shared his thinking about association and causal evidence surrounding environmental disease. He posed nine elements that are critical in establishing causation:
Strength (of observed relationships), **Consistency** (or repeatability of relationship based on observations by different persons, in different places, under different circumstances and at different times),
Specificity (causation is indicated if the associated is limited to specific individuals and to particular sites and types of disease and there are no associations with other factors), **Temporality** (there is a clear temporal relationship between outcomes and periods of exposure and non-exposure), **Biological**

Gradient (a dose-response relationship exists), **Plausibility** (causation is more likely when certain outcomes are biologically plausible, or possible, a caveat being that plausibility depends on the biologic knowledge of the day; this element is best expressed in the statement: "when you have eliminated, whatever remains however improbable, must be the truth), **Coherence** (the cause-and-effect interpretation of data should not seriously conflict with generally known facts of the natural history and biology of the disease), **Experiment** (experimentation or semi-experimental evidence, even if only occasional, can reveal the strongest kind of evidence for causation, and **Analogy** (the recognition that similar cause-effect relationships have occurred under similar conditions).

In corresponding with Professor Punch, he also agrees that all 9 elements that Sir Hill has itemized to support causality are met as written below in a recent expert commentary request for the Neosho Ridge Wind Project in New York:

With respect to the nine Bradford Hill criteria, all have been identified in the scientific literature as pertinent to the relationship between IWT noise and AHEs. The respective analogies are: (1) widespread reports of complaints, (2) consistency of reported symptoms, (3) and (4) concurrence of symptoms with IWT operation, (5) a dose-response relationship between exposure levels (or distance) and symptoms, (6) the role of disturbances of the hearing and balance mechanisms of the inner ear in causing identified symptoms, (7) coherence with WHO, U.S. (federal), and some state noise guidelines, (8) in addition to cross-sectional studies, experimentation is established by the fact that symptoms decline or disappear when receptors leave the area and recur when they return to the area, and (9) noise-induced Sick Building Syndrome.

Sir Hill noted that "all scientific work is incomplete - whether it be observational or experimental. All scientific work is liable to be upset or modified by advancing knowledge. But that does not confer upon us a freedom to ignore the knowledge we already have, or to postpone the action that it appears to demand at a given time".

Importantly, when we consider

1) The strength of the data presented by Wind Energy as "lacking" robust data

2) The absence of any data from Wind Energy to prove that IWTs noise emissions are "safe"

3) Enormous amounts of increasingly supported and complementary data correlated IWT noise to adverse health effects

One must make a decision if there is or is not a true association of wind turbine exposure with adverse health effects. As just written above: Sir Hill recognizes that all scientific work is incomplete, but that does not confer upon us a freedom to ignore the knowledge we already have, or to postpone the action that it appears to demand at a given time.

Wind Energy's stance of "proof" is grossly less than the mass of supportive materials presented in this review. By comparison, in a 2015 "scientific supportive" **opinion** of existing data (not their original data), the Council of Canadian Academies reviewed available data (journal articles, web pages, legal decision and non-peer-reviewed publications on wind turbine health effects. Their reviewed agreed that evidence was sufficient to establish a causal relationship to annoyance, limited evidence for a causal relationship to sleep disturbance but was inadequate to determine if there was a link to stress and other health outcomes.

Although I cannot find evidence that the summary of their opinions was ever "published" in a scientific journal where independent journal review occurs, the results were initially made available on their website. They made reference to the fact that they "used" some of the principles of Sir Hill's elements to support causality (which I listed above), but did not explain the results in terms of tallies of supported principles or their conclusions.

They said that the article was "peer-reviewed" by "an entity" that preferred to remain anonymous. I am told by testifying experts familiar with the literature and arguments over several decades, that there was great outcry about the posted article contents and the article was subsequently taken off the website. I personally tried to contact (by phone) the Academy.

The phone rang several times, was picked up (electronically?) and was disconnected. So much for "scientific rigor" – unexplained methods and results, unpublished in independently reviewed journal, reported was peer-reviewed by an anonymous entity (worthless excuse) and the original publication cannot be found on the website because it was reportedly "taken-down" due to criticisms of apparent "inadequate" scientific process.

Although mentioned elsewhere in this large statement, given the content and direction from Sir Hill, it is good to include here the comments by Mathias Basner, MD, PhD who personally reviewed and helped to summarize the

data for the Oct, 2018 WHO environmental Noise Report. In a 2019 editorial he acknowledged the problem of smaller populations in currently available studies which makes statistical powering of conclusion difficult. (This is exactly the problem with study IWT noise and its production of adverse health effects on nearby residents). He stressed that NONE of the wind noise guideline data from the 2018 WHO report found an "absence of risk". He finished his comments with "the fact that more studies are needed should not lead us to postpone the urgently needed protection of the population from noise. The knowledge we have acquire so far IS SUFFICIENT to take preventative actions and substantiate them with respective legal noise regulation - that is exactly what needs to be done with the Madison County Wind Ordinance. I will later repeat this. Adverse Event Reports: Taken from (Carl V. Phillips, "Properly Interpreting the Epidemiologic Evidence about the Health Effects of Industrial Wind Turbines on Nearby Residents" Bulletin of Science, Technology and Society, vol 31, No 4. August, 2011, P303-315). Epidemiology is the study of health outcomes and their causes.

"There is overwhelming evidence that wind turbines cause serious health problems in nearby residents, usually stress-disorder type disease, at a nontrivial rate. The bulk of evidence takes the form of thousands of adverse events reports. Proponents of turbines have sought to deny these problems by making a collection of contradictory claims including:

Adverse effect reports don't count

The outcomes are not "real" disease

The outcomes are the victim's own fault

Acoustical models cannot explain why there are health problems so the problems must not exist

These claims appeared to have swayed many non-expert observers, though they are easily debunked.

The WHO has described annoyance as a critical health effect - associated with stress, sleep disturbance and interference with daily living. Moreover, though the failure of models to explain the observed problems does not deny the problems, it does mean that we do not know what, other than DISTANCE, could sufficiently mitigate the effects. There has been no public policy or law that justifies imposing these effects on local residents and upon their private properties. The attempts to deny the evidence cannot be seen as honest scientific disagreement, but rather, represents either gross incompetence or intentional bias.

AWEA/CANWEA Report into Turbine Sound and Health

Wind Energy on their promoting websites, has listed the "AWEA/CANWEA" (American and Canadian Wind energy Associations) Report into Wind Turbine Sound and Health, December, 2009 "supports" the safety of IWT deployment. Dr. Malcolm Swinbanks during his March 2015 his expert testimony before the Australian Select Committee on Wind Turbines described that report to "represent the first study to bring together experts from the acoustics community and the medical profession, to examine the nature of adverse health effects associated with wind turbines. As such, it has been widely quoted and has very much defined a perspective which continues to prevail in subsequent, similar studies".

He described two important observations: (He also reminded his audience of his early career experience on the active sound control of industrial gas turbine compressors in the early 1980s in a rural environment... he found it "quite striking" that some expert reports fail event to mention these two important effects).

1) "it completely failed to take account of two of the most important aspects of low-frequency and infrasound perception. Specifically, there is no mention of the fact that the threshold of hearing automatically adjusts to the background ambient sound level, with the result that infrasound levels in cities and suburban areas are well below the threshold and completely imperceptible, where in quiet rural areas, the much lower hearing threshold enables adverse effects from wind turbines to be perceived. Consequently, dismissive arguments which directly equate infrasound levels in these two very different environments without taking into account these significant differences in perception are fundamentally flawed.

2) "the report also fails to mention that continued exposure to low-frequency noise and infrasound can result in progressively more acute physical sensitivity to the sensation and effects.

The ACWEA Review was also critiqued by the Society for Wind Vigilance. Some of their comments:

1) The conclusions of the ACWEA Panel Review are not supported by its own contents nor does it have convergent validity with relevant literature.

2) **The ACWEA Panel Review acknowledges that wind turbine noise may cause annoyance, stress and sleep disturbance and that as a result people may experience adverse physiological and psychological symptoms. It then ignores the serious consequences of those AHEs.**
3) Despite the acknowledgement that wind turbine noise may cause annoyance, stress and sleep disturbance the ACWEA Panel Review fails to offer any science- based review that would mitigate these health risks.
4) The ACWEA Panel Review can only be viewed for what it is. It is an industry association convened and sponsored attempt to deny the adverse health effects being reported.
The ONLY effort made by Wind Energy (locally represented as the Iowa Environmental Council) to provide scientific proof supporting their stand that IWTs do not cause adverse health effects to Madison County residents was in their hand-out entitled "Wind Turbines and Health".
Ms. Kerri Johannsen stated that she wrote the article and that it was peer-reviewed. The title inferred a detailed review of the topic of health concerns associated with industrial wind turbines; there were only 4 papers that were referenced. There was no date of publication on the paper, nor reference that it would be submitted for publication. There was no documentation of any formal peer review having been performed on the article nor any verbal description of the peer review process by Ms. Johannsen; there was no mention of an ethics board, a publication board or any specific entity that actually reviewed the work and the merits/support of the conclusions. There were no references to any World Health Organization and that organization's focus and concerns about environmental noise and sleep disturbance (which is the major health concern about turbine noise). A large part of the paper is focused on the subjective concept of negative perception of industrial wind turbines as the nocebo effect. This is the concept of a detrimental effect on health produced by psychological or psychosomatic factors. This idea is discussed in the first topic of Part - 7.
It appears to me that the peer review process claimed by Wind energy is frequently an informal review done by individuals sympathetic to the pro-wind agenda. One cannot expect other scientists to take seriously an organization that refuses to accept nor comment nor attempt to objectively refute, well supported, "conflicting (to Wind Energy)" scientifically based research. If Wind Energy does not like the conclusions by well-respected investigators, they simply ignore it. Wind Energy continues to insist on unreasonable and unachievable strengths of evidence that are simply "not attainable". More importantly they have not produced any research that proves they are safe by those same "unattainable levels of causality" while a great majority of the rest of the scientific community does believe that a causal relationship, based on the available evidence, does exist.
I have included a copy of a February, 2005 British Wind Energy Association "briefing sheet" on low frequency noise. Although now 15 years old, their public stance has not changed. It is notable that several of their "facts" have been disproved. In the conclusion, they mention that the "main" effect (on humans) depends on the listener's reaction to what they may hear (nocebo effect). (Writer's comments: They imply that all wind turbine noise lies below the threshold of perception - all of which has been discussed as incorrect in the contents of this review (yet no subsequent, more recent statement from Wind Energy acknowledging that science has led us to know that it is perceptible to some degree and can be annoying and can contribute to serious adverse health effects including sleep disturbance and may be causal for serious cardiovascular health consequences). The final statement (by G H Levanthall - whom I have mentioned many times) read: "I can state quite categorically that there is no significant infrasound from current designs of wind turbines". When I looked for the precise definition of "categorical", I found "something that is absolute or without conditions..." Looking at that definition then back to his statement then reflecting the enormous amount of information I have reviewed, I feel comfortable stating that "I am categorically certain that his statement is false and "actively misleading". On 6/28/2020, I reviewed the American Wind Energy website looking for their "claims" about health effects. I went through several layers of "glossy promotional information" and eventually found some information related to health effects. Several bullets under "sound" were reviewed. (In my opinion) nearly ALL of the statements were incorrect or misleading. The details of ILFN, or noise perception thresholds are absent. There is no information about annoyance, home evacuations, sleep disturbance or cardiovascular disease. The site mentioned a "Massachusetts study and a major study in Canada" but we have no further references search tools to find the data and verify their statement as not being taken out of context or being correct in the first place.

Part – 9: Searching for an Explanation Why Harm is Acceptable- A View of the "The Dark Side" of Wind Energy - Behind the Scenes.....Promoting their Vision

Attack on Science Leader who spoke the truth

Wind Energy (as a faceless faction) has been quite critical of research and statements made by notable and authoritative scientists and university faculty. As an example, one of the most premier acousticians in Europe was Dr. Henrik Moller of the Aalborg University, Denmark. He was the head of the Acoustics branch and fully tenured. He wrote a paper saying that larger wind turbines will result in increased low frequency sound. As a result, Wind Industry demanded that his funding be revoked and that he be expelled from the University. He lost his position over his research due to politics and the power of the Wind Energy business in Denmark (likely Vestas).

Wind Energy Self-Protecting Ordinance Writing

The same Dr. Henrik Moller from Denmark and his team of acousticians had been consulted by the Danish Environmental Protection Agency regarding new regulations to limit low-frequency noise generated by wind farms. A new limit of 20 dBA was established to limit sound levels in the 10-160 Hz range. It was designed originally to impose the same limits on wind that are enforced on other industry that produce ILFN. The problem with the wind ordinance was that sound insulation varied considerably with different home standards. From that insulation value, the ordinance had to obtain the calculated indoor noise levels and, as such, higher calculated indoor levels would be accepted in lesser insulated homes. It appears that the "absolute limit" at 20 dBA was not absolute. It was originally passed by the Danish authorities ignoring protests from the Wind Industry. The CEO for Vestas, had in a letter to the Minister of the Environment, warned against plans to introduce a low-frequency noise limit for wind turbines. It would create problems for Vestas's most economical model in the 3 MW class in open landscapes, **since it would be impossible to further reduce the noise within the existing technology**. I have included a letter from Vestas to the Minister of the Environment, dated 29 June 2011 for your review. This letter reflects a strong disagreement about further restricting the limit of low-frequency sound. As you read the letter, you need to endure their self-promotion and their sense of being persecuted rather than acceptance of what the government had requested to protect residents.

Subsequently, they were able to "work out a deal" as described below that essentially negates their concern of not being able to meet new sound limits that specifically designed to increase resident health safety. It continues below:

Out of consideration to the Wind Industry, within the apparent original bill, there was a "political requirement" that the limit for low-frequency noise could never "curtail or limit" the building of IWTs.

Apparently, from the beginning of planning the bill, Wind Industry was strongly represented in the work on the revision of prior regulations and they had great impact on the final result. At an initial meeting, there were nine people in attendance - including five from the Wind Industry. The other three were acoustical consultants with close connections to the Wind Industry. The Danish EPA had one representative (Jakobsen) who worked out the minutes. According to the minutes, Jakobsen found that 20 dBA would be fine but "it depends on the main goal: namely that the new limit does not set new obstacles for wind turbines". In the meeting it was agreed that noise should not be measured indoors in nearby houses; sound measurements would be calculated using an uncertain model and using insulation data from the Wind Industry. It turned out that with the insulation values, 75% would exceed the limit. In addition, complaints could NOT be voiced. The main responsible politician for this "new limit" was the Minister of the Environment. **Dr. Moller also commented** that all the (accepted) errors and insulation "exceptions" produced almost a 10 dBA rise over the original 20 dBA limit. He noted that at such low frequencies, "the perceived intensity or loudness, increases more steeply above threshold than at higher frequencies. This means that when the level is a few decibels above the 20dB limit, the consequences are more severe, than if a limit for higher frequencies is exceeded by the same amount. Moller commented: **"Few people would probably accept 25 dBA in their home at night and hardly anyone would accept 30 dBA". Duchamp, the Executive Director for the European Platform against Wind, commented: "It would appear that the Danish authorities have been cooking the figures to accommodate the Wind Industry. Years ago, governments were protecting tobacco companies; today, they absolve wind farms of all sins and help them commit more".**

Wind Energy: Declaring "Fact" through Misuse of Standard Acoustical Instruments

Previously and repetitively mentioned, is Wind Energy's reluctance to admit that infrasound is present in the noise emissions and is responsible for blade harmonics (and other perceptible emissions) that contribute to resident's annoyance suffering which then contribute to adverse health effects. It would appear they recognize the key "threat" to their narrative that IWTs do not cause AHEs should they acknowledge health impacts produced by ILFN.
In the early 2010 era, Wind Energy claimed that infrasound from IWTs was either non-existent or if they admitted that they found it, they would compare to the levels of other common sources of infrasound to conclude that wind turbine ILFN was lower than what already exists in many communities. Notable acousticians from the engineering firm, Epsilon and Associates (known for their close relationship with Wind Energy) had published earlier, in the same venue, "Noise-Con 2010, April 19, 2010" the article "Low Frequency Sound and Infrasound from Wind Turbines - a Status Update". They introduced their position in this paper commenting on the "argument" of whether IWTs created unacceptable levels of low frequency noise and infrasound. They performed a "world-wide" literature search to determine unbiased guidelines and standards used to evaluate low frequency sound and infrasound. They also performed a field study to measure wind turbine noise outside and within nearby residences. They compared their findings with guidelines and standards from ANSI S12.2 for interior sounds and ANSI S12.9, Part 4 and some European criteria, for thresholds of annoyance. They concluded that "there should be no adverse effects from infrasound or low frequency noise at distances greater than 305 meters from wind farms. They referenced a recent Dr. Leventhall article that presented "an excellent and comprehensive study on low frequency noise from all sources and its effects". They commented that the U.S. government does not have specific criteria for low frequency noise. They used Moller pure-tone ILFN hearing thresholds and made octave band analysis - (both of those acoustical standards have since been shown to be inaccurate and inappropriate for use in the infrasound spectrum).

Fifteen months later, another report (Bray and James) "corrected" the Epsilon consultant assumptions. (Writer: Simplifying their comments), they noted that quantitatively describing the sound pressure levels of infrasound emissions content cannot be accurately performed using the traditional methods of frequency analysis from octave or one-third octave band analysis. Those tools are built into almost all professional grade sound instruments. The current filters are digitally simulated versions of the resistor-capacitor filters used in early pre-digital sound pressure level meters. The newer, digitally simulated version require that the sound being measured is **steady over the period of time required to the saturate the filter.** For frequencies above 20 Hz filter, saturation times are only a few hundred milliseconds. In stark contrast, to measure the sound pressure level at 1 Hz, to reach 90% filter saturation, the filter must be steady for 4989 msecs (almost 5 seconds). IWT infrasonic pressure pulses last about 10-20 msec. Measuring sound of low frequency content with a short 10-20 msec pulse to a filter means that the filter never reaches 90% saturation - not even close. Thus, sound pressure levels that are "outputted" by the filter are all artificially much lower than they really are. The lowest 1/3 octave band sound pressure filter that can accurately measure a 10 msec pulse is 500 Hz. This information describing filter saturation times is found in "appendix 2" at the end of the Article: Noise- Con 2011, July 25, 2011 "Dynamic Measurements of Wind Turbine Acoustic Signals, Employing Sound Quality Engineering Methods Considering the Time and Frequency Sensitivities of Human Perception" and was written by Wade Bray and Richard James - both independent acoustic consultants in the U.S.
The proper analysis of infrasound pulsations, as opposed to steady infrasound, is to make a high-quality recording using a digital recorder and an infrasound-rated microphone. The recording is analyzed using methods based on Fast Fourier Transformation (FFT) which can convert a time domain signal into its frequency domain sound pressure levels without the use of digital octave or 1/3rd octave band filters like the majority of professional sound levels meters use. This is described in the ANSI S12.9 Part 7, Appendix D. The main part of the "Part & Standard" works very well for infrasound that is reasonably **steady over time**. However, the short pulses from the blade-tower interaction (10-20 msec duration pressure pulses) will be dampened by the filters as if being averaged, and, depending on the ratio of onto- off time, will be much lower than the true peak level (which is what we perceive). We feel the peaks or crests of the pressure waves. We do not feel the average of the sound over the period it takes for a digital filter to fully saturate.

In multiple subsequent legal hearings over the years, Rick James has recurrently made this point with offering the data of Appendix 2 as evidence... eventually Wind Energy stopped citing their original incorrect information. Despite the eventual acceptance by Wind Energy of their "flawed assumption at many levels", it is of interest that a Madison County resident during a private conversation with a Wind Energy representative in Madison County (early in the course of MAE's efforts), was again told that IWT infrasound noise levels are less than environmental background levels.

"Normal" People don't Run from the facts ... or, simply not comment. Conveniently ignore the truth

Demand ABSOLUTE Causality when very little in the world can be "proved absolutely".

In a remarkable speech, Dr. Mauri Johansson, MD, MHH, a specialist in community and occupational medicine, delivered a speech at the general meeting of Vestas on Thursday, March 29, 2012 in Denmark.

Previous to and after this speech, he has been active in the area of describing adverse health effects created by wind turbine exposure.

A copy of the translated speech is this Part's appendix.

It has become apparent to me that there is a huge worldwide deception in play. "How can this level of deception exist?", I asked to many (un-named) who have been witness to this business for the last 40 years. Their collective response: "(I) see it in many businesses, especially in the unregulated utilities that are multinational. It is a business model for large firms... through PR firms, lobbyists and outright control of our country's politicians and courts...together work to make themselves richer and immune to citizen oversight".

We have to understand the goals of Wind Energy and their messengers and the rehearsed presentations and their hiding behind their hollow arguments of their "science" and their workings without empathy, or concern ... failing to hear the cries of victims of their manufactured oppression

They (must) struggle violently to believe they are in the right and that "we" are incapable of understanding their (misguided) insights and righteousness

It is not green, sustainable, renewable nor humane... it is not the answer.

This section reveals the extent to which Wind Energy has gone is the past and continues to the very present to champion their industrial wind turbines. The "Non-Wind", i.e.-Health" science is better, more accurate and more complete. The most accurate science that their Wind Energy's acousticians have produced were done by Dr. Leventhall prior to 2004. After that, having become a champion of Wind Energy, those "correct" initial interpretation of ILFN were ignored (but not publicly disputed) by Dr. Leventhall. Once "captured" by Wind Energy, "they" worked together to bring their version of infrasound to the nations of the world that would absolve them of willfully "harming" the recipient residents. The ETSU-R-97 was contrived by a large group of pro-wind supporters (and complicit

governmental ministers who adopted the guidelines that brought commerce and the illusion of clean power to the U.K. and then was later spread to their colonies and eventually to the U.S. (in the vacuum of federal oversight) with pseudo-science that allowed loud audible sound and hence also louder infrasound to be produced at night to levels over 20 dBA above background - among many other nonscience supported assertions.

Wind Energy worked hard to control the narrative particularly when they recognized that they could engineer and produce larger sized IWT with higher energy-producing capabilities. They pressured universities to silence world-acclaimed acousticians who correctly correlated increased IWT size with higher IWT noise emission level in the ILFN spectrum - creating more potential harm to more residents and at farther distances.

Vestas badgered their own government to lessened sound limits on low-frequency noise, then were able to circumvent it through political means.

Vestas badgered the Australian government with incorrect narrative of anti-wind activists and the harmlessness of infrasound

Dr. Johansson saw through their business plan carefully obscured by sanctifying corporate appearances and hollow assertions. It should become much more apparent of what is happening then as is now as one reads his clear distillment of Vestas' real interests. Please read the speech text included in the appendix.

It should surprise no one that the Chairman of the Board of the American Wind Association is leader of the North American Business Unit for Vestas.

These comments are my opinions. I have provided documentation where able. I believe I have made conclusions (included herein) that are reasonable and could be considered as such by a reasonable person. I have fact-checked and cross-checked as best I can. I believe this section's commentary and evidence are crucial for a reasonable person to better understand Wind Energy's Stance on adverse health effects from IWTs.

Click on file below to find 2005 British Wind Energy 2-page informational sheet on their "views" about infrasound noise component in IWTs

Procedure for the assessment of low frequency noise complaints. Dr. Andy Moorhouse, Dr. David Waddington, Dr. Mags Adams University of Salford. Manchester. Defra. Revision 1 . December 2011 Contract no NANR45

1. INTRODUCTION AND SCOPE

Low frequency noise (LFN) is now a recognised problem in many countries in the world. Experience of LFN complaints from the last 30 years has built up a good picture of the typical situations in which disturbance arises. While only a relatively small number of people are affected, those who are tend to suffer severe distress. It is not unusual for sufferers to sleep in a car or shed to avoid the sound, and they may suffer various symptoms such as depression or even feel suicidal. In some cases a source of LFN is found and can be dealt with. However, in many cases (typically 50% to 80% of cases), no environmental sound that could account for the sufferer"s reaction can be found, and the cause of the disturbance remains a mystery.

This guidance leads on from previous reports published by Defra: [Le03] and [Mo11].

Most Local Authorities will receive complaints about LFN at some point, and usually find them particularly difficult to deal with for several reasons. Firstly, existing noise criteria are not appropriate for evaluating LFN; in almost all other situations the established noise descriptors are based on the A weighted sound level (dB(A)) which effectively filters out low frequency sounds.

Secondly, LFN cannot be reliably evaluated on the basis of the investigator"s experience; indeed, officers investigating a case of LFN may not even be able to hear the LFN themselves. This is possible because disturbance by LFN is known to occur at levels only slightly higher than hearing threshold, which varies from one individual to the next. Also, the rate of growth of perceived loudness with level is more rapid at low frequencies so that a sound could appear loud to one person whilst still inaudible to another. An additional factor is that "sensitisation" to low frequency sound appears to occur over time, and therefore a brief visit may not give an accurate impression of what it is like to live with the sound.

Thus, the investigator is left with no suitable criteria and without even personal experience to guide them. Thirdly, the measurement of low frequency sound can be technically difficult. Against this background, criteria for determining acceptable levels of LFN have been introduced in Germany, Denmark, Sweden, Poland and the Netherlands since 1997; the guidance presented in this document has been requested and funded by Defra with the aim of developing a method for the assessment of low frequency noise suitable for use by Environmental Health practitioners in the UK.

Assessment of low-frequency noise from wind turbines under different weather conditions. Chun-Hsiang Chiu , Shih-Chun Candice Lung. J Environ Health Sci Eng . 2020 May 21;18(2):505–514. doi: 10.1007/s40201-020-00478-9

Background

Wind power is used around the world as a source of clean energy. However, wind turbines generate a broad spectrum of low-frequency noise (LFN) in the range of 20–200 Hz, which may be audible or inaudible. LFN generated from wind turbines can be broadly categorized as aerodynamic noise or mechanical noise. With the wind blowing below the cut-in speed, the turbine blades rotate very slowly or are stationary and "parked", thus generating only minimal noise . Sound power level then increases monotonically when the turbine operates between the cut-in and cut-off wind speed, approximately 4 m/s and 30 m/s, measured at hub height, respectively. The most important component of wind turbine noise emission is aerodynamic noise associated with the passage of air over the blade. Sources of aerodynamic noise include trailing edge noise, impulsive noise, inflow turbulence sound, blade tip noise, and blade-tower interaction. The aerodynamic sound level generally increases with rotor speed, which in turn increases with wind speed.

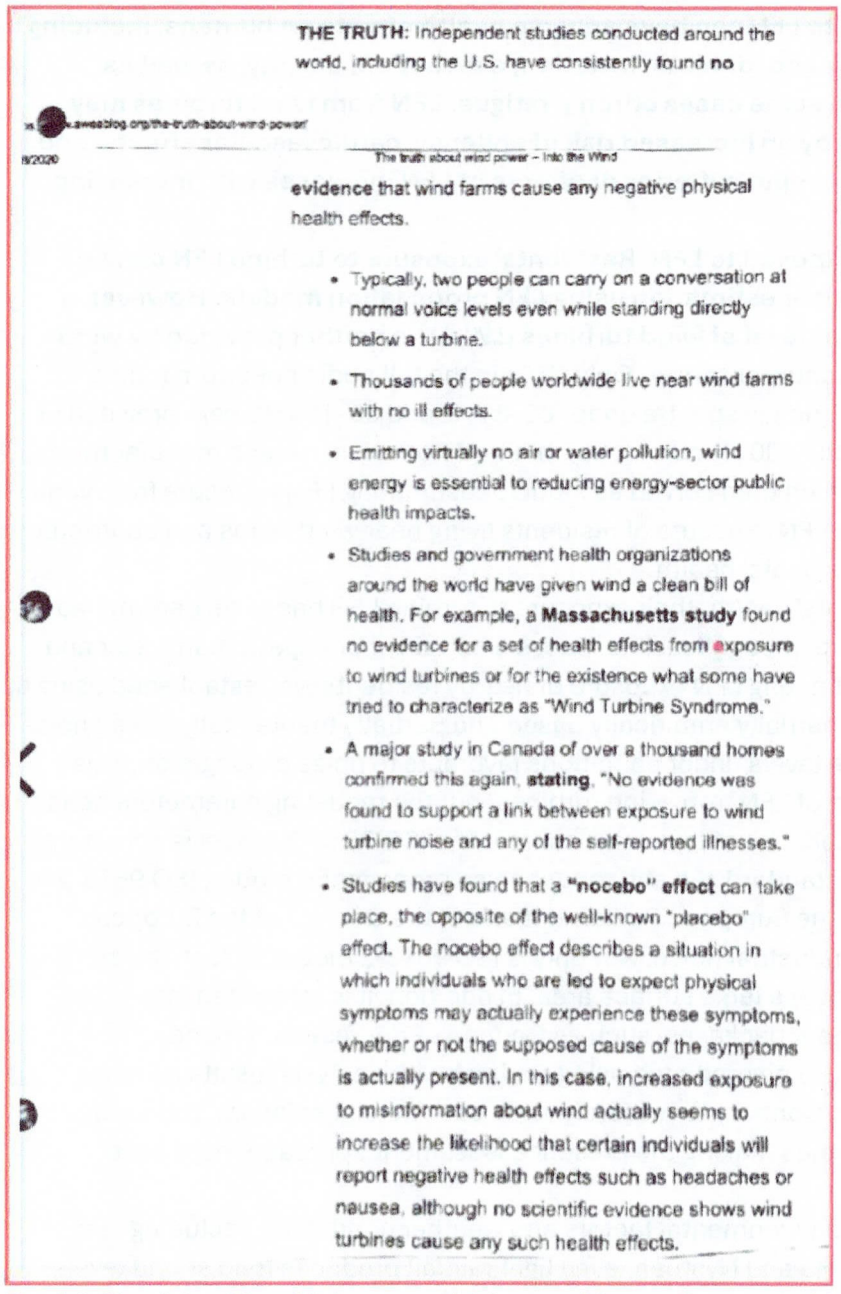
Studies have widely affirmed that exposure to LFN can have adverse health effects on humans, including annoyance, stress, sleep disturbance, headache, tinnitus, irritation, exhaustion, anxiety, as well as hearing loss, impaired concentration, and in some cases chronic fatigue. LFN from wind turbines may cause vibroacoustic disease, characterized by an increased risk of epilepsy, cardiovascular effects, and coronary artery disease. The percentage of people suffering ill effects of LFN increases with increasing noise levels.

Residents near wind farms are constantly exposed to LFN. Residents' exposure to turbine LFN can be obtained through either actual measurement or estimation using LFN propagation models. However, a critical parameter of the model, sound power level of wind turbines (*LW*,A), is neither provided by wind turbine manufacturers, nor found in other documentation. Only *LW*,A in the full audio spectrum (audio frequency range of 20–20 kHz) or in certain frequency spectra under 63–8 kHz and 50–10 kHz were provided in some references. Since the values of *LW*,A at 20–200 Hz cannot be obtained from wind turbine manufacturers, this study estimated this critical parameter, which then served as input for estimating LFN exposure from wind turbines. Knowledge of such can shed light on LFN exposure of residents living near wind farms and contribute to an impact assessment of turbine LFN on residents' health.

To assess the impact of turbine LFN on residents' health, their exposure to turbine LFN has to be determined first. Direct measurement of their LFN exposure, though feasible, poses a certain challenge in manpower and resources. In this study, a methodology of estimating LFN exposure of nearby residents was established using a noise propagation model ISO 9613-2. Being a partially empirically based and partially theoretically based noise prediction model, ISO 9613-2 calculates noise levels under conditions favorable to noise propagation. This model is appropriate for modeling propagation of LFN from wind turbines, but the modeling parameters need to be adjusted to account for the unique characteristics of this noise source. The ISO 9613-2 model is commonly used in wind turbine noise calculations . As a standardized and robust noise propagation model, ISO 9613-2 is recommended in the Directive 2002/49/EC of the European Parliament and of the Council of the European Union as a national computation method for industrial noise. Not only is ISO 9613-2 modeling fast, it also provides estimations of sound pressure level over a large surface area. In addition, it is integrated into commercially available noise prediction software packages, such as CadnaA . Prior research found consistency between noise levels from wind turbine predicted using CadnaA with analysis results on noise generation data provided by the manufacturer. Contrary to research using commercial software, this study applied directly the model to LFN estimation, thus making the present assessment approach more cost-effective.

However, noise propagation is susceptible to environmental factors and weather conditions, including rain, wind speed, and wind direction. According to Ma and Nystuen, even light rainfall produces loud sound levels relative to wind.

Below finds excerpt from American wind energy website on their position about adverse health effects arising from IWT noise. Note no data, references to data, just unsupported conclusions.



THE TRUTH: Independent studies conducted around the world, including the U.S. have consistently found **no**

...sweeblog.org/the-truth-about-wind-power/

8/2020 The truth about wind power – Into the Wind

evidence that wind farms cause any negative physical health effects.

- Typically, two people can carry on a conversation at normal voice levels even while standing directly below a turbine.
- Thousands of people worldwide live near wind farms with no ill effects.
- Emitting virtually no air or water pollution, wind energy is essential to reducing energy-sector public health impacts.
- Studies and government health organizations around the world have given wind a clean bill of health. For example, a **Massachusetts study** found no evidence for a set of health effects from exposure to wind turbines or for the existence what some have tried to characterize as "Wind Turbine Syndrome."
- A major study in Canada of over a thousand homes confirmed this again, **stating**, "No evidence was found to support a link between exposure to wind turbine noise and any of the self-reported illnesses."
- Studies have found that a **"nocebo" effect** can take place, the opposite of the well-known "placebo" effect. The nocebo effect describes a situation in which individuals who are led to expect physical symptoms may actually experience these symptoms, whether or not the supposed cause of the symptoms is actually present. In this case, increased exposure to misinformation about wind actually seems to increase the likelihood that certain individuals will report negative health effects such as headaches or nausea, although no scientific evidence shows wind turbines cause any such health effects.

Danish Physician Mauri Johansson Addresses Vestas Corporate Meeting about need to focus on health safety for potentially affected residents. It is sobering, incredibly insightful and the message is still relevant today. This can be opened and reviewed below:

To my great joy, I read on Vestas' website that "Vestas welcomes the public debate about wind energy – and we hope to provide factual inputs and balanced perspectives". I would like to avail myself of that today.

I searched for 'noise' and 'health'. Issues like noise and health, visual impact and wildlife are often debated when discussing wind energy. I did not find anything about this topic on the Danish website.

However, the English website showed a couple of video clips where a neatly dressed gentleman in a convincing voice alleged that noise has NO negative health consequences. He managed (in a biased manner) to smear one critical report but did not mention a single independent scientific report documenting that there are NO problems.

This is because such reports do not exist, neither in Denmark nor in any other countries, but there are many that document a growing number of serious problems.

Vestas has a huge market in Australia.

At a Senate hearing in the Australian Parliament in March 2011 on the health consequences and potential illnesses caused by neighbouring wind turbines, Vestas' local representative in Australia (Ken McAlpine) stated: "Obviously, the one [issue] that is of most interest to us and closest to our heart is safety. Vestas has safety as its No. 1 priority." ...

"There is nothing about wind turbines that is unsafe. There is nothing about them that is unhealthy" ...
" I can tell you again that there is nothing about the wind turbines that we are installing that would be unhealthy or harmful to people's health and wellbeing."
I think Ken McAlpine's statement was weak and untruthful in several respects.
The Chairman of the National Health and Medical Research Council in Australia, Professor W. Anderson, indeed refuted Ken McAlpine's allegations at the same hearing. Ken McAlpine's submission to the New South Wales [draft proposal] on wind turbines dated 14 March 2012, which proposes that the entire section on health be deleted, is even more outrageous.
Is it really good export policy to despatch a man like McAlpine to run errands on behalf of Vestas in view of the Danish Government's recently announced policy on Corporate Social Responsibility (CSR), now that Denmark clearly HAS recognised that wind turbine noise causes considerable problems, especially low-frequency noise, and has proceeded to regulate the area? Isn't the moral standard too low compared with Vestas' ethical high jumps?
By contrast, I am impressed by what Vestas writes on its website and in the 2011 Annual Report on topics that have been a great interest of mine throughout my adult life and still are: social conditions, environment, human rights (including the right to health), as my medical specialty is community and occupational medicine, including environmental medicine.
A couple of quotes:
Principles in the Vestas Code of Conduct on Ethics and Morals: The Vestas Code of Conduct is a set of rules governing ethical behaviour. It sets standards in different areas which all Vestas employees must adhere to in order to uphold Vestas' reputation as a company with a high degree of integrity and trustworthiness ...
p. 8: All Vestas managers and supervisors must act as role models for the employees by adhering to the Code of Conduct.
p. 5: ... we will be judged by the methods we use to achieve results.
p. 32: Competition: The only way in which Vestas can maintain its position as No. 1 in Modern Energy in the long term is to conduct business in a legal, honest and competitive manner. In addition to harming Vestas' business and reputation, illegal and anti-competitive measures will result in severe punishment for Vestas ...
p. 36: Vestas' role in society: A company is responsible – according to legislation and public opinion – for the impact the company's activities have on nature and the local and global society. [MJ: I must presume that this also applies to humans, i.e. the health and quality of life of wind turbine neighbours?
Vestas is an international company and endeavours to be a socially responsible company at a global level ... However, Vestas is also of the view that it is in the best interests of the company, the employees and the owners in the long term to take responsibility for Vestas' impact on its surroundings: the environment [MJ: In this regard, Danish and EU environmental legislation very much covers the health of individuals and the general population and the local, national and global [MJ: cf. Australia] society and their inhabitants.
Environment
"Environmental considerations are a fundamental part of Vestas' business concept. Vestas endeavours to produce wind turbines that are as environmentally friendly as possible" [MJ: i.e. also for people living in the immediate vicinity of erected wind turbines – or?]
Vestas undertakes:
... to comply with legal requirements to environmental protection [MJ: the Act on Environmental Protection says: "Section 1(1). The Act shall contribute to protecting nature and the environment to ensure that societal development takes place on a sustainable basis with due respect for man's living conditions and the protection of flora and fauna. (2) This Act specifically aims at preventing and controlling pollution of ... as well as nuisances caused by vibration and noise].
... to consider the environmental consequences of all new products ...
... to reduce waste and pollution in all its activities [MJ: i.e. also the considerable amount of noise emission, which is not mentioned at all in the 2011 Annual Report? Or, what has also not been mentioned, the considerable emission of CO2 and other toxic emissions from traditional power plants as a result of the extensive back-up requirements that will always exist due to the unreliable power production of the wind

turbine system – these are external factors for Vestas but deadly serious issues for the average power consumer, tax payer and citizen].

Political co-operation

Vestas supports political activities that promote wind energy. These include activities such as the lobbying of governments, information campaigns or meetings about wind energy with public servants or politicians. But what about the neighbours?

But what happens in real life?

At this general meeting, it is impossible to present the entire amount of evidence of well- documented serious nuisances, sleep disturbance, stress and illnesses that exist today, but Vestas in Denmark, in Australia and elsewhere continues to deny it, and continues to ignore scientific knowledge.

An extremely brief reference list is attached. Vestas says that the company has spent DKK 15 billion on research, but not a single krone of this huge amount of money has been spent on impartial research to ensure that wind turbine neighbours do not suffer nuisances or become sick.

Is this in accordance with Vestas' ethical principles? Research aimed at preventing the considerable increase in the proportion of low-frequency noise, including infrasound, in the latest wind turbine models do not exactly impress – just think of the rumbling of the 3 MW wind turbines.

For decades, Vestas and the wind turbine industry have ruthlessly been pressurising politicians and public servants with demands not to impose stricter rules on noise and minimum distances, knowing full well that the ever larger wind turbines cannot comply with the current (as of 1 January 2012) threshold values aiming to ensure the health of the population, which they fail to do. All problems can be prevented 100% if the limits for noise and distance are high enough. Exactly what is 'ENOUGH' must be clarified by impartial professional health research with the assistance of other disciplines. Until then, all precautionary principles must be strictly adhered to.

This is the responsibility of the municipalities, but they do not know enough about the subject. I and others have obtained documentation for all this by means of our right of access to public documents, including a letter from Managing Director Engel dated 29 June 2011 to the Minister for the Environment (is a CEO a good role model here?) and minutes of meetings from the Danish Environmental Protection Agency, etc. showing how a powerful industry makes demands that are more like ultimatums to the authorities who give in to the powerful industry and ignore weighty, even medical hearing material; documentation that clearly demonstrates that the authorities are bending the 'truth' to the detriment of wind turbine neighbours.

The Danish rules, and often financing schemes as well, have been exported together with the wind turbines and are thus causing damage the world over. The wind turbines have grown steadily larger due to the unhealthy subsidy schemes – money-making machines rather than power plants. Is this an honest and legal way to conduct business? Does it amount to social responsibility? Social consciousness? Trustworthiness?

Why is the company's lack of acceptance of the potential harmful impact of wind turbines on neighbours during operation not mentioned but only the health and safety issues in connection with production and scrapping? And why do the auditors accept this?

On the basis of the above, I have come here to strongly recommend that Vestas, now that so much has to be radically changed anyway, admit the errors they have committed by denying the facts that the wind turbines DO HAVE negative health consequences and start afresh with the development of a completely new wind turbine concept that is sustainable, without subsidies, and of a type that does not harm the health of nearby residents but provide them and others with an additional option for sustainable energy and electricity for the benefit and joy of others than the wind turbine industry and wind turbine owners.

Why not focus on wave energy and geothermal heat? Contact the health authorities and start collaborating with the Danish Society of Occupational and Environmental Medicine (DASAM). Take a look at the more restrictive Swedish noise regulations and adopt them, spearheaded by the two Swedish members of the new board.

References:

1. Christopher D Hanning & Alun Evans: Wind turbine noise. Seems to affect health adversely and an independent review of evidence is needed. Editorial, BMJ 8 March, 2012

2. Carl V. Phillips: Properly Implementing the Epidemiological Evidence. About the Health Effects of Industrial Turbines on Nearby Residents. July 19. 2011
3. Wolfgang Babish: in Occup Environ Med 2003;60:739–745): Policy implications: "Chronic environmental noise stress increases the risk of ischaemic heart disease." "Two conclusions can be drawn from the study: Firstly, noise annoyance/disturbance is associated with IHD incidence (shown in men without pre-existing disease) and may be a risk factor. Secondly, annoyance/disturbance ratings from subjects with health problems (men with pre-existing disease) may be influenced by other factors."
4. Same author: Editorial from 2011 in Noise & Health (May-June, 13:52,201-4): "It is well understood that noise levels below the hearing damaging criterion cause annoyance, sleep disturbance, cognitive impairment, physiological stress reactions, endocrine imbalance, and cardiovascular disorders." "The question at present is no longer whether noise causes cardiovascular effects, it is rather: what is the magnitude of the effect in terms of the exposure-response relationship (slope) and the onset or possible threshold (intercept) of the increase in risk."
5. Bolin/Bluhm: Review of wind turbine noise: (Environ. Res. Lett. 6 (2011) 035103): "the effects on the cardiovascular system by noise are assumed to be stress related and triggered by noise annoyance and sleep disturbance (Babisch 2002). Wind turbine noise is causing noise annoyance, and possibly also sleep disturbance, which means that one cannot completely rule out effects on the cardiovascular system after prolonged exposure to wind turbine noise, despite moderate levels of exposure."
6. Moller & Pedersen: "Low Frequency Noise from Large Turbines" J Acoustical Society America 2011 129:3727-3744: **http://www.wind-** watch.org/documents/low-frequency-noise-from-large-wind-turbines-2/
7. Vestas submission to NSW Dept of Planning: **comment here**.
8. David Shepherd & al.: Evaluating the impact of wind turbine noise on health-related quality of life. Noise & Health September-October 2011 13:54,333-9

Mauri Johansson, MHH Specialist in community and occupational medicine – last draft for speech, corrected 30 March in accordance with what was said at the meeting.

The PDF document below was opened and printed below. The PDF filed is also available to be opened to see original letter format. This 2012 document reflects Vestas' objections to the introduced potential "safety-related" restriction proposed for Wind Energy. Toward the end, they minimize concerns about low-frequency noise.

14 March 2012
Policy, Planning Systems and Reform
NSW Department of Planning and Infrastructure
GPO Box 39
SYDNEY NSW 2001
By email: innovation@planning.nsw.gov.au
Dear Sir/Madam

DRAFT NSW PLANNING GUIDELINES: WIND FARMS

Thanks you for the opportunity to make a submission on the *Draft NSW Planning Guidelines: Wind Farms* (**the Draft Guidelines**).

Vestas Australian Wind Technology Pty Ltd is the local subsidiary of Vestas Wind Systems A/S, the world's largest manufacturer of wind turbines.

Vestas is the world's leading supplier of wind power solutions, having installed more than 41,000 wind turbines across the globe. Worldwide, Vestas employs more than 23,000 people in the design, manufacture, sales, installation, operation and maintenance of wind turbines.

While the home country of Vestas is Denmark, we have significant operations all across the world and we are experienced in comparing policies and regulations in all our markets.

In Australia we have been responsible for the supply of more than half of the wind energy capacity to date. However Vestas is not a developer or owner of wind farms or wind energy projects, and so does not seek planning permits.

Vestas is also a member of the Clean Energy Council (**CEC**), and in addition to our own submission we would also refer you to the CEC's submission regarding the Draft Guidelines.

Executive summary

Vestas opposes the Draft Guidelines, primarily because of the sheer number of new and additional requirements and barriers that would be placed in front of the wind energy industry without any clear evidence, justification or demonstrated need for this additional regulation.

The Draft Guidelines appear to be in conflict with the New South Wales (**NSW**) Government's own renewable energy policies and seem to be primarily motivated by an attempt to appease anti-wind protest groups.

The Draft Guidelines impose new rules that are not faced by any other industry in NSW, and directly discriminate against wind energy. Some concepts, such as the requirement to assess impacts on property values and the introduction of a 2km "gateway" are at odds with many years of existing case law in the planning portfolio.

Other concepts such as the new noise requirements are more stringent than any other jurisdiction in the world, without any justification as to why this is required.

Even though we suspect the Draft Guidelines have been drafted in response to the lobbying of anti-wind activist groups, we confidently predict that the Draft Guidelines will not be accepted by those groups.

Such groups are not interested in compromise or balanced outcomes. They care little for evidence-based policy or addressing genuine impacts that wind farms might cause in specific locations. They seek nothing less than the demise of the wind farm industry, wherever it may be located.

Unfortunately, higher electricity prices will be the legacy of this attempt by the NSW Government to appease a noisy minority of activists. In addition, job growth and investment attraction will also suffer.

This will occur because the additional requirements and barriers in the Draft Guidelines for wind farms will make them more expensive to build and operate, and will force them to be located in areas where wind speeds are lower or transmission access is harder to secure.

By contrast, South Australia provides a good example of how a state government has worked with the wind industry and local communities to attract investment and jobs, build record levels of wind farms and keep power prices low. NSW would do well to follow this example and ignore the small but noisy group of activists that are seeking to destroy the wind industry and keep NSW reliant on fossil fuels.

Background

Over the past decade in Australia, the wind energy industry has grown substantially in almost all states and territories, to the point where more than 2000 megawatts of installed wind capacity is now operating. A further 6000 megawatts of new wind energy projects are currently being investigated or are in the planning stages, many of them in NSW.

Part of the reason for the industry's growth has been the Federal Government's 20% Renewable Energy Target (**RET**) scheme, which has driven most of the investments in wind energy in Australia since 2001. The decision in 2009 by the Australian parliament to lift that target to 20% by 2020 will continue that growth over the next decade.

The other key driver behind this growth has been the policy imperative for all nations around the world to cut greenhouse emissions in an effort to reduce the impact of climate change. Wind power is the most cost-effective form of renewable energy with zero greenhouse emissions, and is forecast to retain this status for many years to come.

Wind energy and its role in energy policy

Wind energy is just one source of energy available to NSW. Historically, NSW has relied heavily on coal to supply its electricity. While coal has provided low-cost electricity during the previous century, this does not mean that this is likely to continue in this century. Labor costs, extraction costs and pollution costs are all good reasons for NSW to consider moving away from such a heavy reliance upon coal and gas.

In addition, the further expansion of coal mining and gas extraction has been facing increased community concern, particularly from farmers. Coal mining is an activity which is not able to coexist with farming activities in most cases, as it usually entails open cut methods or involves such significant activity at the mine mouth that growing crops or managing livestock becomes problematic, and in many cases impossible in the same location as the mining activity or gas extraction.

In addition, access to water is also a major factor that makes it difficult for coal mining and gas extraction to coexist with farming. Unlike other users of water, power stations often obtain their water at sub-commercial rates and this has been under challenge in recent years.

The National Water Commission has examined these issues and said electricity generators "should face the full economic costs of their consumption decisions, so they have incentives to invest in more efficient technologies"1. Coal-fired power stations use large volumes of water for cooling purposes, so this is no small issue.

By contrast, wind energy does not face these issues. Barely any water is required for the operation of wind turbines. They cause no air or water pollution. There are no greenhouse gas emissions from wind turbines. And wind energy, unlike many other forms of electricity generation, does not have a fuel cost.

1 "*Water and the Electricity Generation Industry: implications of use*" National Water Commission, 2009

While other states and countries do not have significant renewable energy resources, NSW does2. It would be prudent for the NSW Government to focus on diversifying into wind energy over the coming years, which appears to be the approach now being taken. It has been pleasing to see that the NSW Premier and a number of his ministers have restated their support for the 20% RET and indicated their willingness to attract investment in renewable energy to help achieve the target, including a statement by Planning Minister Brad Hazzard on radio on 9 February this year.

An increase in wind energy generation in NSW is an excellent strategic move in light of water and greenhouse gas constraints, and such a move will also act as a natural hedge against any increase in the fuel costs of coal and gas-fired power stations.

Against that background, the proposed introduction of a new and discriminatory set of planning guidelines that makes it more difficult to build wind farms in NSW seems short-sighted and highly questionable given the strategic issues discussed above.

Rationale and principles behind the Draft Guidelines

The Executive Summary of the Draft Guidelines includes the following statement:

The NSW Planning Guidelines: Wind Farms have been designed to deliver improved consistency and rigour in the planning assessment process and ensure effective consultation with local communities.

Presumably such goals would also be worthy of pursuing in relation to the planning assessment process for all kind of land use, not just for wind farms.

It is imperative that any proposed changes to the planning assessment process are fair, transparent and efficient.

Assessment of wind farms should be based on objective criteria that all stakeholders can understand.

This can be achieved by ensuring the Draft Guidelines do not place additional burdens on the development of wind farms by creating delays or uncertainties in the planning process.

As is discussed below, many of the provisions of the Draft Guidelines discriminate against wind farm development and should be amended to ensure this discrimination does not occur.

2 "*Australian Energy Resource Assessment*" Department of Resources, Energy and Tourism, 2010

Specific responses to the Draft Guidelines

Section 1.2 Which development assessment process applies?

We note that the minimum 30 days exhibition time for state significant development (**SSD**) projects has been extended to a 60 day minimum in the case of wind farms that are deemed SSD.

While the duration of this period does not particularly trouble us, the discrimination against one form of development certainly does.

In practice, we would expect that wind farm project proponents would work with local communities, local councils and the Department of Planning and Infrastructure

(**DP&I**) to agree on a longer exhibition time for highly complex projects where this is considered to be necessary.

However, we consider it is inappropriate and discriminatory to entrench a longer exhibition period for wind farms as a blanket rule, and we do not consider that the basis for this decision has been justified by DP&I.

Section 1.3 (a) Proximity of turbines to existing residential dwellings (2km)

Vestas welcomes the increased focus on community consultation and engagement in the Draft Guidelines. We also support the requirement to comprehensively document the views of nearby landowners, including any concerns they may have with proposed wind farms.

However, we do not support the requirement to explicitly seek the written consent of all landowners within a 2km range between proposed wind turbines and existing residential dwellings, or the requirement for a Site Compatibility Certificate in the event that written consent is not obtained.

Such a requirement does not apply to any other kind of development to our knowledge, and accordingly it is discriminatory against wind farms without any clear justification for this.

In fact, setting a specified zone for engagement may actually reduce the capacity for wind farm proponents to comprehensively consult with local communities and residents.

In relation to the 2km "gateway" zone, we would note that the 2011 Senate Inquiry into Rural Wind Farms concluded that "the application of scientific measurements for sound and for shadow flicker to alleviate problems for wind farm neighbours may be preferable to prescribed setbacks. Prescribed setbacks are arbitrary and may be too great or too small"3.

That statement is consistent with existing case law. The 2010 decision of the NSW Land & Environment Court on the Gullen Range Wind Farm rejected the local council's proposal of an arbitrary setback distance of 2km, stating that "assessment of impacts on properties should be done on an individual basis taking into account topography, orientation of houses and distances to visible turbines"4.

It has not been made clear by DP&I why NSW should now move away from established law as well as the findings of the Senate Committee. It has not been made clear why wind farms should be subject to this discriminatory form of assessment compared to every other kind of land use.

If it was thought by DP&I that a 2km zone would go some way towards appeasing the various anti-wind groups from the constant political campaigning against wind farms, it won't work. The stated goal of the anti-wind activist groups is to have a 10km buffer zone between residential dwellings and wind turbines5. They continue to claim

that wind farms cause direct and adverse health impacts, even though the peer reviewed evidence on this topic indicates the exact opposite.

In addition, there are practical concerns regarding the very early stage at which landowner consent is required. When developers are investigating sites, various technical aspects are simultaneously investigated including wind resource and planning constraints. This process can take months during which community consultation will be taking place. However, the developer is unlikely to know exactly where turbines will go and thus what consents are required.

The proposal to secure approval for turbines within 2km at the beginning of the project will prove unworkable. it is impossible for the Joint Regional Planning Panel (**JRPP**) to fairly review the impact of a project in the absence of a complete analysis of the project, which can only occur once all the detailed studies have been undertaken.

A wind farm project continues to evolve from the initial turbine layout in response to constraints identified in studies (environmental, technical, cultural, local amenity) as well as in response to consultation with the community. This would be impossible without access to the Director General's Requirements upon which these studies are based.

3 *The Social and Economic Impact of Rural Wind Farms*, report of the Senate Community Affairs References Committee, June 2011, p.20

4

http://www.austlii.edu.au/cgibin/sinodisp/au/cases/nsw/NSWLEC/2010/1102.html?stem=0&synonyms=0&query=%22property%20value%20

5 For example, see the "Explicit Cautionary Notice", viewed at www.waubrafoundation.com.au on 22February 2012

Section 1.3 (b) Community consultation

See comments below in response to Section 2.2.

Section 1.3 (c) Visual amenity

Vestas rejects the need for a requirement for a Site Compatibility Certificate for turbines within 2km of neighbouring homes, for the reasons set out above in the discussion of Section 1.3 (a).

Section 1.3 (d) Noise

See comments below in response to Appendix B.

Section 1.3 (e) Health

The proposed requirement to reference "up to date evidence-based research" gives little guidance as to how this would be judged by a JRPP or any other decision-maker in the planning process. What qualifies as "evidence-based research" is a frequently debated topic, so this clause provides no certainty to anyone involved in the planning process.

Certainly the anti-wind farm activist groups refuse to accept the peer-reviewed evidence on this topic and have continued to rely on the scaremongering of unregistered doctor Sarah Laurie and information they have harvested from various anti-wind websites.

Given that most wind farm planning stakeholders are not medical experts, we think it would be more appropriate if the Draft Guidelines were amended to require that project proponents consider the project's impact on health, with reference to the latest statements from the National Health and Medical Research Council (**NHMRC**) and NSW Department of Health.

Ideally, the entirety of Section 1.3 (e) should be deleted so as not to give the impression that the NSW Government places any credibility in the false claims of the anti-wind activist groups on the topic of health impacts.

Section 1.3 (f) Decommissioning

The Draft Guidelines state that "wind turbines typically have an expected operating life of around 20-25 years at which point they are usually decommissioned".

There are no wind farms of that age in Australia and so what "typically" happens to the turbines at this point is unknown. Thus the statement is a ridiculous one to include in a document of this nature, and it looks suspiciously like the kind of statement that is more likely to have been made by the anti-wind activist groups.

Vestas does support the inclusion of a Decommissioning and Rehabilitation Plan in the environmental assessment report. However, we do not support the requirement for proponents to provide a decommissioning bond. It is not clear how DP&I would calculate the level of this bond and until this is defined, we suggest that the requirement is removed from the Draft Guidelines.

Additionally, the requirement for the decommissioning plan to be updated every five years is an unnecessary burden not required of projects in other sectors. Wind farm operators have a clear incentive to maintain their assets for as long as possible because unlike most other power stations the "fuel" for a wind farm (i.e. the wind) is free. Hence this additional requirement is unnecessary.

Section 1.3 (g) Auditing and compliance

We note this section allows neighbours of wind farms to write to the Director General of DP&I to request independent noise monitoring at their house. This section gives no further detail on what grounds this request would be agreed to, such as:

who would undertake the monitoring,

who would pay for it; and

what actions would result if the readings show compliance or noncompliance.

At a bare minimum, such matters should be clarified.

Section 1.4 Preparing an Environmental Effects Statement

No comment.

Section 2.1 Consultation requirements (documenting "effective engagement")

Vestas agrees that consultation should be "aimed at identifying and considering options for eliminating or reducing impacts". That seems in line with accepted practice and on the face of it is a good policy.

However, the requirement in 2.1(a) that "the proponent's assessment report will not be accepted until evidence of effective consultation has been presented and it has been demonstrated that the issues raised during consultations have been appropriately addressed" could cause major issues.

Without further definition of "appropriately addressed", this requirement could be used by project opponents to delay projects indefinitely. The Draft Guidelines need to clearly state the requirements to be satisfied by the project proponent.

On the specific issue of property values, this is discussed below under Section 3.2.

Section 2.2 Who to consult

Vestas supports wide community consultation with respect to wind farm developments. However, as noted earlier in this submission, we consider the list of required stakeholders should be restricted to **only those who are impacted by the proposed project**.

This means that "organisations that represent those with a state, national or global interest, e.g. peak environment groups and national industry associations" and the "Aerial Agricultural Association of Australia" that currently appear on the list in 2.2 should not require consultation.

Many of them are nothing more than lobby groups, and in any other scenario would not have standing to interfere in a process like this as they are not local residents. In most cases the views of such organisations are well known and are not directly relevant to local planning issues.

The proponent should only have to consult with people, companies and agencies that are directly impacted by the wind farm in the local area.

Any diversion from this key principle leaves the process open to manipulation by organised protest groups who may not have members who live anywhere near a proposed major project.

Furthermore, given the Government's intention to restore planning powers to local communities, we would recommend that any objections to projects should only be deemed relevant if: the objections are from local agencies or members of the public living within a limited distance from the project, perhaps between 0 and 5 kilometres;

the objections are not merely "form letters" or other verbatim forms of communication; and the nature of the objections are restricted to matters relating to the impact of any project on the local environment.

Such restrictions would be likely to focus the planning assessment process so that it addresses local environmental issues and other practical impacts rather than allow anti-development groups from outside the local area to add delay, extra costs and spurious matters and prevent SSD projects from proceeding and making economic contributions to local economies in NSW.

Section 2.3 Consultation approaches

No comment.

Section 3.2 Identifying relevant assessment issues (also the subject of Appendix A)

The list of "issues that typically need to be assessed for a wind farm application" is a long one, and includes many issues that have been raised by anti-wind activist groups in addition to matters that are normally addressed in planning assessments.

Vestas wishes to make comment on a number of them.

Health

As set out in the discussion of Section 1.3 (e) above, Vestas rejects the claims of the anti-wind groups regarding adverse health impacts of wind turbines. We consider that this item should be removed from the Draft Guidelines to properly reflect the most recent peer-reviewed evidence and findings of the NHMRC and the NSW Department of Health on this topic, and to ensure the baseless claims of anti-wind activists are not given any credibility by such a specific reference.

Property values

Property values are not considered valid grounds in planning matters, yet for some reason have been included as a proposed matter for consideration in the Draft Guidelines. In the Taralga and Gullen Range Land and Environment Court decisions this issue was raised and subsequently dismissed as a relevant consideration in the planning framework6.

The quote below makes it clear that the inclusion of such a matter would be contrary to the objectives of the relevant planning legislation:

160 Creating such a right to compensation (for creating such a right it would be) would not merely strike at the basis of the conventional framework of land use planning but would also be contrary to the relevant objective of

the Act, in s 5(a)(ii), for "the promotion and co-ordination of the orderly and economic use and development of land".

In any event, the 2009 independent study commissioned by the NSW Valuer General revealed that wind farms had no identifiable impact on the value of nearby properties7.

That alone means that this particular section of the Draft Guidelines would be yet another example of regulation that is not evidence-based.

6 See in particular paragraphs 107 to 109 and 159 to 160 at http://www.austlii.edu.au/cgibin/sinodisp/au/cases/nsw/NSWLEC/2010/1102.html?stem=0&synonyms=0&query=property%20value%20

7 Preliminary Assessment of the Impact of Wind Farms on Surrounding Land Values in Australia, Duponts, August 2009

Blade throw

The occurrence of an incident where a blade from a wind turbine becomes detached from the generator is a rare one, yet perhaps because of its novelty factor has become a common topic raised by anti-wind groups to scare local communities as part of a campaign to stop wind farms being built.

Inclusion of any references to "blade throw" in the Draft Guidelines may please the anti-wind groups but would be in contrast to most other aspects of planning and environmental assessment, which are evidence-based. DP&I has not provided any evidence to justify such a rare occurrence becoming a necessary issue for consideration in planning assessments. In addition, there are already laws in existence for owners and operators of wind farms to maintain a safe workplace and fulfil their duty of care towards others in the community.

The proposal for planning applications to address such a rare eventuality really widens the scope of matters that proponents need to cover in their applications, and sets a dangerous precedent for all types of planning assessment.

For example, in recent times we have seen reports of anti-wind activists who claim that wind farms could interfere with the migratory patterns of whales8. Again, no evidence is provided for such a claim.

At best, the inclusion of "blade throw" as a relevant consideration in the planning assessment framework is another example where the Draft Guidelines discriminate by placing additional regulatory requirements on wind farms when compared with other forms of development and land use.

At worst, the inclusion of this topic as a relevant consideration sets a precedent that would see all kinds of additional spurious topics included in the planning assessment framework for other kinds of development. Like health and property values, it should be removed from the list of relevant assessment issues.

Section 3.3 Conditions of consent and compliance

No comment.

Section 3.4 Community infrastructure contributions

Vestas supports private arrangements between project proponents and individuals and/or community organisations to deliver community benefits outside of the statutory planning process or assessment framework.

8 Eden Magnet newspaper, 9 February 2012 Section 3.4 of the Draft Guidelines suggests that "The consent may require the applicant to provide a contribution, including monetary, land or in-kind contributions, towards community infrastructure". However they also state that "private arrangements with individuals and or community organisations... are outside of the statutory planning process and are therefore not relevant to the assessment".

The Draft Guidelines should clearly state whether voluntary payments (whether to a local council or to an individual or community group) are relevant or irrelevant to the planning permit. It should not distinguish between these two types of voluntary payments.

Appendix A: Meeting assessment requirements

Many of the issues we have with this section have been discussed above, namely the references to health, property values and blade throw. These should all be deleted from Appendix A for the reasons stated elsewhere in this submission.

In addition, the statement on typical turbine life discussed in Section 1.3 (f) appears again in Appendix A and should also be deleted.

Appendix B: Noise guidelines

Vestas does not support the adoption of the noise guidelines set out in Appendix B as they are unnecessary, discriminatory and unclear.

The Draft Guidelines suggest additional, more stringent requirements and assessments with respect to noise compliance. No justification is provided for moving to a new set of regulations that are self-proclaimed as the toughest noise standards in the world.

Despite a lack of evidence that the current standards are inadequate, these additional requirements add to the large body of standards and guidelines already in use in Australia, which are already some of the most stringent in the world.

Rather than introduce new and more stringent noise guidelines, New South Wales should adopt noise limits in line with accepted standards such as NZS6808:2010.

This will allow for the separate day time and night time limits, and will allow for the differentiation of residential zones labelled 'rural living' and 'high amenity' (where a stricter limit will apply).

Low frequency noise

The Draft Guidelines state that "Analysis of wind turbine spectra shows that low frequency noise is typically not a significant feature of modern wind turbine noise and is generally less than that of other industrial and environmental sources."

It is therefore unnecessary to require the prediction and monitoring of low frequency noise emissions from wind turbines. This is especially so, given the absence of regulation or limits upon the low frequency noise from "other industrial and environmental sources" as mentioned in the above statement from the Draft Guidelines.

This is a further example of the way in which the Draft Guidelines discriminate against wind farms.

In addition, the existing and well validated industry standard models for acoustic propagation are not designed to deal with frequencies at the low end of the audible spectrum, specifically because noise emissions in this band are not considered to pose issues likely to affect the surrounding environment.

Accordingly, Vestas suggests the removal of the requirement to measure low frequency noise from the Draft Guidelines.

Definitions and additional management of noise characteristics

In the Draft Guidelines, the definition of a "sustained exceedance" requires that characteristics are present for not more than 30% in any season.

This places an unfair burden on wind farm proponents who would be forced to test for 12 months in order to demonstrate compliance.

A more reasonable test would be when the characteristic was shown to be evident for 30% of the measurement period which must be more than 14 days (typically the duration required to gather sufficient data for assessment against NZS6808:2010).

When considering special audible characteristics (tonality for example) a sustained exceedance should be used as the test of non-compliance, using our preferred definition above.

Appendices C, D, E and F

No comment.

Retrospective application to existing wind farm proposals and projects

The Draft Guidelines do not make it clear which set of rules will apply to existing wind farm proposals that have already begun their path through the planning system, as well as projects that have already been constructed. The "Questions & Answers" document issued by DP&I in December 2011 states "it is intended that the guidelines will apply" to "existing SSD and transitional applications". Such a proposal has already created significant uncertainty amongst investors and should be rejected completely. The Draft Guidelines should only be applicable to future projects after this current consultation process has been concluded. All other wind energy projects that have already been constructed or commenced their journey through the planning system should be assessed against existing rules rather than the Draft Guidelines.

Further steps

Vestas staff would be pleased to meet with DP&I staff to discuss this letter and answer any other questions you may have. Please contact the writer on (03) 86987300 to do so.

Yours sincerely,

[signed]

Ken McAlpine
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On the Next page, find:

Vestas Letter of Protest to Danish Government regarding Request to Lessen IWT Noise Emissions

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[Stamp:RECEIVED
BY THE DEPARTMENT
30 JUNE 2011]

Date
Randers, 29 June 2011/erkjs

Dear Karen Ellemann,

Following previous correspondence, I am writing this letter to express my concern regarding the limits for low frequency noise from wind turbines now being proposed.

Back in January 2011 we applauded your announcement of the new regulations regarding low frequency noise and the fact that you also then emphasised that those regulations would not be tightened and that it was a question of improving the security in connection with the installation of wind turbines. Accordingly, the reaction from the industry branch back in January 2011 was positive, although as an industry we were uneasy about having heavier demands imposed on us than other industries.

When the new regulations were then published on 26.05.2011, we were of course convinced of your initial point of view. As a result, we were extremely surprised to find that the proposed new regulations do in fact include a significant and severe tightening of the previous noise regulations.

In fact, according to our analyses, the most economical turbines, the 3 MW category, are the ones that will be strongly affected by the new rules. This applies to open terrain in particular, where in future low frequency noise will dictate and increase the distance requirements to neighbours for close to half of the projects that we are already aware of over the next 2 to 3 years.

In a small country such as Denmark this means that a significant number of projects will not be viable as the increased distance requirements cannot be met whilst maintaining a satisfactory business outcome for the investor.

The Danish market for wind turbines is of minor importance for Vestas in terms of sales, typically less than 1% of our sales per year. However, the Danish market provides a number of other functions for Vestas which are of considerable value from a business point of view. By means of its high wind penetration, 24% in 2010 - still a world record - Denmark has a role as a forerunner country and a full scale laboratory for conversion to renewable energy.

This means that other countries often look to Denmark when adjusting their legislation regarding wind energy. We are therefore concerned - justifiably so as history shows - that the proposed Danish regulations for low frequency noise from wind turbines will spread to a large number of other markets with much higher commercial impact for Vestas and consequently for employment in the business.

The Danish wind turbine industry employs approx. 25,000 people in Denmark and boasts an export which is about 8.5% of total Danish exports. Such "over-proportional" presence has become possible because Denmark

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Part - 10 Carbon Management

We Agree on Some Things

Climate Change has been proposed as a potential "existential threat" for over a hundred years. With our expanding human population, Man has increasingly sought and extracted sequestered carbon fuels that were then oxidized to gather the energy held between the atoms of hydrocarbons for the purpose of creating energy and heat. As a specie, over our "brief" moment of time on Earth, we have rapidly transformed at least half of our world's landscape into food production and places where we work and live - all facilitated by the creation of carbon dioxide and other heating-retaining molecules. We have grossly overwhelmed the planet's capability to handle our world ecosystems perturbations and now are facing weather extremes that will overwhelm our

ability to cope. Having actively left long ago our willingness to remain "integral" to our natural world, we now created a "planet in crisis". At 7.7+ billion current members of this species, with a projection of reaching 10.5 billion before the year 2100, ALL possible modes of reestablishing more natural and sustainable resource-use patterns over a relatively "short-term" time frame will be essential to minimize further natural systems losses and our viability as a specie.

Planet of the Humans

This concept recently was highlighted in the Movie "Planet of the Humans". Not available on Redbox, it can be viewed on YouTube: https://www.youtube.com/watch?v=Zk11vI-7czE . There was a greater focus on Biomass as an energy producing option than the financial folly of IWTs. Unfortunately, the movie did not highlight the real concerns of adverse health effects. They viewed recent Renewable Energy focuses as a "profit-driven" venture from the merger of environmentalists and capitalism. The Renewable Energy Tax Credit only incentivizes Wind Energy and their perpetuation of continuing to promote harmful wind farm installations. The movie commented at the end that "it is not CO2 that is destroying the planet, it is us."

Hard Realities that are Catching Up and Now Need Action

We need not only better (safer and more efficient) forms of electrical energy production but also to recognize the central tenets of permaculture design as we transform/adapt our current way of living to more planet-healthy partnering. Single focus, high-expense, non-integrated, inherently unhealthy energy-producing infrastructure is NOT what we ultimately need, nor where we should squander our finite (and borrowed) financial resources. In 2018, two Harvard researchers found that meeting current U.S. electricity needs with wind would require "covering" a land area twice the size of California with IWTs. International efforts to bring answers needs to be first approached with (national to local) appraisals of potential impacts of introduced "solutions". People's health (in all its forms) and a safe integration of energy production, food production must be defined, promoted and observed. Actively cultivating and providing healthy human interactions that fosters inner peace, satisfaction in our relationships with others, and inspiration - coupled with empowerment - to embrace joy in our world should be our steadfast goal. Lofty thoughts indeed, but it is worthwhile to examine our current course and truly ask where we should be heading.

The forced intrusion of closely sited IWTs into human habitation is immoral and deeply divides our communities. Conquering our "carbon problem" will require multi-level responses and re-examination of current energy usages. Responding to slow/halt/reverse this process will require global commitment enforced with incentives - at international to individual levels. Indeed, future energy security will be dependent on simultaneously reduced as well as more efficient and careful energy expenditure. Perhaps more important will be active implementation of enhanced carbon capturing - particularly in farming practices across the world. Truly, to flourish, let alone survive as a specie and as an integrated planet, will take a sobering embracement of "how nature works" implementing realistic rules of natural energy chains and bonding the human psyche back to its ancestral relationship of being wholly dependent on maintaining "vigorous planetary health". The future will be won by understanding, then accepting a sequence of daily opportunities to "live within our means". Much smaller-sized IWTs (avoiding infrasound production and carefully sited to avoid health concerns) may have a future in a growing mosaic of blended energy sources. At healthy and environmental-safe sizing and spacing, they could be a part of localized groupings of distributed energy sources, like solar, wind, in-stream hydro together with better future energy storage or backup generation and load management tools. Akin to local food production serving local food needs, the system could operate as a stand-alone entity or its users can plug into the large grid as needed - hopefully on existing power transmission systems - and collectively supply that grid with bi-directional metering. If able to be built and operated economically, and be sited and retain mandated healthy and safe operational status, such microgrids could be ideally positioned in rural areas along with preservation of food production, near larger cities. Additional, but safely buried energy transmission lines could be added only when necessary; it needs to be presented as and TRULY BE a "win: win" situation.

Renewable Options Without IWT Risks

1) Initiate and incentivize farms to work to restore the ORIGINAL richness of our depleted soils through more complex crop rotations, no-till/less soil disruptive planting, use of multi-specie mixtures of cover cropping AND progressive tapering use of chemical control that perturb and threaten entire ecosystem viabilities. (See below)
2) Energy production with PV arrays and roof-top solar water heating. Surge ahead with battery energy-storage development at "acceptable" environmental cost. "True 100% renewable energy" will be ONLY possible with affordable, reliable, and massive-scale battery storage of energy. As long as we depend on "carbon-producing" back-up energy generation (natural gas, coal, petroleum) to supplement "when the wind doesn't blow and the sun doesn't shine", we are not 100% renewable –despite what the commercials on TV state.
3) Micro-grids with shared co-generation back-up and be willing to support research and development of nuclear options that are reportedly becoming safer.
4) Implement/Re-direct wind energy production to natural environments not shared with human places of work and living. Yes, I understand the concept of long-distance electrical energy transmission and concomitant inherent energy loss. OFF-shore IWT placement might be reasonable (though expensive) and current estimates of potential wind energy world production could be 22,000 Terawatts of power- far greater than projected future needs. (a Terawatt is equal to 1000 Gigawatts). I caution that we should clearly recognize the tradeoffs of off-shore IWTs on that ecosystem (whale groundings, adverse impacts on key natural coastal areas - fisheries, turtles, etc. MUST be done). Cost implications are horrendous with even greater costs/kw energy produced. Responsible, independent and transparent decisions of environmental impact must be incorporated into controlling levels of government that HAVE the scientific resources to evaluate environment noises of all frequencies. The world's current implementation of massive on-shore IWTs being placed close to people is and will, in retrospect, be considered irresponsible. It is very remarkable that when PBS and NOVA educational shows and television advertisements are seen, nearly all have IWTs operating in areas where homes, cities, and workplaces are NOT seen. It used to be only a couple years ago that MAE would show IWTs on the Iowa landscape associated with farmsteads... that is changing. Again, Wind Energy is working to portray their IWTs as "benign" even though they are not implemented as such.
5) In 2018, the IPCC estimated that we'd need to plant 1 billion hectares (1 hectare equals 2.47 acres) of forest by 2050 to keep the globe from warming 1.5-degree C. They commented that not only was that "undoubtably achievable" but global tree sequestration is "our most effective climate change solution to date." This is achievable and absolutely vital at many levels. I have planted, with the help of my family, over five thousand native trees and bushes on marginal land near my home over the last 25 years. Such activities foster personal and participating family hope to help the world ahead and beyond generations present. Participation by all Iowans at "county scales"- at least in shared shovels - to reestablish in Iowa natural diversity and vigor - could bring ownership of our personal and trans-generational destiny, and firm-up the shared responsibility of maintaining our global spaceship.

An Extraordinary Opportunity for Iowa

For the last 70 years, the process of "agrochemical farming" has depleted our soils of the organic component that defines soil fertility. Pre-settlement organic content approached 10% which now has declined to 1-2%, reflecting past farming practices and necessitating current dependence on nutrient supplementation and pest control additives. I am not critical of past farming practices, but now with recent recognition of these agronomic consequences and the impacts on global climate health, we must stop and reassess. Regenerative agricultural practices restore "degraded" land - land which we consider to be our best. Farming practices, including no tillage, diverse (and constant) cover crops, onfarm fertility, no or minimal pesticides or synthetic fertilizers and multiple crop rotations, will help to restore on agricultural fields. Upon implementation over 3-5 years of these practices, farmers will start to reverse depleted fertility and reconnect natural nutrient transport systems in the soil horizons and likely provide greater net profit returns due to the reduced costs of fewer inputs. The practice creates more resilient soil structure that allows greater rain retention at a time of increasingly bigger single event rains and will provide greater drought protection - both needed as climate change brings wider weather swings. It will reverse current farming practices from carbon positive to carbon negative through reconnecting soil mycorrhizal fungi to crop roots returning (sequestering) carbon to the soil

and reducing our direct and indirect dependence on carbon fuels currently used to produce crops. There are much better options we have to individually fight climate change than allowing IWTs to dominate our land use. Very rapid, incentivized, widespread adoption of restorative agriculture would give us a few more years to develop other, less harmful energy production. Wind energy will NEVER be able to stand-alone for our electrical needs. That model will always require increasing large-scale utilization of natural gas (currently being dramatically expanded in usage) that significantly negates the value of "renewables".

It may be that only nuclear energy (in a much safer and secure form) along with maximized solar energy production can save our world. All of this MUST be coupled to dramatically reduced (through improved efficiencies) energy consumption and carbon sequestration along with world-wide adoption of carbon crediting. In the end we will have to face the reality of "living within our means".

I agree with the concept and the threat of Climate Change. (That is the major reason I care so much about understanding the place of turbines in our county and our world). I originally liked the concept of "clean energy", but once learning of the realities of the noise that IWTs make and the human harm they cause (directly or indirectly), I have had to reposition the value of IWTs in the solutions we need to power our planet. After careful study and deep hunting for the "disconnects" of Wind Energy's behavior and position on AHEs, it is my opinion that they must say the "half-truths" that they do because to now acknowledge the much more rational stance against wind turbine noise and AHEs would mean the end of their expansion into populated areas and could possibly topple "the empire" they have created so far.

A Revealing Insight of what has happening in Germany as they struggle to "go Green". Please copy then paste to your address bar to read this May 2019 review.

https://www.forbes.com/sites/michaelshellenberger/2019/05/06/the-reason-renewables-cant-powermodern-civilization-is-because-they-were-never-meant-to/amp/?__twitter_impression=true

Appendix:

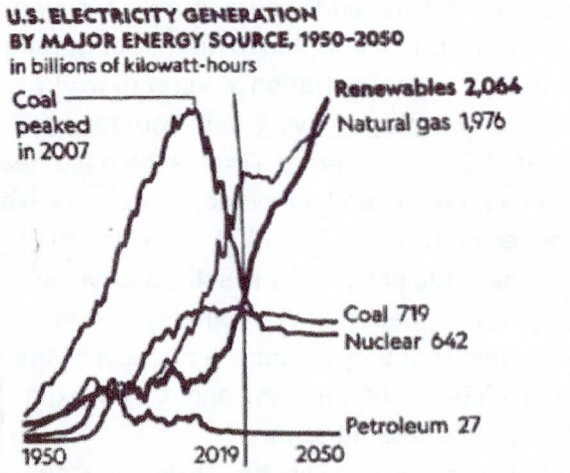
National Geographic Projection of Electrical Generation by 2050. Note Winners and losers of various energy product means. Of note is the steady rise of "renewables" shadowed by expensive back-up generation of power through natural gas carbon-producing sources. Nuclear and coal have plateaued.

Likely net-zero Carbon state has been reached by 2050.

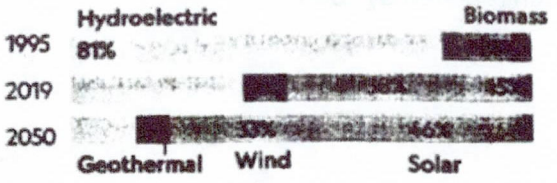
Taken from **National Geographic**, April 2020

Graphs from Earth Day 50th Anniversary Special Issue

An Optimist's Guide to Life on Earth in 2070



Wind energy currently makes up a larger part of renewables than solar, but not for long. Solar is projected to triple its share by 2050 to become the leading renewable.



Part – 11: Applied Regulation of Noise

Relevance of Background Noise:

Rural night-time background noise is conservatively 25-30 dBA in the Arbor Hills area - and certainly WAS that in the Macksburg area. Noise levels from an unwanted source becomes more noticeable and objectional as it becomes louder than background noise. The International Standards Organization, ISO/TC 43, United Nations, 1969, noted that a community's response of a 10 dB rise above background produces "widespread complaints". A 15 dB increase produces "threats of community action".

Additionally, IWT noise is somewhat unique in that it is frequently recognized at levels 10 dB BELOW background levels.

The American National Standard Institute (ANSI) Criteria for Compatibility lists 30 dBA Lmax for night noise and 40 dBA day with a Leq of 34 dBA. This same organization has stated that wind turbine noise is compatible in rural areas when below 30 dBA, marginally compatible between 30 and 35 dBA and incompatible above 35 dBA.

The 2009 W.H.O published guidelines for OUTDOOR noise levels in residential areas based on comprehensive peer review of medical evidence of health effects from noise. They issued average yearly outdoor NIGHT-TIME noise levels:

1) Up to 30 dBA level - no substantial biological effects
2) 32-42 dBA levels - Effects on sleep are noted - body movements, awakening, arousals, Children, shift workers, pregnant women, the chronically ill and elderly are all more susceptible. Effects are considered modest.
3) 42-55 dBA levels - Adverse health effects are observed. Many people have to adapt their lives to cope with the noise at night. Above 40dBA Lmax is incompatible due to sleep impacts with 12% of residents being very annoyed.
In 1974 the US EPA published a methodology that can predict the community reaction to a new noise.
It was developed from 55 communities noise case studies. The baseline noise **levels** include adjustments for the existing ambient, prior noise experience and sound character. Noted at:
32 dBA - No reaction and sporadic complaints
37 dBA - Widespread complaints
45 dBA - Strong appeals to stop noise
54 dBA - Vigorous community action
The published results of the Health Canada study in 2015 reported the percent of people who were very or extremely annoyed (together considered as "highly") to wind turbines as a function of wind turbine noise.
10% in the 35-40 dBA range
13.7% at the 40-46 dBA range
In Germany, the state-mandated IWT sound-limit is 35 dBA Leq. This is equal to levels of 41-46 Lmax outside which means 35-40 dBA levels inside with window partially open or 39-44 dBA fully open.
Resident noise - triggered awakening to full consciousness is seen with the noise levels of 42 dBA or higher. No disturbance at 30 dBA or lower (no wind). Sleep architecture disruption starts at 32 dBA.
Even with those lower levels, the German people are still very unhappy living close to these turbines and complain about the noise.

Lmax vs Leq - Relating to an Open or Closed Window

The L (max) indoors can be related to regulatory requirements outdoors via recent testing in Vermont showing the outside-to-inside noise reduction (OINR is -6 for window partially open). So if you want to prevent impacts such as motility (32dBL(max) indoors) then the intrusive noise outdoors (Lmax) should not exceed 32+6 or 38 dBA Lmax.
Waking up at night Lmax = 42 dBA indoors. Add 6dB for windows partially open, to get a limit of 48 dBA Lmax outdoors.
Wind industry wishes to predict average (Leq), not maximal (Lmax), noise levels. However recent testimony from wind industry consultants (Epsilon, RSG) set the ratio of average Leq to maximum Lmax at +6 to +11 dB.
Regulating sound levels to "thresholds characterization" of biological systems is optimally achieved through Lmax ("shall not exceed") language.

dBA calculations for 108 dBA mean power level (2 MW Vestas 110 IWT)

Feet from Tower	200	500	100	1500	200	2625	3000
Dba (Leq)	61	53	47	45	41	40	38

Calculation Basis:

It is also not widely known that IWT clumping (siting) and other factors can dramatically increase sound levels at the receptor (property line or home).

ISO 9613-2: Results have a +/- 3 dB variability about the calculated mean out to 3300 feet Atmospheric and ground attenuation factors ignored, conservative for low frequency noise.
For two turbines with same distance, add 3 dBA to results
For three turbines with same distance, add 5 dBA to results
For five turbines with same distance, add 7 dBA to results
Sound levels changes at 6 dB per doubling of distance out to 3000 feet
The closest turbine or turbines control the sound level at a location
Decibels should be quoted to the nearest whole number (round up or down)

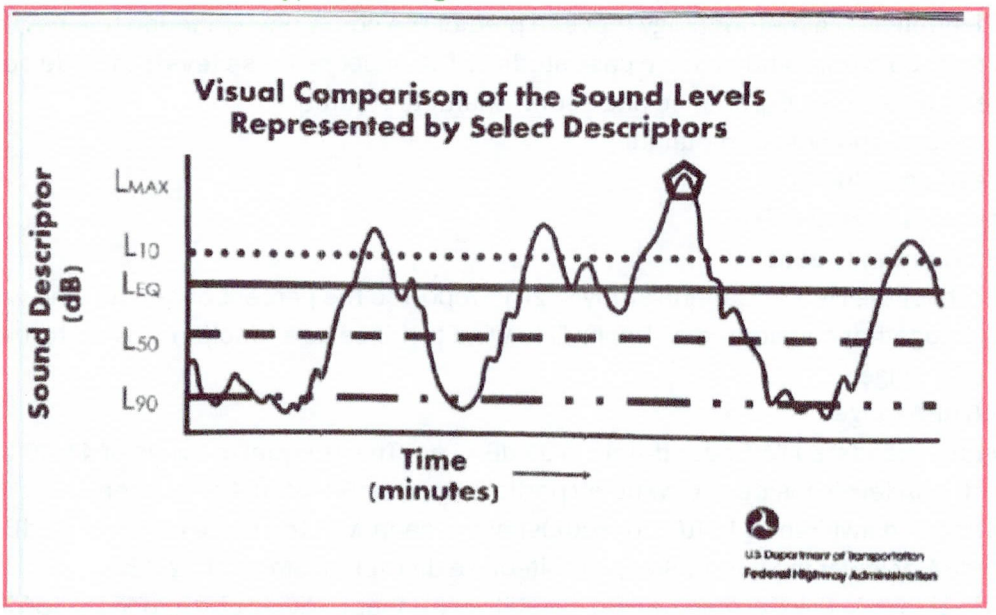
Implication of Leq:

L max is up to 11 dBA higher (between 6-11 dBA) than the Leq calculated. Leq should be considered as an average which Lmax as "shall not exceed". A 40 dBA Leq can produce a 51 dBA Lmax at that location (Epsilon/RSG, Tuscola Wind III Almer Township, 2017 - testimony from wind industry consultants)

Definition of Lmax(fast)

This is the A-weighted, fast time-constant, maximum, sound level – Note maximum is not "peak"

This characterization should be preceded with the "not-to-exceed" phrase as to clarify to project developer. It should not be misconstrued as some type of average.



Outside-to-Inside Noise Reduction:

Confirmed by two independent firms in Vermont, 2014

1) -6d dBA reduction with windows partially open e.g. Windows partially open: 42 dBA Leq +11 (convert to maximal Lmax) and -6 (attenuate for window) = 47 dBA Lmax indoors

2) -1 to -3 dBA reduction with windows fully open e.g. Windows closed: 42 dBA Leq + 6 dBA (convert to conservative Lmax) and - 2 dBA for windows fully open = 48 -2 = 46 dBA Lmax indoors

Windows Open or Closed?

I have not yet heard from any Wind Energy (or Mr. Clifton) as to why a non-participating resident who is suffering annoyance from a IWT placed 1500 feet away from his home in an effort to mitigate the intrusive IWT nighttime noise should have to resort to closing his windows at night in order to lower the audible IWT noise level from a "loud" 45 dBA Leq (56 dBA Lmax) outside to roughly 41 dBA Lmax inside (which represent a 15 dBA reduction (56-15 = 41) which is possible with a well-insulated house but is still remains 9 dBA above the goal of 32 dBA Lmax). We have to consider that people have a right to sleep with their windows wide open and the heads of their beds near the windows. This was a common arrangement before whole house air-conditioning made sleep at night during the warm weather easier.

Very low frequency sound attenuates very little from outside to inside even with "windows partially open". Depending on natural resonance in the home's rooms the drop is dBs can be 0 to 7 for frequencies of 20-100 Hz. For frequencies below 20 Hz that range become smaller, and when the room resonant frequency is similar to the frequency of the outside sounds it can create a higher sound level inside than outside.

The above is one issue that is very influenced by each family's lifestyle and the type and age of their home. To further complicate things, modern homes are built and use HVAC systems that result in very low sound levels inside the homes when people are sleeping. Levels of 18 dBA or lower are common.

That means with the introduction of the newest generation of "quieter" air conditioning systems that the IWT-produced low frequency rumble is no longer "masked" as had been experienced by previous generations of "louder" air conditioning systems at night when people are at rest. Sometimes now, people suffering annoyance during attempted sleep due to significant interior home IWTs noise levels, often have had to purchase "noisy" box fans and run them at night to provide adequate masking noise.

Others have bought Bluetooth speakers and use their smartphones to play white noise or other masking sounds. The point being that modern homes can be too quiet (well sound insulated) if one lives in a noisy neighborhood. And, for a rural population not accustomed to nighttime noise, the new intrusions will be very unwelcome and a source of disturbance. That is why ANSI S12.9, Part 4, Appendix F includes a statement that installing a new noise source in a previously quiet community requires a penalty of 10dBA on that rural noise source to equal the annoyance for a similar noise in a suburban community.

Any way you look at it, IWT will likely disturb your sleep when sited too close to your home. Sleep disturbance is a serious adverse health effect. The only solution is substantial distance separation (2-3 km, 1.25 -2 miles) or (as has been court-ordered after wind farm construction) complete inactivation of IWTs during the night (10 PM to 7AM). At distances of <1.25 miles in flat ground without "grouping" or "in-line" turbine placement, you will have complaints. **Complaints mean that the county has failed to protect their residents.**

2007 WHO Nighttime Noise Guidelines

The 2007 World Health Organization revised its guidelines for nighttime noise. Those guidelines provide the definition of what is required for a causal link to be established between an exterior forcing agent like noise and health. They state:

"Sufficient Evidence": A causal relation has been established between exposure to night noise and a health effect. In studies where coincidence, bias and distortion could be excluded, the relation could be observed. The biological plausibility of the noise leading to the health effect is also well established.

"Limited Evidence": A relation between the noise and the health effect has not been observed directly, but there is available evidence of good quality supporting the causal association. Indirect evidence is often abundant, linking noise exposure to an intermediate effect of physiological changes which lead to the adverse health effects.

In Table 3 of the 2007 Guidelines, the WHO presents the maximum sound levels that should be permitted **outside the walls** of a home to prevent health effects. The new criteria are based on recent research into nighttime noise and health that was not available in the 1999 guidelines. The outdoor criteria (**L**night-outside) represent long-term conditions, not a single night's exposure. I will type Table 3 as it originally appeared:

Table 3. Summary of the relationship between night noise and health effects in the population

Lnight-outside: up to 30 dB Although individual sensitivities and circumstances differ, appears that up to this level no substantial biological effects are observed

Lnight-outside: 30 to 40 dB A number of effects are observed to increase: body movements, awakening, self-reported sleep disturbance, arousals. With the intensity of the effect depending on the nature of the source and on the number of events, even in the worst cases the effects seem modest. It cannot be ruled out that vulnerable groups (for example children, the chronically ill and the elderly) are affected to some degree

Lnight-outside: 40-55 dB There is a sharp increase in adverse health effects and many of the exposed population are now affected and have to adapt their lives to cope with the noise.

Vulnerable groups are now severely affected **L**night-outside: Above 55 dB The situation is considered increasingly dangerous for public health. Adverse health effects occur frequently, a high percentage of the population is highly annoyed and there is some limited evidence that the cardiovascular system is coming under stress

The 2007 version was the preliminary document from the working group and is expressed as WHO researchers intended. When released there was a lot of political pressure put on the WHO to adhere to EU Directive policies. The 2009 version was released to parallel to the EU requirements for annualized limits and other changes that were not appropriate for health effects due to short duration, low level events.

Loudness –Variations Over the Sound Spectrum

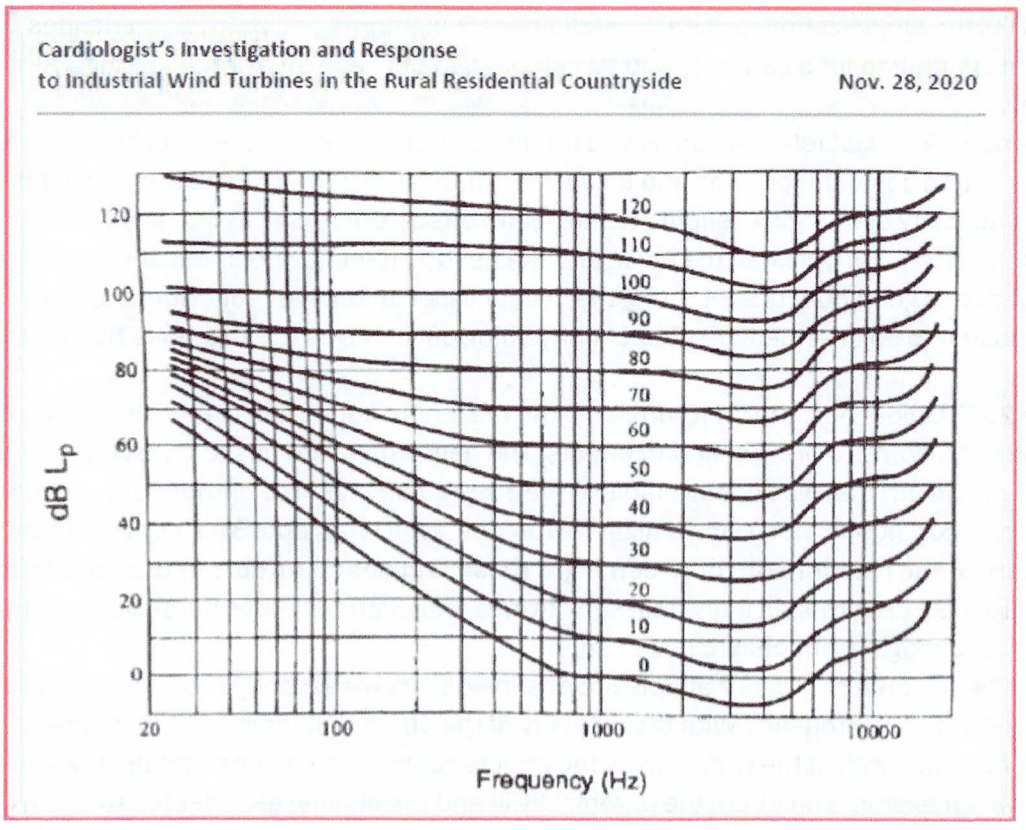
Equating decibel differences (more or less than reference) to a change in loudness varies over the range of the sound spectrum. The "Phon" loudness chart below (40 phon = 40 dB Lp at 1000 Hz) shows how low frequency noise "loudness" at smaller decibel changes.

This shows that lesser changes in sound intensity (dBs) can increase "perceived" loudness at lower frequencies. At 1000 Hz, going from 40 to 50 dB (up by 10 dB) increases the "loudness" by a factor of 2, i.e. twice as loud. While at the lower frequency of 100 Hz, increasing the sound intensity from 41 to 46 (up by 5dB)

also increases the loudness by a factor of 2, i.e. twice as loud. Significant importance of this "steeper" loudness change with lesser dB change within the low frequency noise range is potentially considerable. This noise property may create more annoyance/noise recognition from this already problematic zone in terms of creating sleep disturbance.

Having said that, loudness considerations may be best used in only simple situations. Complex sounds that have tones, fluctuations in the frequencies, where energy is concentrated and other aspects of psycho-acoustics like "sharpness" all make it much more complicated.

The underlying sound physics in judging "loudness" are, as noted, complex. Yet despite that acknowledgement, larger IWTs with greater energy producing capacity are expected to increase both audible and ILFN emissions. Such heightened noise production in the ILFN range may be recognized with disproportionately greater loudness with potentially a greater percentage of residents become capable of "hearing" those lower-frequency emissions.



Part - 12 Ordinance Examples and Regulation

(This is huge topic; I have included SOME of the more important concepts)

Setbacks - Considerations and Recommendations Designed to Minimize Adverse Health Effects

Setbacks should be measured from a non-participant's property line. Wind Energy's template ordinance suggests (essentially assumes) that the receptor locale will be the house. By defining that "house" as the measuring locale, it becomes the closest structure (of importance) to the closest platted IWT. A setback measured from a dwelling limit the non-participating landowner's use of their property, and greatly reduces protections for non-participants from noise pollution and its proven ill effects, shadow flicker, property devaluation and potential property damage from blade failure or fire.

All landowners should have the right to do with their land what they choose as long as it doesn't harm or impede a neighboring land owner. A setback for safety reasons, regardless of its distance, must be maintained. Any ordinance that allows a wind turbine to be built closely next to a non-participant's property line eliminates that property owner from safely using that land. It creates a virtual access easement over the neighboring, non-participating property that eliminates the owner from any further developments. This amount to an uncompensated taking of private property rights.

In Robert Bryce's book "A Question of Power", on page 198, he mentioned in Henry County, Indiana, where seven communities passed resolutions establishing a four-mile buffer zone around their towns.

He also related the thoughts of Kevon Martis who has consulted with dozens of rural governments in the Midwest to help them craft and implement land-use regulations that will protect them from the encroachment of Big Wind. Martis believes the fundamental problems is that, by installing huge turbines, the wind industry if getting "uncompensated nuisance and safety easements" on the unleased property that sits nearby. The result is what he calls "trespass zoning". By establishing setback and noise limits from homes rather than property lines, Martis says that the wind industry is getting a de facto subsidy from neighbors without compensating them. That he argues, "is fundamentally unjust and flies in the face of sound zoning principles". Martis asserts that the only way for the wind industry to continue expanding is for it to acknowledge the costs it is imposing on nearby landowners and to buy easements from them. Of particular clarity, acousticians remark that enforcement of pollution (including sound pollution) begins at the property line.

Siting turbines should include consideration of:

IWT audible noise levels and all potentially harmful IWT emissions (including ILFN) that could impact adjacent, non-participating properties

Safety zone requirements made by the manufacturer

Wake turbulence

Consideration of proximity of other turbines (even not in the same county or owned/operated by same power company requesting permitting) – will increase lower frequency noise levels through amplitude modulation. In general, regulation by NOISE/IWT emissions should be through measured values.

Wind Energy templates often do not specifically measure those noise levels but will state only a distance (e.g. 1500 feet). If accepted, it is not uncommon that IWT clumping or arrangements in a linear row, "can be done" that may markedly increase noise levels at the receptor while remaining in compliance for distance.

Future growth of towns and cities and likely concomitant new hospitals and schools. County Board of Zoning and local communities should coordinate together to anticipate possible 58 years of community potential growth being unthreatened by future unhealthy Wind Energy noise emissions.

Setback Proposals

Because of widespread concerns about health and safety, many jurisdictions scattered around the United States and Canada have adopted larger setbacks.

Noise level regulation typically includes dBA sound rating with more comprehensive noise protection includes some measure noise level that more accurately quantitates the ILFN emissions. The Punch and James review listed several distance setbacks that varies but the average distance was 1.25 miles or 2 km. This distance was chosen to protect against harmful low frequency emissions. That distance was most often derived from evaluations of setbacks that did not produce noise or symptoms complaints attributed to noise emissions. Increasingly – particularly with recent Wind Contractor's practice of re-tooling IWT with larger blades/nacelle generators – that can substantially increase ILFN noise emissions that lead to increased complaints. It might be advisable to limit re-tooling options and limit increases in turbine heights. The impact of multiple adjacent IWT re-tooling to, e.g. 0.5 MW or greater, could markedly increase receptor noise levels changing a marginally tolerable environment to one which requires night-time evacuation to achieve restorative sleep.

Permitted sound levels across most Australian States for all industrial equipment are background noise levels plus 5dBA or 35dBA whichever is less, whereas for wind turbines they are background plus 5dBA or 40dBA whichever is more. There is no scientific evidence or reason for this difference. An increase of 5 dBA represents an approximate doubling of the sound level. Most rural environments have a background noise level of 18dBA to 25 dBA, approximately averaging 22 dBA at night. This represents a huge increase in audible sound. Increases of 10dBA at night are long known by acoustic consultants to raise complaints, and increases of 15-20 dB are associated with widespread complaints and legal action. Averaging measured levels of sound across too-wide of frequency bands also allows the hiding of sound pressure peaks to which the ear responds, understating the true extent of facility noise emission levels.

The WHO (World Health Organization) Night Noise Guidelines for Europe quote the 1999 Community Noise Guidelines: **"If negative effects on sleep are to be avoided, the equivalent sound pressure level should not**

exceed 30dbA indoors for continuous noise" Cities have a higher background noise than country areas.
Denmark limits indoor noise from industrial sources, including wind turbines, to a maximum of 20 dBA at night.
The currently permitted outdoor noise level in New Zealand and some Australian states has been ameliorated somewhat by the addition of a deduction of 5dBA from the 40 dBA limit to allow for especially quiet environments.
History has shown that these Australian guidelines were based on ETSU97 from the UK, and were expressly designed to encourage development of the wind industry, not to protect the health of rural residents from wind turbine noise. Predictably, because the Kelley criteria limiting exposure to impulsive ILFN were ignored, these guidelines have turned out to be completely unsafe. (noted Hanning, et. al. review of ETSU-R-97 guidelines and significant deficiencies to protect health).
It is therefore necessary to predict and measure sound pressure levels across the full spectrum of frequencies in order to predict and control sound energy impacts on project neighbors.
The L (max) indoors, can be related to regulatory requirements outdoors, via recent testing done in Vermont showing the outside-to-inside noise reduction (OINR is -6 for window partially open). If you want to prevent impacts such as motility - (a marker for sleep arousal associated with potential sleep disturbance) (32dBL(max) indoors) then the intrusive noise outdoors (Lmax) should not exceed 32+6 or 38 dBA Lmax.
Waking up at night Lmax = 42 dBA indoors. Add 6dB, to get a limit of 48 dBA Lmax outdoors. Both motility and awakenings reflect disturbed sleep - **BOTH EFFECTS SHOULD BE AVOIDED through ordinance language to reduce in-bedroom levels.**
Wind industry predicts average, not Lmax, noise levels. However recent testimony from wind industry consultants (Epsilon, RSG) set the range of average Leq to maximum Lmax at +6 to +11 dB
So, to determine conservatively the **average** wind industry predicted-level limit, subtract 11dB from 48 and get 37 dB Leq. Anything above that is associated to "waking up in the night" with the windows partially open.

Additional Published Sound Limits:
Health Canada determined highly annoyed residents ramped up quickly above 35 dBA outdoors ANSI (American National Standards Institute) standards for Compatibility with Land use determine in rural residential land use, unfamiliar intrusive noise is incompatible at night above 35 dBA, marginally compatible between 30 and 35 dBA and compatible below 30 dBA.
Hayes-McKenzie Partnership recommendations made in 2006 limited maximum wind turbine sound levels at residences to 38 dBA and no more than 33dBA if "beating noises" are audible.
Michael Nissenbaum. M.D. issued his findings in 2010 from his medical study at Mars Hill, recommending a 7000-foot setback for public health.
Stephen Ambrose and Robert Rand, professional acoustical consultants with decades of experiences with IWT sound emissions, advise the noise level not exceed 32 dBA at the property line of any abutting wind turbine facility to ensure minimal LFN and infrasound content; the 32 dBA measurement would also be a proxy for LFN and infrasound. Wind turbine facility designers and their acoustical consultants would need to have a design target of 30 dBA to ensure 32dBA is realized. Further, if utility-scale (1.5MW to 3 MW) wind turbines are sited at least 1 mile from the property line of any abutting property, it is likely any audible noise will be attenuated below 32 dBA. To avoid devaluating any abutter's property, etc., the abutter property line is used.
Rick James and George Kamperman, professional acoustical consultants, have extensively studied wind turbine noise. They recommend a noise LIMIT at the property line for: 1) audible noise: 35 dBA or no more than 5 dBA above the pre-construction ambient dBA level, whichever is **lower**. 2) LFN 50 dBC or no more than 20 dBC above the pre-construction ambient dBC level, whichever is lower. We need to start quantifying infrasound and LFN permissible levels which will require that Wind Turbine producers need to provide emissions data to reflect "worst possible scenario".
Rural Oregon has set minimum setback at 2 miles.
Victoria and New South Wales, NZ have set the minimum setback at 2 km (1.25 miles) - this despite Vestas getting the approval to "eliminate consideration of infrasound".
In a settlement reached in a wind turbine dispute in Fayette County, Pennsylvania, the setback was set at 6000 feet (1.1 miles)

An investigation into wind farms and noise by the UK Noise association finds an appropriate setback to be 1 to 1.5 miles. (7,900 feet)
Recommendations on the siting of wind farms in the Vicinity of Eskdalemuir, Scotland (2005) found an appropriate setback to be 10 km (6.2 miles or 32,730 feet)
Professor Moller, an internationally known acoustical scientist commented that "at low frequencies, the perceived intensity, the loudness, increases more steeply above threshold than at higher frequencies.
A few people would probably accept 25 dBA **in their home at night**, but hardly anyone would accept 30 dBA".

Part - 13 Recommendations
Recommendations:
Sound levels Limits should be described as (Lmax) and not (Leq). This sound level characterization is more important when considering sleep/school sound environments. It is also a more consistent sound target thus being more than enforceable than Leq. Observed IWT siting patterns by MAE suggest a preference for clustering thus making accurate predictions of target sound level more difficult.
Consideration for IWT siting reflecting the possibility +11 dBA audible sound level amplification likelihood during strong, unsteady winds should be observed. Worst case scenarios should be incorporated into setback calculations NOT just from the manufacturer's listed power sound level (e.g. for V-110 2 MW is 108 dBA) but from that value and perhaps an added 10 dBA to avoid any transient sound levels of >3-5 dBA in "worst case scenarios".
Stated noise limits as "shall-not-exceed"-__dBA Lmax (fast) (fill in the upper range of noise as measured in dBA that you wish. 35,40,45 dBA – the lower, the quieter the noise becomes – particularly at night which is the most important time as that is when the turbines produce the most energy and the wind are more consistently higher aloft. In addition, using a C-weighted Lmax dBC level to regulate ILFN is also advisable with the increasingly common desire to increase energy production density within a wind farm. Values of 50,55,60 have been used. I would point the reader to George Hessler's 2004 article (Noise Control Engineering Journal, 52 (4), 2004 Jul-Aug). The initial summary begins with the recognition that excessive low-frequency noise from (industrial sources) as a serious noise and vibration problem since the early 1970. At the time of this article there was no standardized noise criteria in the U.S. to consult for guide. His paper proposed a C-weighted level criterion. In table 1 – labelled as maximal allowable C-weighted sound level (dBC Lmax) at residential areas to minimize infrasound noise and vibration problems. For very quiet suburban or rural residential areas, with extensive or 24/7 source operation, levels of 60dBC were suggested.
Siting should be connected to a single proposed IWT power design. Re-tooling at a later date with a more powerful IWT **WILL produce** a different spectrum of sound emissions. With larger MW turbines, a much greater percentage of produced sound frequencies will be in the infrasound and low-frequency ranges and sound levels will be higher at every frequency in the ILFN sound spectrum. The frequency ranges can be more harmful in sensitized individuals producing greater sleep disturbance. Indeed, sound profiles may shift such that audible sound produced in the low-frequency spectrum may become louder than those present in the more usual audible frequencies (>200 HZ) - this may be true EVEN if dB**A** limits are in compliance. Using A-weighted filters to measure IWTs with <1.5-2.0 MW power levels is marginally useful. Above 2 MW, assessing sound levels (loudness) with dBA measures will likely miss a majority of harmful frequencies and grossly underestimate their impact on health. The not-infrequent complaints of thumping are more noticeable with more powerful IWT designs. Medical researchers are starting to focus on the startle response to acoustic and vibration input. Wind turbines produce, BY DESIGN, acoustic pressure pulsations (barometric pressure changes) at blade pass rates.
The pulsations are impulsive, not sinusoidal. Larger turbines with their longer blades can create greater vertical disparities of loading along the blade... these are described in terms of blade loading,deformation, eigenfrequencies (resonance) and dynamic stall. Indeed, what you can't hear or choose not to measure in sound pressure levels, **can** hurt you.
The transmission attenuation of longer wavelength infrasound emissions is roughly only half that of longer wavelength audible sound. This leads to IWT sound perception at far greater distances by susceptible individuals. For IWT with power levels >2 MW, the manufacturer's data reflecting sound pressure levels through

the entire infrasound and low frequency noise range MUST be made available prior to permitting. The ANSI (American National Standards Institute - a private, non-profit organization that oversees the development of voluntary consensus standards, limits noise levels in the 16 Hz band (in infrasonic zone) to 65 dB. This NEEDS to be clearly stated in the Wind Ordinance.

There are other published sound measures that are useful to assess sound pressures in the infrasound bands and are even more restrictive. It is likely that Wind Contractors will be willing to adhere to this, as single-band noise intensity measurement equipment is not commonly available.

It should be written in the ordinance that any facility requiring a special permit "shall comply" with all relevant ANSI standards and "shall be compatible" with the existing land use.

The ordinance could require a prohibition for any facility (source agnostic) on recurring acoustic pressure pulsations with peak levels exceeding 60dB re 20uPA below 1 Hz at any point on residential property lines. Ref: ISO 9996 prohibiting "perceived or actual" oscillations in the range of 0.1 to 1 Hz (pertains particularly to avoiding dangerous health consequences of low frequency emissions - particularly a threat with larger MW IWTs)

The 2018 European Commission (EC) in 2002 defined Lden (day-evening-night) as consisting of three parts - the day, the evening and the night average sound levels **outdoors (not inside homes).**

Reviewing all 12 cited recommendations in the Punch and James article with the noise outputs of Mid-American Energy's planned use of 2 MW Vestas Model 110 IWTs the enormity "disconnect" of the Clifton/Price draft of 1500 foot setback becomes readily apparent. In terms of distance, the closest "minimum distance" recommendation was 0.87 miles (1.4 km) among the first six references. The seventh reference (Cummings, 2011) listed a distance of 0.5 miles or greater with noise levels within 5- 10 dB of existing background. Rural noise levels are described at L(90) of 25-30 dBA in multiple references. To keep a projected IWT sound level <40 dBA Lmax (not to exceed 40 dBA) using published data of Leq (average) sound levels, you need to subtract 6-11 dBA from Leq (average) to arrive at the Lmax level (conversion obtained from sworn testimony given by Wind Energy). This conversion reflects that constant oscillatory nature of the IWT-emitted sound that is expressed as a mean value. A Leq value of 40 dBA varies maximally by 11 dBA from the mean (ranging from 29 to 51 dBA) to minimally by 6 dBA (ranging from 34 to 46 dBA). Using the 108dBA mean power level - that is specific to the 2 MW Vestas 110 IWT - mean sound levels as a function of the setback distance can be calculated:

dBA calculations for 108 dBA mean power level (2 MW Vestas 110 IWT)

Feet from tower	200	500	1000	1500	2000	2625	3000	4000	6000
dBA (Leq):	61	53	47	45	41	40	38	34*	31*

* (conservatively estimated at 4000 and 6000 feet)

In general, sound attenuated (lessening, due to travel through air) is -6 dBA for a doubling of distance. This attenuation is reasonably reliable in steady winds up to 3000 feet but becomes less predictable - likely less - beyond 3000 feet. If you assume a dBA variation of 8 dBA inherent with the listed Leq ratings (approximately midway in the 6-11 range), you would need a Leq of 30 to achieve peak Lmax values of 38 dBA. Conservatively acknowledging the problem of calculating audible sound levels at distances greater than 3000 feet, to achieve a sound level of 40 dBA requested by the Cummings article cited by Punch and James, you would need to be at least one mile from the residence. Cummings even suggested 30-35 dBA as levels of 40 dBA or higher trigger large numbers of noise complaints. Finishing the last 5 references that specified sound levels (Lmax), all were <40 dBA with levels of 30,32 and 35 dBA also being listed.

Summarizing, the Clifton/Price setback distance (Wind Energy template) of 1500 feet is nearly 2100 feet closer than the next closest suggested, published setback in the Punch/James article. Noting: 1) various turbines manufacturers have different mean power levels and they may vary as technology changes in the future and 2) separation of noise source to impacted humans is THE primary consideration of separating IWTs with their inherent adverse health effects which increase with shorter distances, **I would Strongly recommend that IWT and residence/non-participating property lines separation be determined by calculated sound levels measured as Lmax.**

Lmax (or expressed as "shall not exceed") is much more definitive as a quantified exposure and understandable and correlatable in reflecting health-related noise exposure. In addition, it is much easier to monitor for industry noise emissions compliance. It is sobering to think that a 50 dBA Leq (average) maximal

noise limit (proposed by Clifton/Price) makes it allowable to have perceptible and measurable sound levels of up to 61 dBA. The very restrictive Dallas County, Iowa limit of 30 dBA Lmax vs the Clifton/Price proposed level of 50dBA Leq with an industry-acknowledge implied peak level as high as 61 dBA Lmax represents 1000 times increase in sound intensity which correlates with 8 times increase in sound loudness. Hard to imagine trying to "force your mind" to sleep with noise levels that high.... Is it reasonable to force residents to actively seek measures (ear plugs or basements/highly sound-insulated structures or sleeping medications or be forced to flee their home) in order to achieve a reasonable night's sleep on their own property that was purchased before a Wind Energy developer sought to achieve substantial monetary gain by placing a 500 foot high IWT only 1500 feet from their home?

Important Included Components of Wind Ordinance (Textbook's and other sources Recommendation)

From the textbook "Wind Farm Noise", (2017), Section #1.6 reported on "regulations". The section is divided in several areas. Some are included here and I have added others.

1) Minimum Setback distance to Residences

The setback distance is the distance from the nearest turbine in a wind farm to a residence, provided that the resident is not a turbine host. They did not specify a suggested setback for a 2 MW IWT although did mention Shepherd, et al, recommendation of 2 km in hilly terrain. This is in keeping with the recommendation of 1.5 miles to the property line as set by the Madison County Board of Health.

That value reflects the average setback as described in the Punch and James comprehensive article that thoroughly reviews this information. For larger IWTs of 3MW, the Wind Farm Noise authors suggested a distance that is "much larger" to provide acceptable levels at night when people are trying to sleep.

2) Maximum Allowed Calculated External Noise level

This is the where one's convictions to protect resident's health is challenged the most. The MAE pattern of IWT citing in Adair County is based off the 1500-foot setback. That will guarantee very serious resident protests, a high level of annoyance, wide spread, multi-level adverse health effects and home evacuations. It is a failed siting arrangement and litigation will certainly emerge. It is unfortunate that MAE can offer only huge industrial - sized turbines. That option was not commented on by Mr. Clifton. **Forcing "close-siting" at <1.25 miles with night-time sound levels of >40 dBA Lmax is NOT SAFELY POSSIBLE!!! I have spent a great deal of my time over the last 2 years to be absolutely comfortable with that assertion. At that suggested distance and nighttime sound level, there is already a compromise.**

Maximum allowed calculated external noise levels approximately 100 feet (30 meters) from the exterior of a residential structure. The ISO (International Standard) 1996 recommended these as "allowable community LAeq dBA noise LIMITS" (These are NOT Background noise levels).

District Type	Day (7AM-7PM)	Evening (7PM-11PM)	Night (11PM-7AM)
Rural	35	30	25
Suburban	40	35	30
Urban Residential	45	40	35
Urban mixed	50	45	40

However, they comment: As wind turbines are mostly in rural areas, a level of 25 dBA is very difficult to achieve, which is why the most stringent regulations currently in force recommend a limit of 35 dBA in sensitive noise areas. Textbook author's direct quote: "However, this limit is too high for many residents so 30 dBA Lmax may be a reasonable compromise for the maximum allowed noise at the exterior of rural residencies". They listed several recommendations from the 2008 Kamperman and James publication. To determine background noise, precise standard conditions were specified:

LA90 is determined using several 10-minute measurements during the quiet night hours between 10 PM and 4 AM when the wind is blowing slightly (<2 m/s at 1.5 m above the ground) from the wind farm to the residence and the wind farm is NOT operating. Daytime levels can be 5 dBA higher.

3. Adjustment for Uncertainties Any noise level calculated using a generally accepted propagation model with down-wind conditions (not turbine design) included, should have 4 dBA added to the calculated level to account for uncertainties in turbine sound powers and uncertainties in the propagation model parameters. Examples of under-prediction of wind farm noise levels are presented.

Despite "uncertainty adjustments", regulation that clearly state a Lmax value (at any time day or night), subsequent post-construction measures of emitted IWT turbines that exceed that discrete Lmax level are not in compliance and should be shut-down or substantially limited via NRO Programming from the SCADA unit while verification of non-compliance is obtained using independent, non-biased, certified acousticians who have access to the SCADA data at the time of the complaint. It has been recognized by extremely experienced, IWT-specialist acousticians that "routine" monitoring of turbines operating at least at "half-power", measures to excess noise production above limit averages 8dBA and can be as high as 12 dBA. Insisting absolute compliance or face marked power reduction reprogramming or turbine removal if compliance cannot be obtained, has and should be a part of a protective ordinance.

4. Maximum Allowed Calculated low-frequency noise level

Maximum allowed calculated low frequency noise level in the range 10-160 Hz should be less than 25 dBA at the exterior of non-participating homes with a 4 dBA allowance for calculation uncertainty, so the calculated level is actually less than 21 dBA. There are also DEFRA guidelines for the 1/3-octave band unweighted noise (Leq) that were exhaustively developed to avoid annoyance. This is a very important aspect of health protection - particularly as IWTs are rapidly increasing in size and power capacity - both directly related to increasing amounts of ILFN production. Limiting total turbine height to <500 feet should prevent introduction of harmful excessive ILFN. Please note above, the use of dBC Lmax language.

5. Accounting for Multiple Wind Farms

There should be the requirement that takes into account the development of more than one wind farm in the same general area. the existing ambient sound level should be the one that existed prior to construction of the first wind farm.

6. Determination of a Compliance Testing Method.

Detail of such testing are complex and could be referred to. Cost to be borne by wind developer.

7. No Change to Turbine Model.

The wind farm developer should not be permitted to change the turbine model after development approval has been given without undertaking another noise prediction study with the new turbines. If the resulting sound levels at any residence are higher than originally calculated, an amendment to the development approval should be sought. Again, a maximal height limit of 500 feet should be enforced and will be necessary to prevent introduction of more dangerous and larger models of IWTs.

However! I have recently learned that MAE is "re-tooling" prior towers with longer blades (forcing the separation from ground to lowest excursion of blade to be shorter) thus allowing a greater "swept area" and a larger power generation capacity. As such, given the risks of ILFN as a concept, the subsequent increased noise emissions (particularly of ILFN) of the higher capacity IWT), and no way to limit emissions except through greater separation of IWT from property line/home, it should be stated that the replacement generator cannot be of a greater energy generating capacity than was the original sited turbine.

8. Acoustic Study Funding

The government body responsible for compliance assessment (should be funded by the wind farm developer) to choose and hire and acoustic consultant to do the testing **independent of any influence from the developer.**

9. Decommissioning Costs

Although not related to noise, it is important that any regulation specifies a required upfront payment for decommissioning (of the order of $350,000 per turbine in 2011, and $625,000 in 2018). This should be put into a long-term investment account or bonds, as it is likely that the company installing the wind farm will not exist when its design life expires (usually 25 years). Periodic reassessment (? every 3 years) of projected decommissioning expenses should be made and the current wind farm owner should produce additional funds (within 2 months of estimated additional cost) necessary to fully cover any decommissioning expenses. This is particularly important as turbine component recycling and removal/disposal may very likely become more rapidly expensive than other "costs of living expenses". This is a difficult point, but assuring (without any ambiguity) that adequate funds are available to remove, safely dispose of all components of the IWT and restore the land to its "original pre-turbine state" is essential. The values listed above are from one Midwest wind farm. Wind Energy may state that components could be recycled to offset any "bond posting", however,

the monies realized through turbine part recycling is a very small percentage of the total costs of decommissioning.

10. Property Value Assessment

The value of properties within 5 km of a wind farm should be assessed by an independent commercial property assessor appointed by the local council prior to construction and the difference between that valuation and any sale price achieved within one-year post construction should be paid to the resident by the wind farm operator at the time of sale. Alternatively, if the property cannot be sold for a reasonable price, the wind farm operator should be required to purchase the property at the market value prior to construction of the wind farm. This would not apply to owners having the property in easement with the Wind Developer nor to any landowner who does not wish to have an appraisal of their property.

11. Existing Noise Ordinances and Regulations

These should be listed and the wind farm operator should be obliged to be in compliance with those existing sound ordinances. Normally those are listed as a part of the Comprehensive Plan which also has instructions for compliance.

12. Clarification of Modeling Considerations:

Models of wind turbine utilities used for assessing land use compatibility should:

1) Recognize the research of the NASA reports and other research that wind turbine infra and low-frequency sound must be handled differently than mid and high frequency sound

2) Be the best suited for representing wind turbine sound propagation

3) Represent the **Predictable Worst-Case Condition**

4) Fully disclose assumptions, limitations and tolerances of any modeling calculations

5) Provide confidence limits to account for the inherent inaccuracy in any model representing a complex set of conditions.

13. Outside Independent Review of Proposal Prior to Beginning Construction

As noted, there are lots of complexities of modeling of IWT siting to protect the health, safety and welfare of affected residents living in/near the proposed wind industry location. The lives and lifestyles of those affected will be forever altered as well as for subsequent generations that may reside there for use that land. They deserve the right to have the opportunity to have project proposal reviewed by an **independent** engineering firm (selected by the citizens) with half of the cost born by the county and half by the affected residents. The reviewing engineer must be a member of the Institute of Noise Control Engineering. The INCE Member has experience in noise impact assessment and control (complaints, annoyance, noise specs) and is committed to the Canon of Ethics. With regard to industrial noise, experts would have to demonstrate their commitment by oath or experience to protecting the safety, health and welfare of the public from industrial and power generation noise pollution.

14. The Bottom Line

Obtaining and reviewing recently developed "protective (to health)" enacted wind ordinance examples is crucial. The ordinances are written in such a way as to be easily transferred into other, developing ordinances. As noted elsewhere, there are NO federal and in most cases state-level experts that can help individual township or county-level citizen or non-captured Supervisors as they will invariably struggle to produce protective ordinances. In addition, any templates from Wind Energy or captured administrators or Supervisors will often include "preamble" verbiage to the effect that ordinance HAVE to be constructed that both protect residents but do not discourage wind turbine investments. That is IMPOSSIBLE. Wind Ordinances should be aggressive to fully protect the health, safety and welfare or the residents who will be living and sleeping nearby. Once safe "human-compatibility" safeguards are established and described, if a prospective Wind Contractor feels he can abide by that regulatory language, then it could be a win-win situation. My experience is that to achieve mutually agreeable but otherwise opposing requirements will be very difficult VERY difficult: Once Administrators or Supervisors have compromised human health protection; they have violated the trust of the citizens that elected them and have violated their oath taken to protect the residents of their county.

IT IS MY OPINION, that IWTs have become so massive and generate significantly dangerous and harmful noise emissions (that have never been proven to be safe ... with that obligation being born and to date "ignored" by the "polluter" i.e. Wind Energy or its contractors) that they cannot be safely deployed in most rural residential

areas. It is "curious" in that recent promotional television or paper ads for wind energy production have, over the last two years, largely eliminated any "semblance" of nearby human habitation or activity. It is almost as if Wind Energy is beginning to understand what they are "doing" to people.

Part – 14: Summary

Brief, High-Level Summary:

IWT = industrial wind turbine
AHEs = adverse health effects
ILFN = Infrasound, low-frequency noise
WHO=World Health Organization
MAE=MidAmerican Energy

In this lengthy section, there is an expedited review of 13 parts (separately chaptered) and sequentially combined to highlight important concepts. These will make reference to available additional data and relevant information that could be accessed with a specific review of that "part". In the front, there is a Table of Contents that will facilitate more rapid focusing to your requested data. Some portions of this summary are from the individual parts directly copied onto the Summary. My goal in beginning this data collection was to discover the "truth" in this highly contentious topic. It was immediately apparent that too little information was being made available from MAE and that the County resources had very little understanding of the implications of these turbines. I have attempted to learn the vocabulary and the concepts behind Wind Energy noise and focused, specifically and intensely, on adverse health implications. Having attended nearly all of the county-level meetings related to the proposed Arbor-Hills wind farm development by Mid-American Energy, it was immediately obvious that that two dramatically different interpretations of this data have evolved.

Review of imprecise definitions, different assertions, conflicting peer-reviewed data and major studies on IWT noise initially failed to clarify why there is such a difference in interpretations. I was then able to contact directly some of the key (literature) authors and ask my questions that led to the origins of international guidelines of turbine siting (e.g. ETSU-R-97) and ask if the principles they were founded upon still made "scientific sense". There were individual acousticians who were pivotal in the pro- Wind faction who initially described IWT noise in a very different "light". It is a remarkable trail to follow and to finally understand. My background in caring for patients and specialization in Cardiology and arrhythmias with a relatively recent recognition of untreated obstructive sleep apnea causing cardiovascular disease (seen repeatedly in my clinics) allowed me "confidence" to explore IWT noise and the development of possible chronic cardiovascular disease as well as other forms of "harm".

Published data in early 2019 of two studies that reported a link of sleep duration and cardiovascular disease - one clinical disease manifestation and the other showing objective increases in atherosclerotic disease progression in those populations with less quantities of sleep were pivotal in recognizing that environmental noise that seriously affect sleep - in quantity and quality - CAN cause serious health effects. Importantly, wind turbine noise is more "annoying/bothersome" than the other three WHO tracked environmental noise sources making the premise that IWT noise is likely harmful to health almost undeniable.

The content of this data collection is not peer reviewed as an entity. Nearly all of it comes from peer reviewed data and publications. My conclusions are supported by many sources and through many lines of logic. I have directly transferred published information from sources which I have referenced in the text into the paragraphs of the various document "parts". Currently, there are no plans for publication of this information (I do not have the time) but may make it available to readers on the Internet.

In the final view, the conclusions are mine being supported by the cited publications and from reputable professionals with vast experience in this area. Absolutely relevant and important "conclusions – made by me" about various organizations and individuals as I have come to "understand them" represent MY OPINION. I wish no malice toward anyone or entity. I just wanted to know "the best discoverable approximation of truth" so that I feel comfortable with my comments and conclusions. I take my responsibility as a health care provider in my community seriously and personally; I appreciate the respect and time you have given me and the TRUST in me that it shows. I have received no financial return in this extended endeavor.

Introduction - Part 1

This was a communication to the Madison County Board of Zoning in anticipation of reviewing Wind Ordinance elements. I will refer the reader to pages 17-19 where that "letter" can be found.

Part 2 - Sleep

The majority of the industrialized world struggles to obtain adequate and restorative sleep.
Inadequate sleep begets mental and physical stress which may beget chronic mental and physical disease.
Disturbed sleep is the most concerning adverse health effect from industrial wind turbines. It may arise directly from the sound emissions of IWTs or may result from other forms of adverse health effects (AHEs) generally termed as annoyance. ANY annoyance (mild, moderate or severe) is considered to be an AHE. Sleep disturbance is the key to a cascade of adverse physiologic consequences that may, in the extreme, be associated with a host of potentially serious cardiovascular outcomes. While it is clear that such a relationship may exist - as judged by the WHO -from exposure to automobile and train and aircraft noises, the data is not robust enough to confirm the same concerns with industrial wind turbines although there is accumulating data to support that association. It is worthwhile reviewing the process and importance of sleep. Recognizing the profound implications of turbine siting distance from homes to lessen the consequences of sleep disruption should be a primary focus in creating a protective Wind Ordinance for affected residents.
Sleep is composed of transitioning through various stages. Non-REM (Non-Rapid-Eye-Movement) sleep typically occupies 75-80% of total sleep each night. This period provides time for essential brain function recovery - tissue growth and repair, energy is stored and hormones that are essential for growth and development are released. REM sleep typically occupies 20-25% of total sleep each night.
This phase is when dreaming occurs, is essential for processing and consolidating emotions, stress and memories. It is reportedly vital for learning and stimulating the brain regions used in learning and new skill development.
Non-REM sleep (also termed slow-wave sleep) transitions through 3 successively "deeper" sleep levels during the night with transitioning to increasingly longer and "deeper" REM periods occurring toward morning. If the REM or non-REM cycles are interrupted multiple times through the night (either as brief, non-conscious arousals or as periods - however brief - of "full" awakening) then we may fail to reach the "deeper" periods of sleep where these "recharging events" can occur. As stated by the National Institutes of Health, "Sleep effects almost every type of tissue and system in the body – from the brain, heart and lungs to metabolism, immune function, mood and disease resistance. Research shows that a chronic lack of sleep, or getting poor quality sleep increases the risk of disorders including high blood pressure, cardiovascular disease, diabetes, depression and obesity".
Your need for sleep and your sleep patterns change as you age and this varies significantly. Babies initially sleep as much as 16 to 18 hours per day which may boost growth and development (especially of the brain). School age children and teens need about 9.5 hours of sleep per night. Generally, adults need between at least 6-7 hours. After age 60, nighttime sleep tends to be shorter, lighter and interrupted by multiple awakenings. Elderly people are also more likely to take medications that interfere with sleep. For these reasons, our younger and older county residents are considered more vulnerable in their age-related obstacles to achieve restorative sleep. In general, people are getting less sleep than they need due to longer work hours and the availability of round-the-clock entertainment and other activities. The idea of "catching up" on weekends actually never can be fully achieved.... although one may try; "sleeping-in on weekends" has been recently associated with heightened degrees of insulin resistances measures than simply returning to a normal sleep pattern.
We are a society plagued by increasing obesity (now about 40% of Americans are considered as obese with 7.7% being severely obese). The American Heart Association has now included obesity and severe obesity in children as cardiovascular risk factors. With the recent redefinition of hypertension going from 140/90 to 130/80 now >46% of American are considered hypertensive. The incidence of type II diabetes (the type related to "high" insulin levels due to acquired resistance of insulin action at the cellular level) continues to increase in incidence. Somewhere in this "modern health epidemic" is the problem of sleep quality and quantity. The 2019 Annual statistical update from the American Heart Association included a new section on sleep and cardiovascular health citing data from the Centers for disease Control and Prevention that only 65% of Americans have a healthy sleep duration (at least 7 hours).

Inadequate or disrupted sleep is the most common complaint from residents living near IWTs. It is extremely important to realize that not only does excessive audible noise cause sleep disruption but can also occur with amplitude modulation from the ILFN noise spectrum. ILFN emissions can travel up to 3-4 km from IWTs to a household given certain wind and atmospheric conditions. Sleep is "disrupted" through both unconscious arousals and with frank awakenings - both disrupting the otherwise healthy progressions through both non-REM and REM sleep periods.

At the 1500-foot setback proposed by Mr. Clifton, **average** sound levels (expressed as Leq) will be 45 dBA (with the 2 MW IWT proposed by MAE) as measured outside the house as predicted by computer modeling. Forty-five dBA Leq means that there may be recorded peaks as high as another 6-11 dBA above the 45 dBA Leq average. Albeit much less frequent that the average value, audible sound levels of 56 dbA are possible. Of even greater concern are possible still higher noise levels yet – reflecting possible poor individual turbine siting's (with IWT clumping, in-line arranging along prevailing wind axes, intermittent turbulent wind conditions or period of significant temperature inversions and other reasons). Turbine separation modeling occurs with the IWT model stated sound power level which reflect sound production with optimal winds and not "worst case scenarios"). Testimony under oath by Wind Energy representatives have confirmed these possible noise ranges that are expected from IWT sources. It also means to achieve bedroom levels of 30 dBA your windows will need to be closed tightly with all exterior audible sound not exceeding 45 dBA. Opening the bedroom window even a little (cracked 6 inches) for cooling or fresh air circulation will markedly increase noise entry into the bedroom - enough to necessitate IWT separation another approximately 2000 -3000 feet farther to reach 30 dBA sound levels inside.

ILFN poses an even greater threat to sleep disruption. Infrasound generally attenuates (lessens in loudness) at half the rate as does audible sound. This means that (roughly) to achieve the same reduction in noise levels for audible sound, you have to go twice as far (in setback) to achieve the same noise level with infrasound. Infrasound travels to some extent by resonating in the ground that can then easily resonate a house foundation and structures within the house - being insignificantly lessened by wall/roof insulation. Infrasound "sound travel" is frequently described as "amplifying" in the house.

Low frequency sound also attenuates at rates less than audible sound ranges - intermediately as compared to infrasound. Low-frequency noise is audible being 40-60 dBs in the 20-200 Hz range.

This would be hard to ignore without sound protection equipment (ear plugs). The sounds in that frequency range are heard/perceived by people in their beds at night when the house is otherwise quiet as "vibrations", rumble and roar. While not particularly "loud", they are perceived because in the rural residential environment there are no other noises in the community to provide masking of these low frequencies. It is for that quality of quietness and solitude that the residents chose to live there.

I Have Seen the "Face" of IWT Harm

Three years ago, while inquiring about used farm machinery, I sought out a farmer who lived nearby in Guthrie county. Arriving at his farm perched along the "Mo-Miss Divide", I was fascinated at the distracting "surging" of spinning IWTs "for miles". Greeted by the farmer, I asked him about how "he and the turbines" got along. He noted that " a lot of people had moved away, and over half of those who agreed with their easement signing now regret having done so." Looking into his face, I could see the likely signature of chronic sleep deprivation (a distinctive appearance that I can easily recognize in those sent to me for atrial fibrillation consultations who have concomitant obstructive sleep apnea). His speech was a bit halting and searching.... I asked how his sleep was and whether he thought the turbines had created a problem sleeping. Looking inward, he paused, then scanned the ongoing turbine "wind chopping" and looked down then back up at me. "I don't think so... maybe you get used to it. A year ago, I built a new bedroom addition to my house putting in the best materials I could find with 2x6 construction, thicker insulation and heavier sheathing. It made it better.....(he paused) ...but on those windy nights I can still hear and feel that pounding...." I sensed an exhausted man who had resigned himself to "deal with it". He was imprisoned on his own farm with his entire livelihood around him.

Part – 3: Wind Turbine Noise - Basics

This part contains the conventional divisions of the sound spectrum. Hz = "hertz". One Hz is equal to one cycle/second, being a unit of "frequency". The greater the Hz value, the shorter the wavelength of the propagated sound. Infrasound is very remarkable for relatively long wavelengths which occur at frequencies of < 20 Hz (cycles per second).
Infrasound: 0.1-20 Hz
Low-Frequency Sound: 20-200 Hz (The lowest key on a piano resonates at 27 Hz)
Audible sound: 20-20,000 Hz
ILFN: Term combining infrasound and low frequency sound.
Unwanted sound is termed "noise"
Weight filtering reflects the "loudness", or "sound pressure level" as recorded within a certain frequency range. They come in multiple designations with "A" filtering being, by far, the most commonly used, which is "centered around" about 1000 Hz. It captures most conversational sound frequencies but, by virtue of the filter designed limitations, is unable to reflect (quantitatively) ongoing low frequencies (such as infrasound). On the other hand, the "Z" filter is "unweighted" and a stated value reflects sound levels combined for all frequencies being measured (e.g., by a microphone).
The industrial wind turbine creates sound from multiple sources: machinery noise in the nacelle (where generator is working behind the hub), the blades moving through the wind causing "blade swish" as air moves around the blade itself, and low frequency (still audible) noise from the blades due to in-flow turbulence - often around the tower. Impulsive sound is generated in the infrasound sound (usually at frequencies just under once/second) that reflect the "blade pass frequency". It is "recognized" not as a tone but as a "cyclic pressure wave" appreciated by the inner ear.
Turbines have both down-wind and up-wind designs reflecting whether the turbine blades are downwind or up-wind of the supporting tower. Both designs were very thoroughly evaluated by NASA/Boeing joint-funded investigations -primarily associated with N.D. Kelley's work (but there were several others who also contributed) in the late 1980s. Down-wind designs were intrinsically "noisier" and led to the current commercially-used upwind designs that produce less infrasound and audible noise.
Amplitude modulation involves air turbulence around the turbine blades and noise interactions with other turbines as well as other sources.
The (3) turbine blades are attached to the hub which is at the top of the tower. These blades can be rotated at that connection changing the fixed canted blade angle with respect to the air inflow interacting with the blade edge. The blades are rotated to achieve the greatest "air purchase" which then effects the efficiency of power production. Greater blade angle rotation can cause more noise production with VERY significant amounts of 11 dBA or more.
The "character" of noise created by IWTs has been described as "distinctly annoying". At a given A-weighted level, it is far MORE annoying than airport, truck traffic, railroad or industrial noise - due to special audible and inaudible modulated and tonal (distinct - sound) characteristics. The noise is often of low amplitude and shifting in character - such noise quality resists "habituation" (getting used to) and hence dramatically can frequently, in an on-going fashion, perpetuate suffering of annoyance. Of special importance is that IWT noise can be easily appreciated at up to 10 dBA BELOW background noise.
Computerized sound propagation models are imprecise, to say the least. There are so many ongoing variables that can influence sound transmission - certainly the weather, but also terrain variations among other factors. Consultants (including Mid-American Energy) claim to have very sophisticated modeling equipment (which they may have) BUT their siting of IWTs in adjacent Adair county (in rows, spaced closely together, particularly at short distances to inhabited residences (500 meters) is prone to calculational noise level errors. Errors in models of IWT noise propagation located on flat terrain have shown to have errors of 5-10dB when studied by independent acoustical engineers. A sound level of 10 dB above an estimate represents a roughly doubling of the perceived "loudness" of a noise.
Of great importance at the initial public courthouse presentation by MAE was the **absence** of a stated sound level that MAE was trying to not exceed (they only had a setback distance on their original Madison County "variance" request). Matt Ott, (apparent MAE engineer) with great imprecision at the time of variance request

presentation stated (with hesitation and implied uncertainty) that noise levels at the "the front door of an occupied residence would be 45 dBA (Leq) and that it would be "safe".
"Worst Case Conditions" (to this writer) should represent the highest (loudest) sound levels ever heard/recorded at the receptor, e.g. property line. A lot of these "discrete, infrequent" episodes may occur at night during higher winds as can be associated with wind shear, temperature inversions or other events. Typical computerized calculation of sound levels is from the stated "sound power level" of a given turbine model. That rating, in terms of loudness, is done with steady winds. Such characterization of rated sound production is significantly lower than what could be produced by the IWT during periods of wind shear, blade angulation, or to other, not-infrequent "worst case scenarios".
I believe that IWT siting should be within 5 dBA of the worst possible noise levels that could be experienced and that level should be signified as a Lmax sound level. Any proposed wind farm "siting map" should state all assumptions and predict worse-case scenarios within 3 dBA. If they are not certain, turbines and residences should be more widely separated to avoid noise compliance penalties.

Part - 4: IWT Sound Emissions, Types -
Wind turbines produce infrasound along with low-frequency and audible noise. The more powerful the wind turbine, the greater the proportion of infrasound and low-frequency noise that is emitted.
Sound with frequencies below 20 Hz is labeled as infrasound. With its initial (historical) "labelling" it was described as not being able to be heard, but with greater scientific investigation, it actually **can** be heard at the higher end of the 20 Hz zone while "perceived" at the lower portions provided the sound pressure level is sufficiently high. The sound is perceived with the ears usually giving a feeling of pressure at the eardrums. Infrasound at an audible level is usually found on the car deck of a ferry and when driving a car with an open window. Infrasound is most often associated with sound at other frequencies, so the experience of listen to "pure" infrasound is uncommon.
The recent rapid introduction of IWTs into rural residential locations at close siting to resident structures of increasingly larger IWT for the purposes of larger energy production per turbine has been without ANY efforts by Wind Energy (as I can see or should have been told) to ensure public safety. These larger-sized turbines with reported production capacities of up to 4.8 MW have similar sound profiles - particularly in the infrasound range BUT produce sound levels that are higher along the ILFN sound spectrum. It has been pointed out by multiple acousticians (Moller, Kamperman) that the levels of sound (loudness in dBs) increase by 3-5 dB for every MW of electrical power generating capacity.

Wind Energy disputes that IWTs produce little, if any, appreciable infrasound. As stated, originally, acousticians were taught that human thresholds for hearing were much lower (i.e. unable to detect) than the typical sound levels produced by IWTs. A lot of scientific and peer-reviewed data has changed that original understanding. In all my readings, I have seen zero rebuttals, comments, critiques or expressed outrage by Wind Energy to any of these newer concepts as collectively they further challenge a fundamental tenant Wind Energy: denial of adverse health effects of ILFN.
1) In the 1970s, structures within the inner ear that allowed low frequency detection were recognized
2) In the 1980s, it was recognized that inner and outer hair cells possess dissimilar mechanical properties. Alec Salt demonstrated that the outer hair cells can be up to 40 dB more sensitive than the inner hair cells at 1 Hz.
3) Original hearing thresholds were defined by recognition of "pure tonal" sound whereas the real-world IWT sounds are more impulsive and varied. As the human ear "reaches" to embrace detection of IWTs, noise recognition can extend another 10-perhaps 15 dB lower.
4) Additional enhanced hearing detection in "some individuals" may extend another 10-12 dB lower.
5) Unique (but clearly demonstrated in "sensitized" individuals) capabilities of hearing or perceiving "socalled harmonic peaking of the blade pass frequency" during "heavy winds" has been noted and has been personally recognized by prominent acousticians.
6) Additional "sound recognition" through heightened tactile detection of vibration is possible

7) Finally, very recent demonstration of "brain recognition" yet not "cognitively perceived" infrasound has been documented during "functional" MRI imaging as seen with activation of "key autonomic brain centers" during sub-thresholds infrasound stimulation. (Max Planck Institute, 2019)
The full extent of our body's recognition of infrasound IWT emissions is incompletely characterized but as IWT noise is more "annoying than traffic, rail or aircraft noise" with these latter noise sources now associated with promoting cardiovascular disease, a reasonable and scientifically grounded individual should be very concerned about yet another environmental risk. Basner and McGuire (2018), published "WHO Environmental Noise guidelines for the European Region: A Systematic Review on Environmental Noise and Effects on Sleep". While they acknowledged the "incomplete state" of supportive research regarding IWTs and cardiovascular disease, they did comment "There is biologic plausibility that chronic nighttime exposure to relevant levels of noise can contribute to negative health consequences like cardiovascular disease". They did add, importantly, that "disturbed sleep has immediate next-day consequences (e.g., increased sleepiness, impaired cognitive performance) that may increase the risk for errors and accidents, and thus sleep deserves protection from noise even in the absence of a direct link to long-term health consequences. This is particularly concerning given the projected future decades of IWT exposure and a likely mechanism for triggering cardiovascular disease (#7 above).
In the 2018 WHO Environmental Noise Guidelines, their concern of IWT sound level exposure (based on the available research) generated the recommended reducing noise levels produced by wind turbines below 45 dBALden. No specific nighttime level was given. With "less annoying sound sources of road traffic, railway noise and aircraft noise, Lden were 53, 54 and 45 dB respectively with nighttime levels of 45, 44 and 40 dB respectively.
Low-frequency sound and annoyance are also described in more detail within Part - 4. Of particular visual intrigue is the ongoing display (Link provided) of modulated low-frequency noise presented by Dr. Cooper at a 2017 International Commission of Biological Effects of Noise. Annoyance **IS** an adverse health effect (AHE) as defined by multiple references (including the WHO) listed in the Conclusion section. Annoyance creates AHEs and with that suffering and a host of relevant health (physical and psychological) consequences. Wind Energy would argue that annoyance reflects a purely negative "attitudinal" response from the appearance, sound, financial implications and other factors that then produces the "annoyance". Such non-direct suffering by residents in windfarms has been rejected by nearly all except Wind Energy.

History - Part 5
This section is immensely important as it supports the scientific data that IWTs cause AHEs but also provides a trail to where the current harmful Wind Ordinance draft proposals originated. Also, it describes the setting where wind turbine manufacturers entered the regulation process and continue (in their protected and "facilitated" state) to introduce harmful noise into our communities.
The focus on community noise (unwanted sound) began (mostly) in the 1970s with the evaluation of low frequency audible and perceived sound associated with industrial compressors and turbines. Later, "sick buildings" were evaluated by highly trained acousticians who found HVAC installations were the source of vague complaints **with and without** noise recognition. Some of the symptoms experienced included mental tiredness, lack of concentration, and headaches were associated with reduced work performance and work satisfaction. Not all the workers complained of symptoms or even audible rumble. It required special studies and tests developed by Dr. Leventhall and others to identify that the workers' sense of being uncomfortable or having other symptoms while in their offices was associated with the modified ILFN. These investigators convincingly showed that pulsations in the HVAC systems corresponded to times when the workers reported symptoms of mental tiredness, lack of concentration, headaches and reduced performance and work satisfaction. Importantly, subsequent research revealed a host of closely-matched symptoms that are reported by those experiencing adverse health effects from IWTs.
Apparently, Dr. Leventhall, despite his early clear research and clarification of ILFN being responsible for symptoms closely mirroring those from IWTs, in the years to follow, uniquely and inexplicably chose to develop and support Wind Energy's stance on the "benign" character of ILFN produced by wind turbines.
He became a champion and referenced leader in Wind Energy's promulgation of IWTs around the world.

Previous research had shown that at AUDIBLE levels, ILFN was able to produce physical responses. However, many scientists and engineers assumed that inaudible levels could not cause any problems. Indeed, Mid-American Energy (MAE) representatives in our Winterset Courthouse during the 2018 permitting process, repeated the saying "what you can't hear, can't hurt you". Many acoustical engineers were taught this as a part of their academic training regarding the perception of ILFN.

Subsequent studies by researchers such as Swinbanks, Ebbing and Ebbing's colleague Blazier, an independent acoustical consultant who worked in the HVAC industry, found evidence that SOME people responded to INAUDIBLE levels of ILFN produced by the machines.

Dr. Malcolm A. Swinbanks produced a nice review of this topic when presenting to the Australian Senate Select Committee on Wind Turbines on March 20, 2015. As noted in the previous paragraph that it is important to see IWT noise as "impulsive and complex".... mean levels of sound fail to take into account either the character of the sound or the relationship between adjacent frequency bands. He also referenced a number of reported cases in the literature where ILFN was clearly being perceived at significantly lower levels than would be assessed by such basic comparisons with the hearing threshold.

He summarized that "conventional hearing perception" is considered to take place via response of the inner hair cells of the cochlea (the sensing structure of the inner ear), but it has been shown that the cochlea outer hair cells respond with greater sensitivity at very low frequency, and induce additional neurological signals. Hitherto, these outer hair cells have been considered to perform only the task of controlling the overall sensitivity of the hearing process, but it is possible that they can also contribute directly to very low frequency perception". He continued with "a further mechanism has been proposed, whereby sound pressures acting through the lymphatic fluid directly on the otolith components of the vestibular (balance) organs have been calculated to exert comparable forces to those induced by motion and acceleration. Any non-uniformity in the compliance of the structures supporting these otolith sensors may then result in a response which is that of physical motion.

Indeed, it has been argued that the correlation between persons who suffer from motion sickness and those who report adverse effects from wind turbines is sufficient to be more than a result of mere chance". Of note is that a resident from NW Madison County, who turned west onto I-80 was faced by a horizon of revolving turbine blades. She soon thereafter felt sick, nauseated and vertiginous enough to be forced to stop her car on the side of the road, attempt to recover, and then proceeded off at the next exit.... eventually recovering upon exiting the turbine field. That same sensation has been noted by others with the above mechanism likely explaining her symptoms.

The U.S. government has known about health effects of infrasound and low frequency noise from wind turbines since 1987. It was concerned enough to commission a study. The study was a research project funded by the U.S. Department of Health, Contract No. DE-AC02-83CH10093. Among many impressive scientific papers, was the following: Dr. N.D. Kelley, Solar Energy Research Institute, Golden, Colorado: "A proposed Metric for Assessing the Potential of Community Annoyance from Wind Turbine Low-Frequency Noise Emissions" Note: "Community Annoyance" is now called Wind Turbine Syndrome;
"Low Frequency" includes infrasound; "Emissions" includes noise and vibrations.

Kelley et al, concluded: "...one of major causal agents responsible for the annoyance of nearby residents by wind turbine noise is the excitation of highly resonant structural and air volume modes by the coherent, low frequency sound radiated by large wind turbines. Further, there is evidence that the strong resonances found in the acoustic pressure field within rooms actually measured indicates a coupling of subaudible energy to human body resonances at 5, 12 and 17-25 Hz, resulting in a sensation of whole-body vibration." Additional investigation by Kelley, found that turbines radiated their **peak** sound power (maximal "SPL" or "loudness") in the infrasound range, typically between 1 and 10 Hz. Annoyance was the result of a coupling of the turbine's impulsive low-frequency acoustic energy into the structures of homes and that the annoyance was frequently confined to "within the home itself".

In Kelley's and in three other investigators work, the studies report similar findings, namely that perception, generally is non-auditory in character, begins when the rms SPLs (loudness) of the modulating tones that are as low as 35 dB rms with increasing impacts as the rms levels rise to 50, 60 and to 70 db and higher. In all these

studies the dynamic modulation of the blade-pass tones produces pressure peaks that are often 10 dB or more greater (sometimes much more), than the rms values.

I would strongly recommend that this link be opened (find listed in part 5) and the history of the recognition of infrasound and its potential for adverse health effects was first described by N.D. Kelley and how it was "forgotten or intentionally overlooked". Despite the recognition of potential human harm, this information was discarded by Wind Energy and specifically by the turbine manufacturer, Vestas, the manufacturer of turbines proposed for installation in Madison County.

Two primary researchers, Hubbard and Shepherd (1990) (30 years ago), reported the following:

1) Wind turbines produce primarily infrasound and low-frequency sound.

2) Sound propagates from IWTs at a decay rate half that of common (audible) "point" sources

3) IWT noise travels farther than other sounds.

4) IWT noise will be a significant indoor noise problem due to room resonance and a dominance of ILFN acoustic energy.

Fifteen hundred (1500) feet was the distance (in the original Mid-American Energy (MAE) request for siting of IWT from rural residences for the proposed Arbor Hills Wind Farm. At none of those initial and none of the subsequent follow-up meetings at any level was there a description of how that distance was proposed, how long it had been in use nor ANY description about the human health implications of that distance. Otherwise, in the written proposal, there was no listing of the anticipated noise exposure level to residents. Some of the presenting MAE representatives were not clear as to which model of IWT was planned for Arbor Hills (i.e. suggesting they do not link MW -rating with sound level productions). The only mention of noise levels incurred by the IWTs was the verbal comment (during the meeting) by Matt Ott (MAE) that he anticipated no more than 45 decibels at the front door of an occupied residence. He claimed that it was a safe level. Fifteen hundred feet setback was the only specification in not only Madison County's proposals but also that of Adair County and any proposal IWTs that I have seen for Iowa. So where did it come from?

Noise regulation in the United Kingdom was "originally" via the British Standard BS4142 (described as "method for rating industrial noise affecting mixed residential and industrial areas"). A document described as the Planning Policy Guidance 24 (PPG24) was generated in the UK that outlined some of the main considerations which local planning authorities should take into account in drawing up development plan policies and when determining planning applications. PPG24 provides advice on how the planning system can be used to minimize the adverse impact of noise without placing unreasonable restrictions on development or adding unduly to the costs and administrative burdens of business. The document introduced the concept of noise exposure categories (NECs) ranging from A-D for residential development and recommends appropriate levels for exposure to different sources of noise. A proposal for residential development needed a determination of which NEC categories would be operative also taking into account both day and night-time noise levels. The PPG24 takes into account the recommendations of the Noise Review Working Party which reported in October 1990. PPG24 - 1994 recommended using the British Standard BS4142. This regulation was formulated to assess facility external noise (outside at a property) based on the likelihood of complaints.

Background noise levels (LA90) should be measured. Source-specific noise levels (rating level) are then obtained from manufacturer's data or measured in situ. The background noise level is then subtracted from the Rating Level. If there is likely to be a tonal content or "specific character" to the building services plant noise then a +5 dBA correction is applied to the Rating Level. This assessment method is only applicable to external areas. Assessment of excess value:

1) A difference of around +10 dBA or more indicates that complaints are likely

2) A difference of around +5 dBA indicates a marginal significance of complaint.

This is the same formulation as used in the United States ... as in the ISO TC/43.

This BS4142 regulatory limit was based on reasonable likelihood of complaint generations was too restrictive for IWTs **as wind turbines have no noise control options except greater distancing**. Other industrial facilities don't have this problem, because they can enclose machinery in buildings, use mufflers, duct wrapping, etc. As such, Wind Industry had to come up with a "guideline" that raised background noise levels with the definition of 'LA90 -10 min' and convince U.K. regulators to use that guideline instead of BS4142. (Unfortunately, the LA90-10min measurement is effective for broadband noise such as traffic noise but not when measuring intermittent

noise as produced by wind turbines). And that is exactly what they did as they developed ETSU-97. BS4142 continues to be used for industrial permitting and apparently remains a thorn in the side of consultants working to permit wind turbines and promote more noise in rural areas.

ETSU-R-97

ETSU-97 is a set of guidelines and not a set of regulations. The acronym stands for "Energy Technology Support Unit". **The ETSU working group was formed by the British Wind Energy Association for the purpose of preparing wind energy friendly guidelines and research**. In that capacity, it worked on behalf of the Department of Trade and Industry (DTI); generally, with no independent oversight and no transparency. "The Assessment and Rating of Noise from Wind Farms" was published in 1997 and remains the UK government's preferred method of assessing wind farm noise for planning purposes.

Rick James (in his article "Wind Turbine Infra and Low-Frequency Sound: Warnings signs that Were Not Heard") described the "inadequate" design of the ETSU-R-97 which was a "guideline only" for the UK that was developed specifically to circumvent more science-based UK regulations that were more restrictive to IWT placement. The guideline was developed by the Working Group on Noise from Wind Turbines which consisted of several acoustical consultants with ties to the wind industry in the UK, representative of companies or their attorneys involved in or with the wind industry, several representative of local governments and the chairman, who represented the government's Department of Trade and Industry (DTI).

The introductory comments about ETSU's purpose to "offer a reasonable degree of protection to wind farm neighbors without unreasonable restriction on wind farm development" has been met with near universal worldwide contempt (as also occurred in Madison County during a joint writing session with the Supervisors) as the guidelines should not provide the justification to impose greater levels of wind turbine noise intrusion than would be permitted by other forms of development (or which could still produce human harm to nearby residing residents).

ETSU-97 compares the turbine noise with a level 5dB above background noise, but when background noise levels are low (particularly in rural areas), it sets a higher lower limit. The day time lower limit can be anywhere between 35 and 40 dBA and the night time lower limit is 43dBA. The most bizarre result is that night time background noise level can be "assigned" up to 8dBA more than the day time noise. No other standard anywhere in the world has a night time limit higher than a day time limit.

There are a host of other concerns listed in Part-5 that are reviewed. Others, such as method of background noise measurement techniques, also exist but are complicated to explain.

It appears that the ETSU-R-97 was produced to permit introduction of wind farms into inappropriate low background noise locations where they and other comparable industrial installations could not meet planning conditions derived from the long established BS4142. It could be reasonably supported that the Department of Trade and Industry (DTI) worked with the British Wind Energy Association that formed the ETSU to develop "fuzzy-science" based guidelines. I would view this as "pseudo-science to support policy, NOT policy to support science". The ETSU is lengthy and complicated - intentionally so - and contains assumptions and omitted critical considerations. These included, among many, the existence and (already described) risks of ILFN and amplitude modulation, and allowed night-time audible sound levels to exceed those of daytime limits - all based on assumptions of background noise level changes at night associated with increased wind speeds. These guidelines were adopted and have remained largely unchanged over the last 23 years despite enormous increased understanding of IWTs physics and health effects.

After being informally adopted (but not approved as regulation) by the British government, British acousticians Hayes and later Leventhall were pivotal in the adoption of the ETSU-R-97 tenets - particularly to former British colonies (Australia, New Zealand) - being presumably sent to establish control of the narrative and establish a template that the local firms could subsequently use for other wind energy projects. Leventhall formally started his pro-Wind energy work when he became a spokesperson for the British Wind Energy Association in the early 2000's after Dr. Van den Berg published his thesis "The Sound of High winds" and two other papers that observed wind turbine blades create pressure pulses as the blade passes the tower. For the next 15 years, reportedly at the request of industry trade groups, Leventhall and others organized "international" wind turbine noise conferences where research was promoted and reviewed that reflected the Wind Energy vision. Hayes

(British acoustician) apparently consulted on a project in New York state in the mid-late 2000's where working with US consultants reportedly "borrowed ETSU concepts" to get their projects approved in later projects. Those "templates" reportedly initiated by Hayes were "used around the world" being only changed to accommodate regulations. It is highly likely that such "original" language perpetuates to this day; with the various "Wind Energy Associations" sharing the recipe to Wind Energy Industry – a great many of whom sit at the Wind Energy boards.

Meanwhile, interest and evolution of power production through wind conversion energy systems continued with continued evolution of turbine size to accommodate higher production capacity and progressive interfacing into rural residential areas of the U.S. Madison County Supervisor Aaron Price stated, in a prior county meeting, something to the effect that the Federal government would not have allowed IWTs to become so "widespread" if there was some inherent risk to human health. The unspoken fact is: There is **NO** regulation of IWT by the federal government. This fact, in the course of my reading, remains completely unaddressed by Wind Energy; they get to define if IWTs are safe or not and convince local counties in Iowa that they are OK. They have found that financial incentives seem to facilitate adoption of IWT placement - both for the landowners and the county tax rolls.

The U.S. Environmental Protection Agency (EPA) created the Office of Noise Abatement and Control (ONAC) following enactment of the Noise Control Act of 1972. In 1981, Congress agreed to the Reagan Administration's proposal to cease funding for ONAC. Congress, however, did not repeal the Noise Control Act when it eliminated ONAC's funding.

Before its elimination, ONAC engaged in a wide variety of activities to abate noise pollution under authority of the Noise Control Act and, after 1978, the Quiet Communities Act.

The Quiet Communities Act of 1978 amended portions of the 1972 Noise Control Act to require coordination between federal agencies on noise control. It was intended to speed up FAA response to noise regulations proposed by the EPA and required the FAA to provide the public with a detailed analysis of EPA proposals. These included identifying sources of noise for regulation, promulgating noise emission standards, coordinating federal noise research and noise abatement, working with industry and international, state and local regulators to develop consensus standards, disseminating information and educational materials and sponsoring research concerning the effects of noise and the methods by which it can be abated. It also authorized the EPA to provide grants to state and local governments for noise abatement.

The EPA ceased most noise abatement activities after ONAC's funding was eliminated. There is still some minimal enforcement in the area of airport noise. Responsibility for the enforcement of EPA's railroad and motor carrier emission standards was shifted to the Department of Transportation.

Since defunding ONAC, federal noise emission and labeling standards have not been subjected (best I can find in the internet literature) to critical evaluations despite the evolution of relevant science and technology and a better understanding of the effects of noise on people. The EPA has been unable to provide technical assistance to state and local governments or to participate in private, standard-setting efforts. State and local governments have been preempted from adopting their own noise emission and labeling standards that differ from EPA standards for sources or products that EPA has regulated.

Apparently, there were never any EPA standards or regulations for industrial wind turbines. State and local governance has had to pick up that protective effort... but as said many times... without funding or other vital resources to do that. Specifically lacking are technical resources and highly trained engineering specialists to understand the science of industrial wind turbine sound emissions and interpret and stay current with the rapid explosion of our understanding of those sound emissions causing adverse health effects. Unfortunately, relying on Wind Energy and the Wind industry for objective knowledge and guidance in protecting human health has never happened. In my opinion, executing their agenda has, by necessity, eliminated their concerns of protecting human health.

Currently, control/monitoring of IWTs is mostly at the county level (as it is in Iowa). However, in some states, it is regulated at the "state level". Such governance levels lack the funding and personnel resources to adequately protect threatened residents. Over the past twenty years, the wind industry has presented "their" evidence implying that IWTs are "safe" near people's home. Yet the reports of nearby residents suffering annoyance, sleep disturbance and the consequences of chronic nonrestorative

sleep and body/vestibular responses have been received from people living within 2 or more kilometers of IWTs not only located in this country but in countries around the world. Responding to this suffering of the affected residents, individual scientists and acoustical engineers, citizen groups, national and international action groups have developed to counter the "effective playbook" developed in the wake of ETSU-R-97's acceptance and current twisted/mis-information provided to the targeted "unsuspecting" residents by Wind Energy and their industry developers.

Aside from individual acousticians and appropriately trained independent engineers and researchers, most of the safety information is provided to that governance level by Wind Energy and its paid promotional entities including the Iowa Environmental Council among many others. 758

Part – 6: Adverse Health Effects

This aspect of IWTs has been the focus of this entire review. Part 6 is quite lengthy with many studies being reviewed or summarized; there are many details that are worth reading. The first part reviewed Dr. Robert Thorne's 2012 study (Australian) as well as some of the concepts from his "textbookequivalent" (2014). It is important to recognize that annoyance (all forms) are adverse health effects.

Adverse health effects can "arise from extreme psychological stress from environmental noise, particularly low frequency noise with symptoms of sleep disturbance, headache, tinnitus, ear pressure, dizziness, vertigo, nausea, visual blurring, tachycardia, irritability, problems with concentration and memory, and panic attack episodes associated with such sensations when awake or asleep. More serious harm to health occurs when, related to the presence of IWT noise, residents suffer recurring sleep disturbance, anxiety and stress. Thorne's review suggested that 5-10% of the individuals in the vicinity of a large wind farm will experience serious harm to their health. That AHE prevalence was generated on his study of residents living at an average distance of 1400 meters which is three times farther than the distance proposed by Madison County supervisor, Phil Clifton. Within Thorne's study, the observed markers for serious health effects were noted with wind farm noise: 1) 32 dBA Leq or more OUTSIDE the resident and 2) if it is perceived or heard in any form inside the house. He defined "serious harm" if 1) the resident is obliged to remove themselves from the exposure in order to mitigate the harm 2) if three serious AHEs are present as listed as a state of constant anxiety, anger and helplessness and having abnormal "scores" from validated sleep and mental health surveys.

Many pieces of information are included, briefly:

Dr. Daniel Shepherd described Wind Energy's actions to deprive a resident of his health also extend to his well-being, quality of life and amenity.

Dr. Hanning commented on sleep disturbance (which I too have seen in patients presenting with heart arrhythmias and obstructive sleep apnea), that "inadequate sleep has been associated not just with fatigue, sleepiness and cognitive impairment but also with an increased risk of obesity, impaired glucose tolerance, high blood pressure, heart disease, and depression". Sleepy people have at least a doubling of their risk of traffic accident related mortality.

Dr. Michael Nissenbaum declared a "high probability" of significant AHEs for residents living within 1100 meters and a significant risk of AHEs in a significant subset of people living out to 2000 meters from an IWT. (Mr. Clifton has proposed 500-meter separation from IWT to residence).

Dr. C.V. Phillips in testimony before the Wisconsin Public Services Commission summarized that there is ample scientific evidence to conclude that wind turbines cause serious health problems for some people living nearby. In addition, he commented on the observation of people vacating their home being an "exposure-disease" combination. Furthermore, 'the (Wind Energy) reports that claim that there is no evidence of adverse health effects are based on a very simplistic understanding of epidemiology and self-serving definitions of what does not count as evidence. Though those reports probably seem convincing (on first appearances), they do not represent proper scientific reasoning, and in some cases the conclusions of those reports do not even match their own analysis".

McBride, et al (2014) found that some people living near wind farms had a lower quality of life than others due to increased levels of stress and poorer sleep. It also became apparent that the objective manifestations of health effects associated with noise-related annoyance may emerge after some years of exposure.

Schmidt (2014) produced a particularly "interesting" characterization about sound levels: "....at present, it seems reasonable to conclude that noise from wind turbines increases the risk of annoyance and disturbed sleep in exposed subjects in a dose-response relationship. There seems to be a tolerable limit of around Leq of 35 dBA. MY COMMENT: Why is the resident required to "tolerate" a detectable noise level? Toleration implies ongoing annoyance which, in itself, an AHE. The audible noise threshold (known for at least 20 years) is 30dBA as a Lmax, i.e. "shall not exceed" discrete sound limit. 32 dBA Lmax and above disturbs sleep which causes adverse health effects.
The remainder of the section reviews annoyance, low frequency noise related AHEs and infrasound recognition and AHEs. The latter two are felt by some investigators to be even more annoying than audible sound and potentially more concerning for serious adverse health effects.

Cardiovascular Disease:
(Some of this was reviewed in the prior section)
The World Health Organization in 2018 produced a document reviewing impacts from environmental sources. These focused-on road traffic, rail and air traffic and included wind turbine and leisure noise sources. The WHO data review boards measured 3 critical health outcomes of cardiovascular disease, effects on sleep and annoyance. Cardiovascular disease could lead to more severe disease and/or mortality and both sleep and annoyance may be in the causal pathway to cardiovascular disease. The data directly from available IWT exposure studies is considered "conditional" with available studies not being of sufficient "power" to currently consider the evidence to be "strong" enough to include IWT noise. NONE of the available data suggested otherwise. Notable is that wind turbine noise has been described as having a character that makes it far more annoying and stressful than other sources of noise at the same A-weighted level, including traffic and industrial noise. Additionally, Thorne, has pointed out that human perception of noise is based primarily on sound character rather than sound level, and that wind turbines are unique sound sources that exhibit special audible and inaudible modulated and tonal characteristics.
Particularly noteworthy are the WHO recommendations to policy-makers to reduce exposure from wind turbines in the population exposed to levels of 45 db Lden. Other forms of environmental noise which also had recommended noise levels were:
Aircraft: 45 dB Lden, 40 dB Lnight
Railway: 54 dB Lden, 44 dB Lnight
Road Traffic: 53 dB Lden, 45 dB Lnight
Industrial Wind Turbines: 45 dB Lden - nothing specified for night given inadequate data to allow a recommendation. The review data committee conditionally recommended that policy-makers implement suitable measure to reduce exposure from wind turbines in the population exposed to levels above the guideline values.
Given the current strength of available data, those sound level noise limits above are state in L"den" which means day, evening and night are set to hopefully avoid significant cardiovascular disease caused by environmental noise. Note that IWT level is equal to the aircraft level and much lower than railway or traffic noise. Lden is a "European 24-hour metric" with 5 and 10 dBA penalties for noise levels for evening and night respectively. A Lden of 45 dBA is approximately 38 dBA Leq that would imply (through normal calculation of Lden to Lnight - not specifically stated) a Lnight of 35 dBA Leq.
The reported guidelines were published by the WHO Regional Office for Europe. In terms of their health implications, the recommended exposure levels can be considered applicable in other regions and suitable for a global audience, as a large body of the evidence underpinning the recommendations was derived not only for European noise effect studies but also from research in other parts of the world - mainly America, Asia and Australia.
Under Part - 2 Sleep, I reviewed two more studies (that were published in 2019 - after the 2018 WHO report) that correlated sleep duration with cardiovascular disease presentation and with the development of asymptomatic cardiovascular disease (ultrasound-measured atherosclerotic vascular disease burden) These were large studies that linked sleep duration with disease endpoints without consideration of mention of sound levels, specific noise sources. Both of these studies initially appeared in "Cardiology Today" in February 2019 and were

explained under the title of "Sleep: the new frontier in cardiovascular prevention". Both studies have been published in prominent cardiovascular journals.
We know (as described in Part-2), that sleep is a required body function to restore and maintain normal health. It is much more complex than a set minimum duration but is composed of a complex set of stages (characterized as "architecture") through which sleep progresses to achieve specific organized neural activity (brain waves) during which memories are laid down, and metabolic by-products are removed - all in preparation for the "the next day". Stress (also termed allostatic load and caused by a variety of factors - sleep disturbance, annoyance - at various levels/sources) may interfere with "wholebody" health through chronic autonomic activation in mostly the "fight-or flight" (i.e. sympathetic) limb of an otherwise balanced and freely "oscillating" shift of the sympathetic and parasympathetic limbs.
Sleep duration in the studies above WAS associated with measured objective adverse cardiovascular endpoints. Obstructive sleep apnea has been associated with increased cardiovascular disease endpoints as has inhalation of very small particle sizes, post-traumatic stress disorders and an increasingly number of "chronic disease states". As described in the May, 2014 Journal of the American College of Cardiology, "Dysregulation of this system (autonomic) due to aging, acute and chronic stress, organic and idiopathic and other causes contribute to cardiovascular pathology, including hypertension, ischemic heart disease, arrhythmias and congestive heart failure and often contributes to fatal outcomes".
For the purpose of providing evidence of an existing framework through which autonomic dysregulation operate, I briefly described the mechanism involving the renin angiotensin aldosterone system (RAAS) and included a description of chronic stress and Endothelin-1 which is a vasoconstrictor agent that is integral to stress-triggered disease states. I also reviewed the complex relationship of obstructive sleep apnea (and associated chronic higher sympathetic tone) and the development of cardiovascular diseases.

Part - 7 Additional Topics

The Nocebo Effect, in my mind may be Wind Energy's most original piece of "science", however has no relevance to chronic annoyance associated with IWT exposure. The WHO has completely rejected any relevance of the Nocebo effect. The Wind Farm Noise textbook pronounced Wind Energy's literature "claiming to prove that all adverse health effects are a result of a nocebo effect" is based on suspect data. A fair and thorough critique of the nocebo effect also appeared in the Punch and James review article. They reviewed the Chapman, Crichton and Taylor studies and pointed out multiple shortcoming and improbable conclusions. They concluded that "we believe that while psychological expectations conceivably can influence perceptions of the effects of wind turbine noise on health status, no scientific studies have yet convincingly shown that psychological forces are the major driver of such perceptions. Punch and James believe those drivers are the physical stimuli themselves and the internal physiological reactions they induce.
There exists a range of noise sensitivities across a population of people; there is NOT a precise and specific noise threshold for sound sensing for all people. People respond differently to different sound types and sound levels. This simple fact of normal human "variance of phenotype expression" (...everyone is a little different) is almost always missed or is unknown by most people. At the series of three Supervisor "town hall" meetings requesting public opinion about IWTs, many "pro-wind" individuals (who lived in the Macksburg Wind Farm) provided oral testimony saying that there was no danger from wind turbines as they were unaware of any problems they had noticed and that they could work all day and were not bothered by turbine sound. They also commonly mentioned that they "had no trouble sleeping". Such testimonies represent the "lucky ones"(....so far) as well as well-known auditory responses involving background noise levels, etc. Minor degrees of annoyance could include up to 30% of individuals where IWT siting is within 500 meters of a house. Such interpersonal differences do not reflect that IWT noise recognition is more emotional-based or subjective or easily ignored or in any way "contrived".
"Human rights and social justice" reflect upon and reviews the loss of respect that we have for our neighbors that are "forced" to endure chronic IWT noise and frequently become victims of its annoyance and adverse health effects. A very recent article (Krogh, et. al., published June 28th, 2020) on why residents evacuate their homes provides intimate connection to their perceptions of imposed injustice. One resident asks "why is it the responsibility of the potential sufferer to prove the proposed adverse health effects rather than the initiator of

the risk to adequately demonstrate the absence of health consequences prior to initiating the risk? Affected residents rightly ask why they are considered "expendable". Current turbine approval practices violate the "precautionary principle" that would require that a particular industrial activity not be undertaken unless there is no doubt that such an activity will not harm any people. Again, my recurrent statement to Wind Energy: Industrial Wind Turbines have never been proven to be safe. No response - which is their response when they have nothing to counter that statement (and they hope the question eventually just "goes away").
There is a review of vulnerable populations in a very complete review of acoustic considerations for schools and other learning environments. The WHO and ANSI (American National Standards Institute) talk about the concerns of a noisy classroom, noting that a signal to noise ratio of +15 dB (i.e. speech signal is 15 dB louder than the background noise) is needed to optimize classroom communication.
Since 50 dBA is the sound pressure level of normal speech, room noise levels of 35 dBA or more interferes with the intelligibility of speech in smaller rooms. Mr. Clifton and Price believed that school room sound levels in West Des Moines were possibly 45 dBA. Of particular relevance is that "learning" goes on at home as well as in schools. In addition, high quality, restorative sleep with more sleep time needed by developing children - a critical part of health brain development - is needed when children return home. Such "brain development" may be affected by neuro-cognitive impairment from inadequate sleep.
Of substantial importance to the "healthy growth" of Earlham or any other town will be "room" to grow at outward from the current town margins. Please see my suggestion in that section.
Cardiovascular disease remains the leading cause of death in the United States - unfortunately that trend is increasing over recent years. The decrements in cardiovascular outcomes have been worse for people living in rural counties. Madison County is considered a rural county without an urban core.
There is now at least a 20% disparity with rural counties having a worse death rate as measured by "excess death rate" per 100,000. Data from the 2017 CDC showed a 40% higher prevalence of heart disease among rural residents - a gap that has grown over the past decade. Rural areas have higher rates of uncontrolled traditional cardiovascular risk factors compared with urban areas. There are other listed "sobering" facts.
Placing annoying/sleep-depriving industrial wind turbines in rural populations seems particularly cruel and insensitive as the additional negative health (physical and mental) consequences of IWTs on rural populations will likely be much worse in that population with already worse existing cardiovascular disease.
I reviewed some thoughts about electricity costs, decommissioning costs, blade disposal, minimal recycling potential "realities", shrinking turbine warranty periods, and the usual practice of placing IWTs in close proximity to residents to essentially guarantee "resident outrage and annoyance". Current practices by MAE reliably invite litigation which should be seen as a "replacement of science and a failure of leadership".
Blade throw has been mentioned at most meetings concerning IWT placements and ordinances. A study from a university engineering department in conjunction with a Wind Energy consultant at a national IWT testing center made the follow conclusions and recommendations: setback from IWT to property line should be 2 times the overall turbine height and from IWT to residence should be 3.5 times the height. Mr. Clifton suggested 1.1- and 3.0-times height respectively without providing any source documentation for that empiric distance except to "try to get more turbines inside a section – his words".

Part – 8: Peer Review

I first describe the purpose and the execution of research undertaken (mostly in medical situations) of new products, new dosing or combinations of existing treatments, comparison of new treatment regimens to existing "current standard of care" treatment for human illness such as cancer and heart disease and a host of other human conditions. It also covers new devices - implantable insulin pumps, pacemakers, defibrillators, leads that used with such implantable devices, neuro-stimulators and many other "gadgets" in which safety is paramount and showing that the medications, treatment, device is effective. As commented, there are multiple layers of oversight from local to regional to national levels. Training of investigators and co-investigators is needed. Of particular importance is that close monitoring of "adverse events" is done and reported to the study sponsor and the local IRB (Investigative Review Board). The latter entity is charged with the protection of study subjects, acquiring informed consent from participating subjects, monitoring the occurrence and types of adverse events and making sure that death, heart attacks, bad infections and on and on.... are recognized,

treated and changes to the research are made if necessary and close follow-up is maintained. The IRB has the right to "shut-down" an ongoing research study in which unexplained, or excessive amounts of serious events among other endpoints, occur.
An initial study examining potential adverse events associated with IWTs never occurred or I am sure I would've heard about it - particularly after describing it in an article I wrote for the Madisonian newspaper. I am not suggesting (because I do not know for sure), that "formal" IRB oversight for a trial designed to confirm safety should have been done but the shear amount of AHEs and the controversy and unsubstantiated claims made by Wind Energy/turbine manufacturers does demand a complete and transparent study examining health consequences. Given the amount of unreported events and uninvestigated problems associated with IWT exposure, unknown short- term vs long-term consequences of exposure and the complete (best I can tell) lack of detailed medical investigations of adverse health events by trained medical personnel in conjunction with biomedical engineers with ongoing dramatically increasing size and noise emissions outputs of new IWT models without initial and interval reassessment of human impact is (in my opinion), unethical. This is even a more dramatic omission given the rapid growth of our understanding of sleep and its importance and the environmental noise levels that trigger sleep disruption being substantially exceeded by "current accepted" practices of close siting of IWT to places of residence. Of particular concern which is essentially ignored, is the possibility of vibroacoustic disease in animals and humans occurring with resonance energy transference to solid organs. Visual complaints are not infrequent in residents in recently activated wind farms. Reports of blindness in ducks, donkeys, horses and occurrences of unexpected sudden death in farm animals, dogs and other pets has been reported by residents. Post-mortem examination on animals have found "enlarged organs". To my knowledge this has not been evaluated in formal studies. It certainly has not been reported by the manufacturer of IWTs nor energy contractors. The occurrence of these observations is not disclosed to easement participants. As I explained to our county supervisors, "I am not aware that people and their live animals are considered 'expendable' when forced to endure unwanted and uninvestigated powerful low-frequency noises". Reading about infrasonic acoustical weapons research (where available) in the U.S. and the former Soviet Union, raises concern – particularly for more chronic (long-term) exposure at "just-less than weapons grade power levels". Remember, as the IWTs keep getting larger and more powerful, there is a progressive relative increase in levels of ILFN emissions they generate.
There is also a review of scientific processes to determine causality by properties of causal relationship. Sir Bradford Hill's work was summarized. The value of adverse health reports as related by Carl V. Phillips was reviewed. Outside critiques are included of one of Wind Energy's promoted studies that honor their view: the AWEA/CANWEA Report into Turbine Sound and Health.

Part – 9: A view toward "The Dark Side"
In this section, I listed several visions through the cracks in Wind Energy's veneer of corporate sainthood and righteousness. These primarily focus on the Danish company Vestas which is the leading manufacturers of industrial wind turbines. They are worth reading and placing into the bigger context of "why they say what they say and do what they do". I provide these as "past actions" that have happened. I do not cherish these "uncloaking's" but, personally, they, at least, helped me understand the more important "bigger picture"... perhaps more important than "arguing decibels". Please see my disclaimers.
An exceptional "profile in courage" was a speech to Vestas Corporate by a Danish physician who (in my opinion) laid out the facts and asked Vestas to do the right thing. Powerful...

Part – 10: Carbon.... What to do.
Here I humbly present my concerns about global warming and review some of the concepts that keep me up at night - loss of biodiversity and loss of a lot of happiness.
I list what I believe are better choices for energy management in our future. I vaguely refer to "nuclear energy" as I have listened to others far brighter than I who see this as more sustainable, cleaner and, when deployed and monitored closely, much safer. What is clear and has been for far too long, is that our current ways of utilizing planet resources are simply not sustainable. I strongly believe in the environmental promise of regenerative agriculture which works to sequester atmospheric carbon particularly in Iowa. Although it has

been a recognized way to farm for more than 150 years, (we) have switched to an agrochemical style farming practice (this opens up a huge area of complexity).
Regenerative farming restores the CRITICAL connection between growing plants and organic soil rejuvenating processes. Others have seen this farming practice and jumped in to find extraordinary rewards. Observed phenomenal benefits of increased soil fertility through regenerated organic content of our soils are observed returning the soil back toward the complexity of pre-settlement soil architecture. Such increasingly restored soils facilitate much less carbon-producing farming practices, greater ability to retain water with better avoidance of soil erosion - the latter problem being another new reality of "Man-induced" global warming. It is truly a win-win option that we should acknowledge and pursue NOW – in Iowa and at a world-wide scale.

Part – 11: Applied Regulation of Noise
In this section, there is a focus on achieving an optimal residence sound level for achieving restorative sleep. Consideration of outside-to-inside audible sound attenuation are discussed in line with WHO recommendations. Difference of Leq vs Lmax are described and why, to protect sleep, the Lmax sound limits are much preferred. The math of decibels is described illustrating why 45 Leq as seen with a 2 MW IWT at 1500 feet from a residence will NOT achieve the recommended level of 30-32 dBA Lmax.... instead setbacks to be in compliance with those nighttime sound limit levels will require separations of 2km or about 1.25 miles WITHOUT IWT clumping or in-line siting. Anything shorter creates significant annoyance and leads to complaints, lawsuits, home evacuations and other severe adverse health effects.

Part – 12: Recommendations
In this section I included scenarios and considerations that protect the residence form annoyance and most other forms of adverse health effects. I do not believe a "compromise to permit co-existing industrial energy production that is associated with noise effects that harm residents are acceptable.
The energy developer must be willing to compensate or "buy-out" the resident if at a pre-wind farm placement appraisal price. Setbacks distances are not the primary metric of IWT siting – target receptor sound levels are THE PRIMARY determinant. Setback distances from property are important as well and should be 2 times the total height of the turbine. It is unfortunate that IWTs currently deployed have such serious health consequences at previous utilized distances of 1500 feet. Indeed 3600 feet is the shortest distance listed in the Punch and James review article and that depends on a calculated target sound level likely not possible with such large IWTs. Realistically, 2 MW IWTs will have to be >1.25 miles to achieve safe home experienced emission levels. At that distance, annoyance will be minimal and serious AHEs and litigation will be likely non-existent. Utilizing unapproved ETSU-R-97 guidelines that employ "pseudo-science" considerations for nighttime sound levels in rural residential environments with background noise levels of about 25 dBA is absurd and presents "willful abuse and unethical actions" of an energy contractor. I would like to see a maximal permissible/worst case scenario resident sound level of Lmax of 40 dBA or a Leq of 30 dBA. These are concordant with textbook recommendations and countries who have responsibly responded to the demands of health safety and property rights. In addition, separate Lmax regulation of ILFN emission using C-weighted values is strongly suggested.

Part – 15: Conclusions
Avoiding "Adverse Health Effects" is the focus of health care. "Doctoring" in early America (simplistically) revolved around fixing bones, sewing up lacerations and delivering babies. As our understanding of disease processes and normal and diseased human physiology has exploded in recent decades, we now see applications of endless technologies to address the physical and mental health needs of our suffering fellow human beings. Recognizing and attempting to encompass all "contributors to disease" in our desire to reach "optimal health" has broadened our focus from individual disease expression to include societal factors that can trigger and exacerbate disease and limit the high quality of life we all seek. Indeed, the Affordable Care Act (whether you like it or not) as well as competitive private health plans and Medicare services emphasize "prevention and wellness".

As stated, the WHO defines health as "a state of complete physical, mental and social wellbeing and not merely the absence of disease or infirmity". This model of health considers the physiological, psychological and social factors in health and illness, and interactions between those factors. The WHO definition links health explicitly with wellbeing and conceptualizes health as a human right requiring physical and social resources to achieve and maintain. "Wellbeing" refers to a positive rather than neutral state, framing health as a positive aspiration. Health is considered as "a resource for everyday life, not the object of living". Health is a means to living well, which highlights the link between health and participation in society.

Mental health and physical health are inextricably linked; with mental health influencing physical health and vice versa. Stress responses are known to affect physiological processes regulated by the autonomic nervous system including cardiovascular, respiratory, digestive, repair and defense functions.

While it is clear that physical ill-health can be accompanied by mental health problems such as anxiety and depression, the resulting psychological state may in turn impede the recovery or stabilization of medical conditions, thus producing a vicious circle in which wellbeing is difficult to attain. All this is said to emphasize that annoyance - at almost any level - can contribute to adverse health effects. This is particularly relevant when the source of annoyance is not wanted and cannot be eliminated and leaving one's home is the only remedy.

It is important to demonstrate past recognition of "annoyance as an adverse health effect". Please see the following citations:

The 2009 WHO Night Noise Guidelines for Europe created a flow diagram of (environmental) noise exposure with high sound levels directly activating "stress indicators" including the sympathetic limb of the autonomic nervous system. Moderate noise levels were pictured to follow an indirect pathway noting sound disturbances of activities, sleep, communication producing cognitive and emotional response - described as "annoyance".

The Council of Canadian Academies (4/9/15) described their review of supportive evidence for "annoyance" to be sufficient when referring to contributions to adverse health effects.

Data from the LARES study (2006) "confirmed, on an epidemiological level, an increased health risk from chronic noise annoyance. (further) The results of the LARES study in relation to severe annoyance by neighborhood noise demonstrate that neighborhood noise must be classified as a serious health endangerment for adults".

Pedersen and Persson Way in "Wind Turbine Noise, Annoyance and Self-reported Health and Well Being in Different Living Environments" (2007) stated: "Annoyance is an adverse health effect".

The WHO Training Package states that adverse effects from noise exposure can include direct ear damage, indirect adverse effects (physiological and psychological effects) and impaired cognition....

Cognitive effects can include reading, concentration, memory and attention issues. Chronic noise exposure impairs cognitive function (reading comprehension and long-term memory) and that dose response relationships are supported by both laboratory and field studies and that "over 20 studies have reported that noise adversely effects children's academic performance".

Bakker, et al, in "Impact of wind turbine sound on annoyance, self-reported sleep disturbance and psychological distress" (2012) noted: "A dose-response relationship was found between emission levels of wind turbine sound and self-reported noise annoyance. Sound exposure was also related to sleep disturbance and psychological distress among those who reported that they could hear the sound, however not "directly" but with noise annoyance acting as a mediator. Respondents living in areas with other background sounds were less affected than respondents in quiet areas".

In 1991, Suter on "Noise and its Effects - Administrative Conference of the United States" stated: "noise has a significant impact on the quality of life, and in that sense, it is a health problem in accordance with the World Health Organization's definition of health....along those lines, a 1971 WHO working group stated: "Noise must be recognized as a major threat to human wellbeing....annoyance can connote more than a slight irritations; it can mean a significant degradation in the quality of life. ..... this represents a degradation of health..." Michaud, et al "Noise Annoyance in Canada", Michaud is a staff member of Health Canada, Referring to the WHO definition of health, "under this broad definition, noise-induced annoyance is an adverse health effect".

(2010) Heath Canada document: "Health Canada considers the following noise-induced endpoints as health effects: noise-induced hearing loss, sleep disturbance, interference with speech comprehension,

complaints and change in percent highly annoyed" Jeffery, Krogh, Horner (2013) "Adverse health effects of industrial wind turbines", Canadian Family Physician, "noise-induced annoyance is acknowledged to be an adverse health effect. Chronic severe noise annoyance should be classified as a serious health risk". General Purpose Standing Committee.... (2009, Australia): "...reputable research has shown that noise annoyance is an adverse health effect that can result from wind farms, as it can result in effects such as negative emotions and sleep disturbance.

Of great importance are comments from Wind Energy's principle thought-leader acoustician, G. H. Leventhall: Leventhall (2009) attributes these reported IWT symptoms as effects of 'annoyance by noise' stating, "I am happy to accept these symptoms, as they have been known to me for many years as the **symptoms of extreme psychological stress** from environmental noise, particularly low frequency noise". The effects of low-frequency noise-induced annoyance and stress from various sources have been researched". Levanthall (2004), "Regulatory authorities must accept that annoyance by low frequency noise presents a real problem.... " and that "The claim that their 'lives have been ruined' by the noise is not an exaggeration..."

From Wind Farm Noise (textbook):

There is a considerable amount of anecdotal evidence and published research that suggests that wind farm noise does seriously and adversely affect a small but significant proportion of the population.

Nevertheless, many acoustic, social science and medical **professionals ignore this evidence by defining 'scientific evidence' in a very narrow way and then stating that there is no 'scientific evidence' available that proves beyond doubt that wind farm noise can harm anyone. (Writer comment: This is exactly the wording and precisely the tact that Wind Energy uses to dispute the magnitude of contrary data that I have summarized and presented here).**

As pointed out by May and McMurtry (2015), there seems to be a tendency in the medical research discipline to interpret the lack of rigorous evidence of a causation link as proof that the link does not exist.

(Writer's comment: Previously, in part - 8 "Peer Review", I described the nine elements that Sir Austin Bradford Hill felt were critical in establishing causation are relevant and adequate to declare (in assessment of the data) that IWTs cause adverse health effects. Sir Hill noted that "all scientific work is incomplete - whether it be observational or experimental. All scientific work is liable to be upset or modified by advancing knowledge. But that does not confer upon us a freedom to ignore the knowledge we already have, or to postpone the action that it appears to demand at a given time. In other words, if it quacks like a duck, looks like duck and flies like a duck, (and 6 other features) ... then it is reasonable and appropriate to believe it is a duck).

There have been many hundreds of case studies that demonstrate that the health of a significant percentage of people has been affected by wind turbines. **Whether or not these adverse effects are directly caused by wind turbine noise or are indirectly caused by such things as sleep disturbance as a result of a nearby wind farm is a moot point, as either case results in the same conclusion: that is, wind turbines result in some people living in their vicinity suffering adverse health effects.**

Even further to support that wind turbines cause adverse health effects, it is remarkable (in light of the strong wording of implausibility Wind Energy carefully uses each time when proclaiming "non-causality") is that the literature that Wind Energy offers to support that phraseology, state that "IWT noise produces annoyance". Annoyance as a concept is well-established and used by both sides of the argument. The World Health Organization (and MANY other researchers) define annoyance as causing adverse health effects. Indeed, Wind Energy's "top acoustician", Dr. Leventhall, explains symptoms created by wind turbine noise exposure as consistent with his experience with low frequency noise effects he himself has experienced. Dr. Leventhall did some of the earliest evaluations of low frequency sound found in the evaluation of "noise-induced sick building syndrome". He helped to conduct the controlled tests needed to separate out the characteristics of HVAC sound associated with the reported symptoms and poor work performance (range of symptoms of HVAC were quite similar to later symptoms associated with low frequency wind turbine noise). These symptoms were linked to modulated low-frequency (and infrasound) HVAC noise.

Earlier, in 1982, Leventhall and Vasudevan published "A study of Annoyance Due to Low Frequency Noise in the Home". The abstract described annoyance leading to health problems in some cases. ... low frequencies were capable of causing annoyance, especially when the noise fluctuated in level (Writer comment: "was modulated"). In his introduction he also commented "when the noise nuisance also involves low frequency

noise, much evidence exists to suggest that the annoyance reaction to the low frequency noise is greater than that implied by the (measured) estimates of loudness of the noise. The A weighting scale... takes little account of the low frequency sound energy. This practice in industrial noise regulation often encourages machinery manufacturers to concentrate almost entirely on attenuating energy in the middle and high frequency ranges. As a consequence, modern plan and machinery - increasing in size all the time - may be making a growing contribution to the sound energy in the low frequency range. The noise could become subjectively louder although the dBA level is reduced". (These comments by Dr. Leventhall almost exactly express the current observations and concerns of industrial wind turbine noise. Again, Leventhall was a pioneer in our understanding of infra- and low-frequency environmental noise which then was "mirrored" by wind turbine noise.

Somewhere in the mid- 2000s decade he became aligned with Wind Energy- essentially becoming their acoustician scientist - and his concordance of opinion (with other peer acousticians) that IWT noise cause adverse health impacts essentially reversed without explanation).

Dr. Malcom Swinback, during his 2015 testimony before the Select Committee on wind Turbines in March, 2015, added his observation about health effects associated with wind turbine infrasound. "one of the reasons for confusion in the reporting of adverse health effects from wind turbines lies in the fact that permitted IWT sound levels in the USA are generally significantly higher than those in other countries. Whereas many countries now seek setbacks of typically 2 km, in the USA, setback of 300 - 400 meters are not uncommon, with corresponding permitted sound levels of 45-50 dBA or higher.

Consequently, there are considerably more complaints from affected residents, compared to other countries with more cautious standards. Worldwide discussion and assessment of such problems often does not make this distinction clear, with the result that there can be significant confusion as to which problems arise from these VERY CLOSE SETBACKS, and those which can still prevail at larger setbacks.

(Continuing from the "Wind Farm Noise" text): "It seems that the only type of scientific evidence that would be generally acceptable to those who do not believe that there are any adverse health effects results from wind farms, would be longitudinal epidemiological study of thousands of people with confounding factors removed, which is clearly an impossible task.... The situation is very similar to the debate on anthropogenic global warming. This too has not been proven beyond any reasonable doubt, but there is plenty of evidence that global warming is occurring and that it is a result of the activities of man. However, there are always those, who for whatever reason, will deny the patently obvious and continue to do so regardless of any evidence with which they are confronted".

In the "Wind Farm Noise" textbook, their conclusions continue...

It is time to stop debating whether or not a problem exists. It is well known that wind farm noise does result in sleep disturbance and adverse health effects for some people and the time has come to decide what to do about it. However, further research is needed to determine whether the problem is inaudible infrasound (writer's comment: or perceivable infrasound - particularly as infrasound noise levels rise as IWT power generating capacity increase) or low-level, audible low-frequency noise. (Writer comment: the textbook continued with reminding us of a "normal" (associated with a bellshaped response curve) distribution of hearing sensitivities which permits 2.5% of the population to have hearing sensitivities up to 12 dB lower than published sound "limits" and that some people have become "sensitized" over time to wind turbine infrasound. Low-frequency noise rather than infrasound may generate adverse health effects through a stress response as a result of the audible noise being annoying or depriving sensitive people of sleep. The low-frequency noise from wind farms is particularly prominent in rural residences where the ambient noise level is low - especially at night).

The Wind Farm Noise textbook continued: "Affected people find wind farm noise to be very annoying and, as time goes on, they become more and more sensitized to it, (Writer comment: rather than habituated or that their "negative attitude softens or accepts" as Wind Energy may suggest), so they become more stressed and also suffer from insomnia and /or sleep disruption. Whether the problem is infrasound or low-frequency noise is not the most important issue. The fact remains that some people are so affected by wind farm noise that their health suffers and some are forced to leave their home in order to achieve an acceptable quality of life. Thus, it is important to begin work on new noise guidelines for new wind farm developments based on

maximum acceptable levels of A-weighted noise as well as acceptable levels of low frequency noise. Existing allowable levels (even the lowest of 35dBA) are too high for a significant proportion of the population who live in quiet rural area: the levels of 40 or 45 dBA allowed in some jurisdictions are well over what would be considered acceptable by most people. In addition, all jurisdictions should determine what would be a fair offer of compensation for those who have suffered ill effects, which would at a minimum include the offer to purchase their residence at the price it would have realized prior to construction of the wind farm.

An almost identical set of concluding responses are included in the Punch and James (2016) article: Wind Turbine Noise and Human Health in their response to Wind Energy's "blanket statement that there is no evidence in the literature to support a causative link between wind turbine noise and adverse health effects. The authors responded to this statement which is cited as factual by wind industry advocates in the literature and in legal proceedings. (In stark contrast) ... "there is an abundant literature, much of its peer-reviewed and authored by highly reputable researchers, indicating that audible and inaudible noise emitted by IWTS adversely impact the health and well-being of substantial numbers of people who are regularly exposed to wind turbines. It is clear that the literature review and papers claiming no AHEs **fail** to include important studies, international standards, guidance from the WHO, and research conducted on wind turbine noise and other sources of infra- and low-frequency sound. Whether this is through oversight or calculation, only reports that cite scientifically credible references should be considered legitimate sources of information. Our review has shown that it is unacceptable simply to state that the literature contains little or no evidence of a causal link between wind turbine noise and adverse health effects. At a minimum, those effects have been shown to be regularly correlated to living in proximity to IWTS, and there is sufficient evidence that those effects are highly associated with objective measurements of audible noise and infrasound".

The extensive Punch and James, 72-page article that included 180 references, finished with a needed "goal" of refocusing as described below: "Based on all the evidence presented, our fundamental view is that the controversy surrounding adverse health effects should not be polarized into two groups consisting of either 'pro-wind' or 'anti-wind' factions, but rather one in which there is room for a third, 'pro-health' perspective. Essentially, the pro-wind view is that IWTs should be installed wherever feasible, that definitive scientific research is lacking to indicate that turbines cause AHEs and that if you can't hear it, you can't feel it. The antiwind view is that IWTS should not be installed anywhere because wind is not an economically viable source of renewable energy, that all government subsidies and development efforts should end and that what we can't hear can hurt us. A pro-health view is that there is enough anecdotal and scientific evidence to indicate that ILFN from IWTs cause annoyance, sleep disturbance, stress and a variety of other AHEs to warrant siting the turbines at distances sufficient to avoid such harmful effects, which,
without proper siting, occur in a substantial percentage of the population. That view holds that what we can't hear can hurt some of us and that the precautionary principle must be followed in siting IWTs if such health risks are to be avoided. Industrial-scale wind turbines should not be located near people's homes, educational and recreational facilities and workplaces. It is our belief that the bulk of the available evidence justifies a pro-health perspective. It is unacceptable to consider people living near wind turbines as acceptable collateral damage while this debate continues."

I too, have pursued an entire life's career to "Pro-Health" goals - in the treatment of my patients as well as my neighbors and the community that I live in. Believing that IWTs placed "in harmful proximity to places where people live and work" to represent the answer to our world's energy production is like a discovering a bottle on the beach and expecting to find a genie inside that will provide answers to our wishes. When you look at the whole picture of wind-sourced energy to be clean and renewable and provide a clear pathway to environmentally-safe energy production, you realize that there is a misdirected faith in its supposed benefits. Instead we have to look toward other answers - rapid escalation of regenerative agricultural practices to sequester (ongoing) massive quantities of CO2 back into the soil, safe nuclear energy production, tolerable placement and recyclable photovoltaic electric production, much higher standards of efficiencies of heating and (particularly) cooling and many others and always...living "within our means". Afterall, we are sharing this planet with more than 3 times as many people than is reasonably sustainable given the finite resources of our natural world.

Mathias Basner, MD, PhD, attempted to frame the latest information about potential physical harm with environmental noise in a 2019 medical journal editorial. Dr. Basner is an Associate Professor of Sleep and Chronobiology in Psychiatry. He is the President of the International Commission of Biological Effects of Noise who personally reviewed and helped to summarize the data for the Oct, 2018 World Health Organization Environmental Noise Report. In the editorial, he acknowledged the problem of smaller populations in currently available studies which make statistical powering of conclusions difficult. He has stressed that NONE of the wind noise guidelines data from the 2018 WHO raised found an "absence of risk". He finished his comments with **"the fact that more studies are needed should NOT lead us to postpone the urgently needed protection of the population from noise. The knowledge we have acquired so far IS SUFFICIENT to take preventive actions and substantiate them with respective legal noise regulation."**

Bullets:

With the possibility of adverse health effects and industrial wind turbines it comes down to:

1) We have to accept that operating IWTs do produce noise that is harmful to an important percentage of those nearby; they are not harmless "pinwheels spinning in the distance".

2) Industrial Wind Turbines have never been shown to be safe for human health with respect to developing adverse health effects - particularly with long-term exposure to turbine noise. Accepting Wind Energy's proclamation that there is no credible evidence of a causal relationship between IWT noise and adverse health effects is to deny the existence of an enormous amount of information that link adverse health effects to exposure to IWT noise.

3) There is a range of human sensitivity to hearing or perceiving wind turbine noise. This means that some people will have serious adverse health effects while some may experience none. This variance in experienced health effects, after review of the bulk of literature (per Punch, James), are the physical stimuli themselves and the physiological reaction they induce.

4) Sleep disturbance is the most frequent of the most serious adverse health effects. It is not only related to excessive audible noise level but also to amplitude modulation in lower frequencies and audible and perceivable portions of the infrasound noise spectrum. Significant disturbed sleep will lead to mild to severe annoyance suffering and may promote serious cardiovascular disease.

5) We need to recognize the heightened susceptibility of adverse health effects in vulnerable populations that live within the range of wind turbine noise emissions. Providing quiet home and learning environments for children is essential for normal brain development.

6) As recommended by a wide range of supportive literature, World Health data and recommendations, textbooks that have very thoroughly researched all aspects of IWTs including health effects, greater scientific understanding of the importance of restorative sleep and strong confirmation of a need for a precautionary approach to avoid AHEs and likely serious health outcomes, we need to act NOW to implement protective ordinances for our citizens. Such adequacy of an ordinance is judged by the resultant absence of resident complaints and initiated legal action. To knowingly inflict resident oppression that compromises health is immoral. Continued optional IWT close-siting practices done solely to generate increased financial gains for wind contractors represents a failure of leadership by both parties and intentional disregard of voluminous concordant scientific data.

MAS
ENVIRONMENTAL

Ireland's Draft

Wind Energy Development Guidelines 2019

Review of guidelines by

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19th February 2020

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Appendix A - Institute of Acoustics article on noise

1.0 Executive Summary

1.1 MAS Environmental have exceptional expertise in relation to wind farm noise effects on residential neighbours and draw upon 45 years experience as well as its considerable background in research. MAS have been fundamental in identifying noise issues and how to evaluate them and provide wholly independent analysis of the draft guidelines.

1.2 Observations are based on our considerable experience and extensive wind farm noise database that is unrivalled in the information it provides.

1.3 Intended principles of tighter controls and addressing some AM character as well as low frequency noise is supported but the methods and wording adopted result in the guidelines permitting substantially more noise and undermine any enforcement of controls due to extensive ambiguity and misdirection of statements.

1.4 The approach adopted does not follow the science of acoustics, permits higher noise during periods of adverse impact due to long term averaging and applies insignificant penalties. I understand similar inappropriate averaging was recently considered in the case of *Lies Craeynest and others v Brussels Hoofdstedelijk Gewest and Others 2019* in an opinion of Advocate General Kokott.[1] At around paragraph 85 it was stated:

> *"There is a risk of adverse effects on health wherever the limit values are exceeded. Appropriate measures must be taken there in order to prevent adverse effects. It is only of limited importance to that risk whether an exceedance applies to the entire zone or agglomeration on average. This is clearly illustrated by the joke about the statistician who drowns in a lake even though it averages only a few centimetres in depth."*

1.5 Notwithstanding the averaging problem, procedures proposed to be adopted have been shown using our extensive database to fail to recognise the main forms of amplitude modulation experienced and that proposed for low frequency

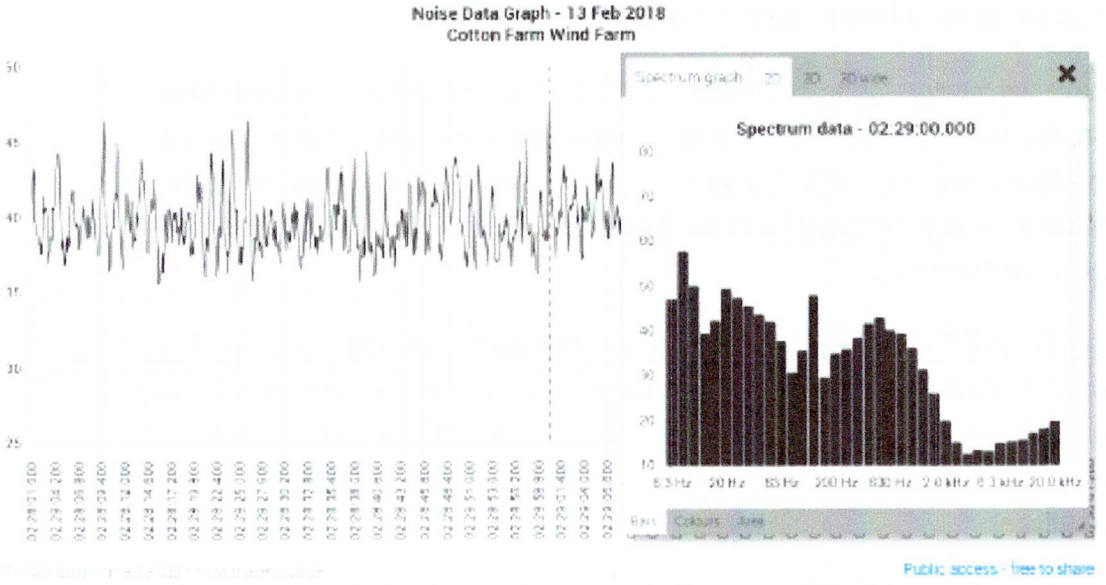
[1] http://curia.europa.eu/juris/document/document.jsf;jsessionid=CC659AAC994F94CDA0EA7FC24F86309F?text=&docid=211190&pageIndex=0&doclang=EN&mode=req&dir=&occ=first&part=1&cid=6525478

noise can only be used post development inside dwellings. This contradicts the objective of using external measurements only and reliance on prediction that is incapable of identifying this problem.

1.6 At the link directly below the noise shown and audible using good quality headphones attracts a penalty but is still compliant with the guidance as the penalty is small. This is before the period with the penalty is averaged with those periods when the noise impact does not arise and no penalty is applied. In reality even with the noise demonstrated in the graph and which can be listened to using the link, substantial margin remains through averaging. The spectrum graph on the right shows a significant low frequency peak at the point of an AM peak. This is common.

1.7 https://www.masenv.co.uk/webgraphs/cotton_farm_180213

On-line graph shows a level of AM wind farm noise compliant with proposed guidelines occurring 02:28 at night. Compliance arises when considered in isolation and before long term averaging



1.8 A substantial number of wind farms in Ireland cause widespread community complaints. The planning controls recommended in the WEDG do not address these problems and more insidiously would give the appearance of addressing noise issues without resolving the nuisance caused. The controls do not

correlate with protection of living standards or residential amenity. A different approach is required.

1.9 There are some positive points in the draft guidelines but ambiguity within terminology and phraseology permitting multiple interpretations is a major problem and is avoidable. Methods of control are employed which operate contrary to the science of acoustics and noise such any minor penalty arising will not change adverse noise into an acceptable level or form of noise. Intrusive characteristics will remain dominant and prominent resulting in inconsequential changes.

1.10 Attempts to reflect the WHO use of Lden exacerbates impact as erroneous adjustment for character is applied. An appearance of protection is given with prolonged investigation and measurement but incapable of preventing impact.

1.11 The procedures permit substantially more noise than other commercial and industrial sources when using BS4142:2014. There is no justification for this especially as wind farm noise can impact 24/7/365.

1.12 Benevolent interpretation of controls is required which ensures the most lenient interpretation would have to be applied regardless of intent. This is avoidable with clearer phrasing of the guidance. It can be concluded the methods of assessment being adopted facilitate the wind farm development to the detriment of all other concerns.

1.13 Good evidence of the extent of problems now exists but has not been drawn upon to evaluate the proposals. Many noise characteristics are ignored including important forms of AM. Further the prosed penalty becomes diluted by averaging in a manner not used in other guidance rendering it entirely insignificant.

1.14 Procedures in BS4142:2014 are entirely applicable and effective for wind farm noise and would place them on "a level playing field" with all other sources of industrial and commercial noise.

1.15 Guidance in England and Wales has moved away from specifying decibel limits due to the failure of such an approach and has not led to difficulties. The decibel level is a minor consideration in the human response to noise in cases where

impact is due to dominance or prominence. In England and Wales each case is assessed on its merits. A framework can readily be formulated that is fair, as found in BS4142 and that would be wholly applicable to wind farm noise mixing sound energy and noise character control requirements.

1.16 There is widespread support for adopting a different approach instead of the recognised flawed ETSU-R-97 approach. There are fundamentally two types of noise and their assessment and control for each differ significantly. Both arise with wind farms but separating their assessment and control is wholly undermined by the draft guidelines. Noise with special character affects people moment by moment and the frequency and duration of adverse incidents needs to be addressed. This is not addressed through long term averaging when incidents of impact are lost through averaging. Long term averaging can apply and assist with benign steady wind farm noise but not the moment by moment characteristics which impact due to their dominance and prominence at the time.

1.17 Wind noise has significantly different spectrum content to turbine noise as experienced at residential receptors. Even when of a similar level wind does not mask turbine noise. The exceedance permitted indicates it can always be dominant and prominent and comply. Furthermore, when moving inside dwellings the difference in spectrum means the wind noise is differentially reduced far more resulting in increased dominance by turbine noise inside. What is required is to ensure periods of significant adverse impact rarely occurs as it is masked.

1.18 Additional key findings include:

a) Most wind farms causing noise nuisance appear as compliant with the planning guidance now proposed.

b) Ambiguity in any guidelines serve to compound issues over their interpretation. There could be compliance despite serious adverse impact upon local communities.

c) There are repeated cases that arise where data shows serious intrusion, but assessment of planning guidance leads to arguments of compliance.

Adoption of these procedures as part of the Irish guidelines can only be likely to produce the same conflicts and contradictions.

d) The MAS website includes a case accepted as causing nuisance but which complies with the proposed Irish guidelines as benevolently interpreted.

e) The wording of the document introduces considerable ambiguity and this permits application of the most lenient interpretation following the need to meet criminal standards of proof. These problems and contradictions can readily be addressed.

f) Long term averaging of what already is the average level, using the LA90 index (the wind farm's quietest 10%) is being adopted in these draft guidelines. This is contrary to commercial noise guidance equally applicable such as contained within BS4142: 2014.

g) Adverse impact from wind farms most commonly occurs when background sound levels are lowest and worst case AM, thumping and other characteristics such as low frequency effects are greatest. This is lost through averaging.

h) Long term averages are useful in terms of benign sources of continuous noise occurring 24/7/365 that lack significant attention drawing character. Noise which draws attention due to its character and also non-acoustic elements is unsuitable for assessment using such methods.

i) Adjusting such long term average limits to reflect special character in the noise with an average penalty is fundamentally flawed as it needs to relate to its dominance and prominence moment by moment. It can be described as a "smoke and mirrors" procedure that does not address the problems.

j) No support for the procedures adjusting the noise controls adopted in these draft guidelines are found in the WHO European Guidelines 2018. Instead they provide significant warnings.

1.19 Low frequency noise has been shown as a major and common problem with modern wind farms but this appears denied in the draft guidelines. We have routinely measured low frequency noise problems at wind farms in Ireland and

the UK. Procedures to address this are not adequately formulated in the draft guidelines and mislead.

1.20 Reference is made to the Defra curve but this is an internal procedure where different time periods of measurement could be applied. There are other methods for low frequency noise not considered. The draft guidance argues against internal measurements. There are various misrepresentations summarised as follows:

1) Internal impact is commonly very different to external impact.

2) Various internal measurement locations can be utilised giving different results so no consistency.

3) Argument arises how external levels relate to internal levels.

4) The Defra method does not consider varying amplitude modulation as a form of low frequency noise nor impulse content.

5) It is impractical to measure its effects pre-development.

6) Alternative external procedures based on detailed research have been developed but are ignored.

1.21 Analysis of background sound levels is misleading. Graphs used falsely show levels barely dropping below 20dB LA90 but this is dictated by the limitations of instruments. A serious problem arises over false indication of higher that actual background sound due to common use of instruments with limitations. This is not addressed in the draft but perpetuated and misleads. At MAS we use special microphones with a noise floor between 6.5-8dBA. We routinely record level externally in rural Ireland as low as 10-12dBA.

1.22 Arguments ETSU-R-97 and therefore the draft guidelines reflect BS4142 is seriously misleading. It is stated in ETSU-R-97 but false. In this document I demonstrate this is wrong in relation to averaging, index used, analysis of background sound applied, the way penalties are applied and their extent and principles of acceptability. Simple comparison reveals the draft guidelines indicate acceptable noise when BS4142 identifies unacceptable noise.

1.23 The draft guidelines wrongly argue changes to ETSU-R-97 reflect development of modern large turbines. The converse is true. They operate to hide the added impact of large turbines.

1.24 For example, there is the adoption of standardised wind speeds rather than wind near the ground that reflects wind masking noise. This means true wind speeds are ignored at any moment in time and a standardised one is substituted. The greatest adverse impact arises under an atmospheric state called "stable atmosphere". This is a common occurrence at night. During these conditions the blades experience high wind speeds at the top of their rotation but at ground level there is extremely little wind due to high wind sheer. In terms of background sound it is quiet.

1.25 Standardised wind speeds assume much higher masking winds at ground level that arise and much higher background sound levels are assumed.

1.26 The outcome is that the worst periods of adverse impact occur with very low masking noise but much higher background sound levels are assumed. Resulting in significant understatement of impact.

1.27 The method of evaluating Amplitude Modulation (AM) proposed has been shown to manifestly fail to reflect or be triggered for two critical forms of AM. No explanation why such a flawed methodology is proposed or recognition that it has been shown to fail. There are various serious flaws:

a) Extensive ambiguity how to apply the procedures permitting a range of outcomes and interpretations.

b) Penalties are applied to the LA90 index general noise but AM is not measured by it and requires separate control. At most it means very slightly lower energy levels are permitted but without any change to the adverse impact.

c) Averaging of the penalties wholly diminishes any adjustment they might apply..

d) Evaluation of correct application is impractical.

e) False positives and more commonly false negatives are common.

f) It does not relate to actual impact during any period other than potentially identifying one form of AM arose. It misses much AM.

1.28 It is questioned why a set of procedures which knowingly miss many forms of adverse character impact and result in minor and irrelevant penalties are proposed. Annual averaging also renders the analysis and adjustments impractical.

1.29 There is reliance on ETSU-R-97 based procedures but Defra wind farm nuisance guidance confirms its lack of usefulness. This is not addressed.

1.30 The procedures underrate or wholly miss the effects of:

a) Erratic and irregular AM

b) Simultaneous occurrence of whistling and whirring in some cases with the AM.

c) Occurrence of low frequency noise with the AM which may or may not also modulate.

d) The effect of very large variations which can be up to 15dBA on a second by second basis.

e) Changes in the character and spectral content of the AM beats on a moment by moment basis such that successive beats exhibit a different pitch or characteristic.

f) Changes in impulsivity of AM beats where some rise more gradually and others have distinct impulse content with sudden change.

g) Directional effects where different forms of AM arise in different directions.

h) The additional underlying roar of general wind farm noise on top of the characteristics identified.

1.31 There is selective reporting of the guidance provided by the WHO 2018 in the draft guidelines. The WHO's precautionary application of an Lden also includes

substantial concerns and caveats regarding noise character that the Lden does not cover or address.

1.31.1 Due to a lack of high-quality evidence, as defined by the WHO, the recommendations on wind turbine noise are conditional and for many of the investigated health effects there was insufficient evidence. However, the WHO has set a recommendation for reducing noise levels from wind turbines below 45dB Lden.[2] It is also noted within the guidelines that below this exposure level there might still be a risk of annoyance. In addition, and of note, the WHO caveats that the descriptors Lden and Lnight may not be appropriate for describing wind turbine noise and this may limit the ability to draw associations between wind turbine noise and health effects.

1.32 The Lden precautionary recommendations cannot differentiate locations such as being adjacent a motorway, within a dock or large industrial complex where there are high levels of masking noise. These do not compare to a remote rural area where there is no mechanical or industrial noise other than the wind farm. The application of the same limits to both is illogical and not intended.

1.33 There is no basis to try to adjust the Lden based on averaging penalties especially when the index is viewed highly precautionary. Such an approach is in scientific terms, perverse. Penalties can apply to short periods of noise impact but not in relation to long term values in this way.

1.34 The WHO lists several characteristics of wind farm noise that may exacerbate impact compared to the sound energy level alone and why the Lden and Lnight descriptors may not be appropriate. This is a case of inappropriateness and not trying to adjust them by minor penalties that are unrelated to the impact at the time. They state:

[2] The Lden is a long term average noise level. It is calculated assuming that there is an equal (or equivalent) level of noise over a whole day. Greater weighting is given to periods where more freedom from noise is expected, evening and night time. It is a descriptor typically used for transportation sources. It can be used to investigate noise dose; however, caution must be exercised when looking at sources such as wind turbine noise where there are specific characteristics to the sound which may cause adverse reaction at lower levels than sources without these characteristics. The Lden cannot describe how the sound environment changes on an hourly, minute by minute or second by second basis.

"Wind turbines can generate infrasound or lower frequencies of sound... The noise emitted from wind turbines has other characteristics, including the repetitive nature of the sound of the rotating blades and atmospheric influence leading to a variability of amplitude modulation, which can be a source of above average annoyance (Shäffer et al 2016). This differentiates it from noise from other sources and has not always been properly characterized. Standard methods of measuring sound, most commonly including A-weighting, may not capture the low frequency sound and amplitude modulation characteristics of wind turbine noise (Council of Canadian Academies, 2015).

1.35 Rather than apply an averaged penalty to an Lden value the WHO caution against use of A weighted values. The WHO guidance reinforces a common theme recurring throughout recent noise guidance and research that context and character play a large part in determining human response to sound. The WHO were unable to determine a separate night time criteria for protecting health from wind farm noise. This seriously undermines the attempted adjustments which are unsupported by WHO advice.

1.36 Adopting the guidelines as written is predicted to lead to continued serious land use conflicts where local residents have abandoned their homes or live in continuous stress with no relationship whatsoever between acceptable noise in the home and the levels permitted by the proposed guidelines.

1.37 Recognition of the lack of utility of decibel based controls has progressively led to the abandonment of planning guidance other than in a minor way in the UK that is based on decibel levels. The findings of the WHO support the serious need for caution. However an effective method is found, with minor adjustments in BS4142:2014 and such an approach is recommended.

1.38 Part 2 of this submission provides extensive research which demonstrates the principles and observations made in this part.

2.0 Expertise of MAS Environmental and background to comments

2.1 MAS Environmental Ltd. (MAS) have unrivalled expertise in wind farm noise impact upon local communities which is combined with its unique work and experience in nuisance investigations. We employ a team of five environmental noise specialists four of whom work extensively in relation to wind farm noise.

2.2 Our main research and publications are found on our website at the link below along with a large number of wind farm noise samples which demonstrate many of the characteristics. The second link connects with more of our work and actual samples of wind farm noise.

https://www.masenv.co.uk/publications

https://www.masenv.co.uk/windfarms

2.3 Much of the work of MAS is focussed in assessment of apparently compliant wind farms but which result in serious and continued community complaints. We consider we are able therefore to provide extensive guidance on the proposed guidance.

2.4 MAS operate internationally and in collaboration with researchers across the world. This includes providing data for other researchers from our extensive database obtained from a community monitoring station which has run continuously for over six years. We are responsible for some of the most exhaustive studies and international papers looking at wind farm noise characteristics which cause extensive problems within homes. s that affect people inside their homes.

2.5 Our work identified amplitude modulation as a common and serious problem through a survey of 18 wind farms 9 years before this was finally admitted by the industry in the UK and similarly spearheaded research showing there were significant low frequency problems.

2.6 At MAS we hold potentially the largest database of wind farm noise in the world which correlates with community complaints and as a result have been able to test different measurement methods for their efficacy. We also have extensive

survey within dwellings which demonstrate real life impacts permitted by planning limits.

2.7 MAS pioneered listening room experiences to better understand industrial wind farm noise and are responsible for exposing the wide range of amplitude modulation forms and how they impact residential neighbours differently.

2.8 Our internationally recognised expertise is supplemented by extensive work on nuisance determination and separately issues with constructing enforceable planning conditions.

2.9 **Independence.** Throughout all our research and work on wind farms MAS Environmental have maintained a complete independent position where all our research is self funded.

2.10 **Support for wind farm development.** MAS strongly support wind farm development and consider this is best achieved through better identification and understanding of any impact in order that these can be appropriately balanced.

2.11 We have been extensively involved in noise issues relating to wind farms since 2004. We highlighted the problems of amplitude modulation and low frequency noise from that time including presenting evidence at Institute of Acoustics meetings from 2009.

2.12 **Industry denial of wind farm noise problems.** Denial of these problems within the UK by wind industry acousticians continued until 2013 when publishing our work internationally at the same time the Japanese released their almost identical findings but with more extensive study marked a turning point. This led to what can best be described as reluctant acceptance albeit seven years on effective controls are still not in place.

2.13 Low frequency noise problems are still denied by many UK acousticians despite my releasing data in 2009, months before the majority of the industry acousticians released a statement stating there are not low frequency noise problems. I understand, many of them maintain resistance to such findings. This arises even though the WHO now recognise this aspect of the problem and

others providing extensive independent study of research confirm the situation[3]. In part 2 of this response I also provide some references of the independent study.

2.14 Denial of AM and low frequency noise problems from wind farms in the UK at the time of ETSU-R-97 and since persists and as a result it is recommended little weight is given to what happens in terms of UK guidance. Independent research such as contained in the Colin Hansen book identified in footnote 1 demonstrates significant criticism of the ETSU-R-97 methods upon which the Irish draft guidelines seek to rely.

2.15 In my experience most nuisance cases being pursued in the UK and Ireland relate to AM and low frequency noise character as well as the general level of noise and all the cases I am aware of are argued as compliant with the UK and Irish planning guidelines. There is now widespread acceptance of serious low frequency noise problems, especially by the WHO. This is discussed further below and in part 2 of these comments.

2.16 **Cotton Farm permanent monitoring station.** In 2013/2014 the MAS team established a permanent monitoring station with the community and have over 6 years of continuous data with probably the most comprehensive database of wind farm noise that is directly correlated to community complaints, in the world. This has enabled us to provide extensive independent research and also test metrics proposed for testing features such as AM.

2.17 Tests show the UK IoA method manifestly fails in many respects and serious concern arises that the Irish guidance is looking at adopting it. Simply put the metric has failed to adequately characterise the noise in every single nuisance case we have looked at since around 2013.

2.18 **Independent Noise Working Group.** MAS were asked to assist and provide research for an independent group reviewing wind farm noise issues in the UK and have been instrumental in relation to significant parts of their work.

[3] See for example the comprehensive study in "Wind Farm Noise : Measurement, Assessment, and Control" 2017 by Colin Hansen. This detailed book provides extensive study by experienced and neutral academics.

2.19 **Work in Ireland in relation to wind farms.** At MAS we have been working on wind farm noise issues in Ireland since 2013.

2.20 **Support for the intention of lowering limits.** The draft guidance appears to present stricter controls compared to 2006 and as a concept MAS support this principle. There is also an indicative intent to control amplitude modulation and low frequency noise. Regretfully due to the way these controls are formulated, experience demonstrates they will make control and restriction farm more difficult and effectively and extensively fail their intended purpose.

3.0 Discussion and principle conclusions of MAS analysis

3.1 It can be concluded a substantial number of wind farms in Ireland cause widespread community complaints. The planning controls recommended in the WEDG do not address these problems and more insidiously would give the appearance of addressing noise issues without resolving the nuisance caused. This includes every case recognised as causing nuisance or where people are complaining that I am aware of, including many where residents have abandoned their homes.

3.2 The extent of noise nuisance permitted by these draft guidelines is readily demonstrated in an example case on the MAS Environmental UK website at the link below:

https://www.masenv.co.uk/windfarms

3.3 As far as we can establish, to date the noise limits proposed show no correlation with protection of communities and the proposed draft guidelines do not have any credible evidence to substantiate their application to control noise nuisance in an Irish context where there is extensive dispersed rural settlement.

3.4 **Need to address core guidance issues.** As a result of the serious and almost universal lack of any correlation between controls and impact upon humans, attempts to address minor technical issues without addressing the core noise nuisance problems serves as a "smoke and mirrors" coverup of the real issues. Whilst increased controls and stricter limits is to be encouraged, without relating them to the factors that actually affect humans discredits and undermines their use.

3.5 **The ability to protect communities and permit wind turbine development** requires a different approach to the problem that cannot be addressed through a technical review of the current draft proposals.

3.6 Whilst there are some positive points arising in relation to the wind farm guidelines, issues of serious professional concern arise. To take two main points:

3.7 **Ambiguity within terminology and phraseology**. This permits multiple interpretations is a major feature. This was present in the 2006 guidelines leading to current abuse. As an example it is argued reference to ETSU-R-97 in the 2006 guidelines meant variations developed to procedures re-interpreting ETSU-R-97 in the UK post 2006 are also applicable to the Irish guidelines. This appears to have been accepted in a large number of cases in Ireland which then introduced the application of long term averaging. This effectively undermined the controls. This long term averaging was contrary to how ETSU-R-97 was written and introduced much later. In the new draft guidelines controls applied could be interpreted in an extremely lenient format which in effect results in no control. This widespread and extensive flaw appears to arise in part through misunderstanding how some of the procedures operate. Thus problems found with the 2006 guidelines over interpretation are repeated in the current draft guidance. It is avoidable and it is questioned why this is not addressed. Ambiguity and multiple interpretations relate both to the main limits and procedures for AM and low frequency noise.

3.8 **Unscientific forms of control.** Methods of control are employed which operate contrary to the science of acoustics and noise. This arises as it adopts a limited decibel penalty adjustment for the effects of character content in the noise. This fails to recognise the important premise that reducing a highly intrusive noise slightly in level but without it then being masked and / or no longer dominant does not address the effects it has on humans. This should be obvious to experienced acousticians.

4.0 Summary review of key issues and proposal.

4.1 It is my expert finding that the draft guidelines adopt a fatally flawed approach to assessment and now increasingly recognised as not reflecting impact upon people. This is exacerbated due to the attempt by its authors to try and reflect the precautionary interim limit proposed by the WHO in 2018. However, the WHO limit relates to long term permanent health effects regardless of character content but not harm to amenity or nuisance.

4.2 **False appearance of protection.** The approach adopted will subsequently present an appearance of protection as it will involve prolonged measurements and data filtering but which is ultimately incapable of reflecting or addressing the impacts that occur moment by moment and thus not remotely protecting homes. This is due to misapplication of the science of how noise intrudes.

4.3 Thus the approach adopted does not follow the science of acoustics, permits higher noise during periods of adverse impact due to long term averaging and applies insignificant penalties.

4.4 I understand similar inappropriate averaging was recently considered in the case of Lies Craeynest and others v Brussels Hoofdstedelijk Gewest and Others 2019 in an opinion of Advocate General Kokott. At around paragraph 85 it was stated:

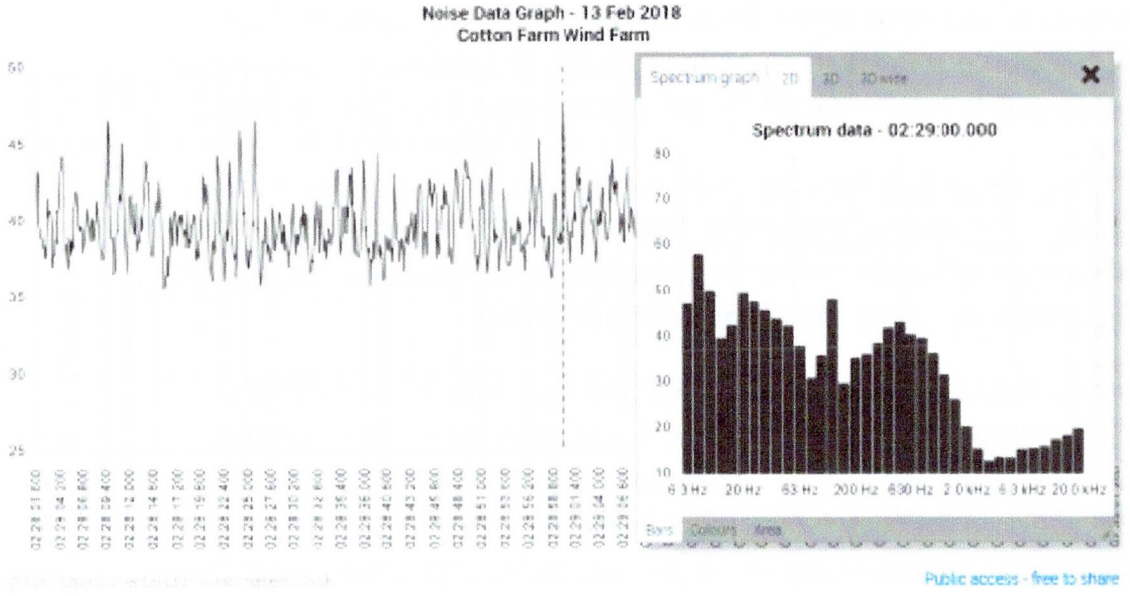
> *"There is a risk of adverse effects on health wherever the limit values are exceeded. Appropriate measures must be taken there in order to prevent adverse effects. It is only of limited importance to that risk whether an exceedance applies to the entire zone or agglomeration on average. This is clearly illustrated by the joke about the statistician who drowns in a lake even though it averages only a few centimetres in depth."*

4.5 Notwithstanding the averaging problem, the procedures proposed to be adopted have been shown using our extensive database to fail to recognise the main forms of amplitude modulation experienced and that proposed for low frequency noise can only be used post development inside dwellings. This contradicts the objective of using external measurements only and reliance on prediction that is incapable of identifying this problem.

4.6 At the link directly below the noise shown in the interactive graph and which is audible with good headphones attracts a minor penalty but is still compliant with the guidance as the penalty is small. This is before the period with the penalty is averaged with those periods when the noise impact does not arise and no penalty is applied. In reality even with the noise demonstrated in the graph and which can be listened to using the link, substantial margin remains through averaging.

4.7 https://www.masenv.co.uk/webgraphs/cotton_farm_180213

On-line graph shows a level of AM wind farm noise compliant with proposed guidelines occurring 02:28 at night. Compliance arises when considered in isolation and before long term averaging



4.8 **Permitting of higher noise than other industrial sources.** The methods proposed allow substantially more noise than any other industrial sources such as factories, warehouses, docks, transport depots and other commercial sites. These are commonly assessed using BS41432:2014. There is no basis for permitting substantially more of a source of noise especially where it is recognised as highly intrusive compared to other industrial sources. This is particularly relevant in remote rural areas where such noise is an alien and incongruous element. In context it would normally be the case that such rural locales would be given higher protection due to the absence of mechanical and

industrial noise other than in relation to farming machinery which is normally limited in occurrence.

4.9 It is instructive that most industrial sites are quiet or quieter at night and weekends but in the case of wind farms there is no distinction and they function 24/7/365 days a year. In context and having regard to rural pastoral type sound environments, stricter standards would be expected rather than substantial relaxation.

4.10 Interpretation of planning controls.

4.11 Benevolent interpretation of any controls applied would be necessary for enforcement or compliance assessment purposes. In turn this favours developers as any enforcement would need to consider criminal standards of proof. Reference in the draft guidelines to Lden, an annual averaging method strongly supports such benevolent interpretation as using long term averaging.

4.12 In practice use of long term averaging renders enforceable conditions which follow the draft guidelines impractical. Monitoring cannot extend a full year and would operate contrary to the Human Rights Convention as such a period of loss of sleep before evaluating effects cannot be reasonable.

4.13 An annual method can be used for prediction purposes where variations are known statistically but not as a measurement procedure. The averaging of periods of no or minimal impact with those of significant impact and assessing the average does not consider the actual impact and the effects of variations at the time it occurs. Concern arises over the failure to recognise this fundamental limitation.

4.14 The outcome of benevolent interpretation is the permitting of serious and uncontrolled nuisance. There is a plethora of evidence that shows this. Some is discussed in this document.

4.15 Frequency and duration of impact varies with distance.

4.16 At distances of only 500m the most serious and intrusive forms of noise arise including both upwind and downwind impact, meaning those dwellings at such

distances would not get respite even when the wind was towards the turbines. Work by MAS in its six year study and at sites in Ireland have shown this.

4.17 The draft guidelines provide no advice in relation to frequency and duration of exposure to noise. It is no consolation when there is a sustained wind direction resulting in residents being seriously impacted until the wind changes direction again. Long term averaging would undermine this impact by averaging it with periods of little or no impact.

4.18 Balance in favour of wind farm development over residential needs.

4.19 It can be concluded the methods of assessment being adopted facilitate the wind farm development to the detriment of all other concerns. This was not the case to the same extent with the 2006 guidelines as they did not consider long term averaging as now applied and any period of exceedance could be argued a breach in isolation. It is important to recognise; the historical guidelines were developed on a basis the noise was of a type that was benign and devoid of character such as AM except when very close to the turbines. In effect it was misled by the discussions in ETSU-R-97 that have consistently been shown as flawed and are widely criticised[4].

4.20 The former 2006 guidelines were formulated at a time it was believed levels below 43dB LA90 at night would not disturb and that there was not a plethora of intrusive characteristics contained within the wind farm noise. This has been consistently shown as erroneous. The erroneous statements and beliefs in 2006 are therefore understandable.

4.21 The draft guidelines now proposed are produced at a time when there is a plethora of good evidence of the adverse effects of wind farm noise. A starting point would be to consider the book by Colin Hansen, Con Doolan and Kristy Hansen, 2017 on wind farm noise as discussed in this submission as it represents an entirely independent set of views reliant wholly on research. This independent scholarly book contradicts a lot of what is reported in the draft guidelines.

[4] See the 2017 book by Colin Hansen for a resume of some of these.

4.22 Multiple wind farm characteristics arise additionally to AM.

4.23 Low frequency noise and amplitude modulation are important regular features of wind farm noise impact but are part of a wider range of effects and it is disappointing there is a failure to consider the wider range of effects. It is questioned why this is not recognised.

4.24 Adopting a procedure recognised in research as missing the majority of AM incidents and especially erratic and irregular AM and that is more intrusive because of these factors, is of serious concern.

4.25 Failure of decibel penalty as wholly inadequate.

4.26 Applying a penalty structure that permits AM to remain dominant and prominent and therefore its intrusiveness does not reduce, is of serious concern. This should have been obvious to the authors. It provides an illusion of control that is ineffectual and it is asked why this is being replicated.

4.27 In noise impact terms, rendering a noise slightly less loud but that remains dominant and prominent does not stop its effects on the unconscious listener and its distracting effects. It does provide argument noise character has been taken into account but then fails to address its effects. It is akin to cladding a building in a slightly less flammable cladding arguing it is better as a result. In the event of a fire it will still rapidly combust as temperatures significantly exceed their point of combustion. It is similarly like reducing flood water levels with better drainage. Reducing the flood level to half a metre than 1 metre does not stop complete disruption and loss of the home. Rendering a noise less intrusive but still exceeding the point it seriously disrupts is effectively an insignificant change in the same way. This is effectively what is provided in this case, especially as many features including two main types of AM do not trigger a penalty and it only applies to the impacted periods which are then averaged.

4.28 Existing effective procedure available.

4.29 A perfectly good procedure (albeit it has some elements which could be better defined) exists in the form of BS4142:2014. This industrial and commercial noise guidance would place wind farm noise "on a level playing field" with other

sources of industrial noise. No basis for ignoring such a set of procedures as developed and evolved since 1967 has been put forward. BS4142 is wholly unlike either ETSU-R-97 or the Irish Guidelines despite a statement to the contrary in the draft Irish guidelines. This is further discussed below. The critical difference is that it includes decibel penalties that place far more weight on the noise character than the sound energy level. It also appropriately uses LAeq and not LA90 for source noise.

4.30 Concerns with RPS analysis.

4.31 The RPS analysis fails to recognise and correctly apply the principles of the science of noise and acoustics, inappropriately mixing methods that were shown not to work previously but still using them as they were used before. This is inappropriate with current understanding and as a result can only continue to lead to the serious land use conflicts now commonly arising in rural Ireland.

4.32 In simple terms the guidelines are ineffectual in controlling noise impact due to the ambiguity and resulting ability to formerly look at long term averaging. In addition there is the use of procedures which ignore many characteristics in the wind farm noise including many forms of AM at the same time combining periods of less and more noise. It is also skewed by adopting unrealistic adjustments such as averaging periods where penalties are applied with perids that are devoid of a penalty. Also assuming a standardised wind speed applies which in turn hides impact during worst case conditions by adopting an unrealistically high background sound level.

4.33 The lengthy and complex algorithms built into the procedures devised by acousticians and as now proposed to be adopted rather than the more simplistic approach previously identified leads to significant and prolonged data processing. Whilst this raises acoustician's fees it is effectively indecipherable and incapable of mirroring or reflecting elements in the noise that actually impact upon people. In contrast measuring the noise as it impacts people on a moment by moment basis relates the character of the noise to the effects and their regularity and duration. The long term averaging both hides this but is also incapable of providing a realistic boundary between acceptability and unacceptability. One important reason for this is two wind farms can produce

identical average levels but in one case impact is minor as periods of high noise character arise when it is masked and the converse arises in the other case. The long term average cannot be analysed in a way that shows how dominant or prominent the noise is and separating the differences. Nor can it address when this occurs and what the corresponding background sound level was at that time. It cannot show what was disrupted nor for how long.

4.34 The mathematical procedures introduced are not understood by many acousticians and lead to an automated process that cannot be properly examined or related to actual impact upon people as they occur and clearly does not match human experiences.

4.35 In 2020 it is clear the introduction of long term averaging and adopting character penalties but which ignore much of the noise character or apply small penalties when averaged, is contrary to the science as to how such noise impacts upon people. It allows substantial noise although appearing, simplistically, to introduce tighter controls than those in 2006. It does not introduce tighter controls . The approach is wholly undermined by the science. The main problem is the application of ambiguous terms and phrases which permit various inappropriate interpretations. This transfers into a lack of control in practice.

4.36 Move of UK planning guidance away from decibel limits.

4.37 For many years planning guidance in England and Wales on noise has moved away from setting decibel controls that cannot relate to non-acoustic characteristics and attention grabbing special characteristics within noise. This is seen in the England and Wales National Planning Policy Framework and Planning Practice Guidance with only wind farms and minerals sites remaining that need revision. This change arises mainly as it is recognised the decibel level is a minor consideration in the human response to noise.

4.38 Abandonment of decibel based limits in guidance in England and Wales has not led to chaos and decibel controls remain an important element but are informed on a case by case basis adjusting to the circumstances.

4.39 A framework can readily be formulated that is fair, as found in BS4142 and that would be wholly applicable to wind farm noise. For the avoidance of doubt wind

farm noise in the UK can and is appropriately assessed using BS4142: 2014. This arises as it is only disapplied where other guidance applies and ETSU-R-97 only relates to town and country planning considerations. Where subsequently complaints arise BS4142 is appropriate and helpful.

4.40 Wider support of MAS observations.

4.41 Many of my findings are supported by the comprehensive book Wind Farm Noise: Measurement, Assessment, and Control, 2017 by Colin Hansen and colleagues. Various other supporting guidance is also provided in summary in part 2 of these comments. Whilst I have raised this here the independent views of the book by Colin Hansen and his colleagues warrant further consideration, especially in relation to procedures following ETSU-R-97 methodologies and low frequency noise.

4.42 Types of noise.

4.43 It is well recognised there are effectively two types of environmental noise[5] when considered simplistically. The methods adopted in ETSU-R-97 and now being considered in the draft Irish guidelines were formulated on the basis the noise was steady and relatively benign, readily being masked by wind noise. This was factually incorrect and misleading. Wind farms do exhibit general wind farm noise considered similar by some to road traffic on a concrete road which roars in a relatively steady way but it also includes a wide range of noise forms that draw attention and trigger adverse human responses not related to level but audibility, dominance and prominence of their attention drawing features.

4.44 Wind noise has significantly different spectrum content to the wind farm noise as experienced at residential receptors and even when of a similar level does not mask it. Furthermore, when moving inside dwellings the difference in spectrum means the wind noise is differentially reduced far more than the wind turbine noise. As a result the latter becomes even more dominant, prominent and obtrusive.

[5] To properly address the range of noise types and differences would require an extensive document but to provide some insight the attached article in Appendix A and published recently in the IoA journal provides some background.

4.45 The long term averaging and applying an averaged penalty as now proposed in the draft Irish guidelines in relation to the latter form of noise (containing special characteristics) including obtrusive and inobtrusive periods offends the science of how the human brain is triggered and runs contrary to long established principles how humans react to such noise.

4.46 Reaction to noise with special character is a moment by moment response depending on a range of factors such as what is disrupted, how often, how avoidable, importance of the living elements disrupted, duration, frequency of occurrence, expectation and neuron development of memories in relation to the noise along with other elements. Importantly UK planning guidance on noise is now recognising these factors and the seriously limited assistance of the decibel level. Ultimately we need decibel level controls but many features inform how they are to be derived when containing special characteristics.

4.47 In simplistic terms to consider a noise which perhaps seriously disrupted sleep for a period of five nights during a particular month and led to lower quality sleep another five nights, as acceptable is wrong. Just because on average over the 30 nights, levels were, on average, okay, is to seriously mislead as to impact. This is effectively what the methods appear to adopt. It is accepted there is significant ambiguity in the draft guidance but this simply permits such an interpretation. What is required is to ensure periods of significant adverse impact rarely occurs as it is masked.

4.48 Findings based on experience

4.49 Some important findings in my 45 years of experience of noise impact and the detailed studies of wind farm noise I have been involved with since 2004 are discussed below. It generally shows and can be demonstrated that:

a) most wind farms causing noise nuisance and serious repeated complaints in the UK and Ireland may appear as compliant with the planning guidance now proposed.

b) Ambiguity in any guidelines serve to compound issues over their interpretation and their application as to whether it is complied with. However, in general the contradiction still arises that there could be

compliance despite serious adverse impact upon local communities. Despite this the draft guidelines appear to seek procedures that will continue the lack of correlation between impact and guideline level.

c) MAS Environmental have reviewed repeated cases that arise where data shows serious intrusion, extensive and continued community complaints arise but assessment of planning guidance leads to arguments of compliance. This includes where the procedures proposed as in these draft guidelines are applied. In one case in England there are literally thousands of complaints and six years of data corroborating them but it is argued as compliant. Adoption of these procedures as part of the Irish guidelines can only be likely to produce the same conflicts and contradictions.

d) The MAS website includes a case accepted as causing nuisance but which complies with the proposed Irish guidelines as benevolently interpreted. There are many cases where homes have been abandoned due to impact of this level and type and what would be considered acceptable under the proposed guidelines. This contradiction could be addressed in revised guidelines that reflect human response.

e) The procedures being adopted and the wording of the document introduce considerable ambiguity and multiple interpretations as to how they apply. In turn this then permits application of the most lenient interpretation following the need to meet criminal standards of proof. These problems and contradictions can readily be addressed but as worded are permitting continuation of such ambiguity. It is not understood why this is so worded.

f) A long term averaging approach of what already is the average level, using the LA90 index (the wind farm's quietest 10%) is being adopted in these draft guidelines, contrary to commercial noise guidance equally applicable such as contained within BS4142: 2014. There is no basis for such differentiation for what is simply a mechanical and industrial noise impact significant rural areas of Ireland.

g) Evidence shows adopting the long term average using an index that is itself a statistical average of the quietest emissions of wind farm noise leads universally to compliance outcomes. Thus even in worst cases of noise and

community complaints, compliance is commonly indicated. This is instructive that the proposed procedures do not remotely relate to actual moment by moment and day by day impact. They are also wholly impractical to determine in practice. Critically though it permits substantially more noise as it averages quiet and noisy periods together compared with averages of low and high background sound levels.

h) Adverse impact from wind farms most commonly occurs when background sound levels are lowest and worst case AM, thumping and other characteristics such as low frequency effects are greatest. This low background versus high noise containing lots of intrusive character is lost through averaging.

i) Long term overall exposure limits are recognised as useful in terms of benign sources of continuous noise occurring 24/7/365 and lacking significant attention drawing character. In terms of this aspect of wind farm noise in isolation it can have value. However, noise which draws attention due to its character and also non-acoustic elements is unsuitable for assessment using such methods. This is partly why the WHO are clear in their 2018 guidelines that their guidelines do not apply to industrial and commercial sources of noise, other than leisure noise and wind farms to a limited extent.

j) Adjusting such long term average limits to reflect special character in the noise is fundamentally flawed as it needs to relate to its dominance and prominence moment by moment. This is how it impacts. In contrast BS4142 applies penalties designed to achieve loss of dominance and prominence. Applying small penalties to sources with special character as arises with the procedures proposed offends the science of acoustics in this regard as it mixes loudness and character methodologies but does not counter the effects of either. It can be described as a "smoke and mirrors" procedure that does not address the problems. Simply it does not stop the impact of AM and low frequency noise etc. and results in barely perceptible changes in loudness if at all.

k) No support for the procedures adjusting the noise controls adopted in these draft guidelines are found in the WHO European Guidelines 2018. The

precautionary adoption of an Lden of 45dB LAeq by the WHO relates to all forms of communities exposed and is subject to various caveats. These are ignored by the draft guidelines. If those procedures proposed in the draft guidelines were remotely appropriate, it is reasonable to conclude the WHO would indicate this. Instead they provide significant warnings, discussed later in this document.

4.50 Low frequency noise.

4.51 This has been shown as a major and common problem with modern wind farms but this appears denied in the draft guidelines. It is instructive this problem is recognised by the WHO but virtually ignored in the draft guidelines. Denial of low frequency noise was long made by industry acousticians even after I released data showing its presence in relation to the well documented case of Deeping St. Nicholas in 2009. Denial has continued by a number of acousticians since despite the WHO recognition of it and recognition by other serious independent researchers.

4.52 At MAS we have routinely measured low frequency noise problems at wind farms in Ireland and the UK.

4.53 Procedures to address low frequency noise are not adequately formulated in the draft guidelines leading to serious ambiguity. Reliance on the Defra curve is flawed as it is internal criteria, which when reached serves to confirm a problem. Problems arise at lower decibel levels than this curve applies but is not considered in the draft guidelines nor are the procedures for assessing this.

4.54 The Defra procedure can only be used post development so fails as a tool used to assess acceptability of a planned development. This can be readily addressed but has not been.

4.55 Analysis of background sound levels is misleading.

4.56 Graphs used show levels barely dropping below 20dB LA90 but the reality is this is dictated by the instruments used with have a noise floor (limit that they cannot record below) of 18-20dBA and corruption affects recorded levels up to around 28dBA. This means a recording of say 20dBA is possibly and most likely only

showing electrical noise generated within the instrument. This wholly misleads as to the true sound environment.

4.57 At MAS we use special microphones with a noise floor between 6.5-8dBA. In turn this means a measurement of 20dBA is an accurate reflection of levels unlike that used in the draft guidance. We routinely record level externally in rural Ireland as low as 10-12dBA. Limitations on equipment seriously corrupts data and has led to a common misunderstanding that normal background sound levels are in excess of 20dBA and typically 30dBA or more. It is noted many acousticians report internal bedroom levels of 30-35dBA as normal when it actually relates to levels where critical health effects, even from benign sources of noise are likely.

4.58 There is an extensive problem of instrument limitations leading to false readings and it is concern this has filtered into the draft guidelines.

4.59 Wrongly argued adopt BS4142 principles.

4.60 The Draft guidelines claim ETSU-R-97 is based on BS4142 and in effect it is adopting those principles. This is seriously misleading. Demonstrating this is wrong requires extensive examination so some key points demonstrating this are provided only. Whilst the ETSU-R-97 document states this, it is clearly not the case and simple application of BS4142 to wind farm noise reveals the stark difference in results. In other words apply both and the ETSU-R-97 and Irish draft guidelines indicate acceptability when BS4142 shows significant adverse impact.

4.61 ETSU-R-97 as now applied (not as originally intended) uses long term arithmetic averaging ranging from two weeks to 6 months. This was never the intent but an interpretation permitted through ambiguity in wording and so adopted by operators as it permits substantially more noise. The draft guidelines aim to extend this to a year. Human response to noise is moment by moment. If an alien sound wakes someone as we commonly find wind farms do, they do not assess acceptability of that incident based on either a two week or six month average and now annual noise level. Impact relates to the noise at the time but the draft guidelines indicate this is to be ignored. BS4142 as worded at the time

ETSU-R-97 was developed assessed impact over a 5 minute period at night with no averaging of that. This is a fundamental difference.

4.62 The approach now adopted in the draft guidelines means any intrusive noise events which intrude due to their frequency and duration of occurrence as well as the times they occur, what they affect and the nature and character of the noise, would now be viewed in terms of its annual average. These events are averaged as part of the overall long term decibel level. It cannot relate to the circumstances of the case or the intrusion experienced. This averaging approach can work in relation to road traffic noise that is relatively continuous every day of any year and that does not commonly and unconsciously draw attention due to any special characteristics. However, it would not work if there were regular horn sounding and tyres screeching but this is rare experience and the norm is a background steady roar. Averaging includes periods of little or no noise and so hides the impact from wind farm noise which is highly variable.

4.63 **Typical analogy.** This averaging approach to noise is equivalent to saying an individual's driving is safe because their annual average speed is below the speed limit. In the same way this does not relate to safe driving on a particular road, in particular circumstances. The annual wind turbine noise dose does not reflect how many awakenings or periods of disruption occur and has very limited utility.

4.64 **Flaws using LA90 index.** The draft guidelines adopt the LA90 index for the source noise. BS4142 does not as this excludes important elements and it is lower in level, typically 2dB less. This difference can be much more when the noise is erratic. BS4142 adopts the LAeq value that takes variations into account. Not only does BS4142 compare the level of background masking sound at the time of impact rather than an average, it seeks to ensure any noise which intrudes more during a period than other periods, due to its character, is actually at or below the background sound level to mask it. In contrast the draft guidelines allow an exceedance of the background sound level by 5dB using the LA90 index. This translates to a 7dBA exceedance when comparing the BS4142 methods. Thus, as a minimum the draft guidelines and ETSU-R-97 equate to an exceedance of background sound by 7dB when using the LAeq index as applied in BS4142. This equates to a substantial difference to BS4142. This 7dB level

is a point where the noise is wholly dominant and prominent even when it is absent any intrusive character such as AM and thumping.

4.65 ETSU-R-97 and the 2006 Irish guidelines adopted the LA90 index on the basis levels were believed to be steady. At times they are but critically at times of high intrusion they are erratic and very unsteady.

4.66 **High decibel penalties in BS4142.** The decibel penalties used in BS4142 serve to require the resulting noise to be progressively masked the more the character in the noise draws attention. The principle is a good one where intrusive character is masked to minimise its unconscious attention drawing features. The greater it draws attention the lower it must be in relation to background masking sound. In contrast the draft Irish guidelines apply an extremely limited penalty which adopts the IoA method that in turn misses most forms of amplitude modulation, especially the erratic and irregular forms. It is not in practice a 5dB penalty. The penalty is only applied to the periods it was observed meaning it is further averaged out and would rarely be at 5dB in any event. Commonly a 1-2dB penalty might arise from the process but only applied to the periods where it was triggered meaning that even if triggering 50% of the time it would add half this. The outcome that results is permissible levels remain dominant and prominent and continue to draw attention. The adverse effects are not prevented. Conversely BS4142 now applies penalties that could, in theory total 21dB and penalties of 10-12dB are common.

4.67 **Different background levels used compared to BS4142.** BS4142 uses a typical background sound level so that protection is based on what is commonly occurring. In other words it looks for the most commonly occurring background sound level and how the sound emerges above this. ETSU-R-97 and the Irish draft guidelines do not, they apply an arithmetic average which, in relation to rural localities is always higher due to windy periods that would be ignored when using BS4142. These differences increasingly add up to substantial differences between intruding noise and masking background levels.

4.68 Human response does not apply background sound experienced during windy periods to the wind farm noise but periods of little or no noise. This is how human memory and characterisation occurs. Applying a higher background

level based on higher wind is misleading. Furthermore, high wind shear conditions also mean this is a false comparison.

4.69 BS4142 applies a penalty to a wide range of sound characteristics that increase intrusiveness simply due to their presence. ETSU-R-97 and the Irish guidelines, as interpreted by Irish acousticians working for wind energy developers have been applying fractions of the penalties based on the fraction of periods when they occur. This further understates their impact. Such interpretations are permitted by the proposed guidelines but not applied in BS4142. Furthermore, a significant range of intrusive characteristics are ignored by the draft Irish guidelines and the ETSU-R-97 procedures, meaning many elements that intrude are simply ignored. BS4142 does not ignore them and has another penalty category for other characteristics within a source of noise.

4.70 Summary in terms of BS4142. It can be seen the procedures adopted in BS4142 are manifestly different to ETSU-R-97 and the Irish draft guidelines. To imply otherwise is to mislead in precisely the same way the original ETSU document misled.

4.71 Whether adjustments to ETSU-R-97 reflect impact from modern turbines?

4.72 To argue this is the case as the draft guidelines do is to seriously mislead. The draft guidelines, if adopted provide added protection to the wind farm industry but seriously diminish it for residents. One simple example is adoption of standardised wind speeds. This means true wind speeds are ignored at any moment in time and a standardised one is substituted.

4.73 The greatest adverse impact at night arises under an atmospheric state called "stable atmosphere". This is a common occurrence and in our six year data study this can arise typically up to 80% of night time periods although occurrence will vary. During these conditions the blades experience high wind speeds at the top of their rotation but at ground level there is extremely little wind (pin drop quiet). This happens as there is high wind sheer and lack of atmospheric friction leading to atmospheric layers. This means faster winds high up do not transmit down to ground level where it becomes still and in terms of background sound it is quiet.

4.74 Standardised wind speeds assume that when the wind turbine is at maximum noise output there are much higher masking winds at ground level that arise in reality with high wind sheer. In turn much higher background sound levels are assumed and compared than actually occur.

4.75 The outcome is that during the worst periods of adverse impact the assessment method planned to be adopted assumes a much higher background sound level to compare against. This understates impact. It is also the case that greatest AM occurs during these stable atmospheric conditions as the blades encounter the greatest range of wind speed differences from top to bottom of a rotation and cannot be pitched appropriately for the range of wind speeds using standardised wind speeds. AM thumping commonly occurs during these meteorological conditions. However, the method adopted assumes a much higher and false level of masking noise. This problem is exacerbated as measurement equipment uses standard microphones which cannot go low enough to show the true difference between the very low background sound levels during stable atmospheric conditions and the resulting high levels of turbine noise and thumping AM.

4.76 In summary, the critical point is that the worst impact arises when weather effects generate minimal masking noise and there is an expectation of quiet and tranquillity. Instead this is precisely when the most serious forms of noise intrusion commonly occur. Rather than address this the adoption of standardised wind speeds hides this impact.

4.77 The draft guidelines make little reference to wind speed but adopting the language it has and procedures proposed, it will have to use standardised wind speeds which then hide the periods of greatest adverse impact.

4.78 Method of evaluating Amplitude Modulation.

4.79 The method proposed to be adopted has been shown to manifestly fail to control two critical forms of AM which arguably are the most intrusive. There is no explanation why such a flawed methodology is proposed or even recognition that it has been shown to fail as identified. In effect no effective control is applied.

4.80 There are many serious flaws with the method proposed to be adopted. Some are outlined here:

a) There is extensive ambiguity how to apply the procedures permitting a range of outcomes and interpretations.

b) Penalties are applied to the general more steady wind farm noise which is measured using the LA90 index. AM is not measured by it. This is contrary to the need to separately control noise with special characteristics as a standalone problem. This penalty approach means at most very slightly lower energy levels are permitted but without any change to the noise impact itself.

c) Averaging of the penalties as interpreted as permitted in the procedure by only applying them to individual periods where it is triggered further reduces its effect. This results in a false element of protection produced which in fact does not change impact as it does not take the character in the noise below any point where it no longer draws attention or unconsciously disrupts thought processes, including leading to awakening.

d) The complex technical procedures render it hard to evaluate whether any analysis using data has properly or reasonably been applied in the evaluation of the data.

e) False positives and more commonly false negatives are highly common with the process wrongly indicating periods do not contain such noise when they do. There is no method of addressing this.

f) The dense virtually indecipherable procedures cannot be related to the impact experienced at any point in time and therefore it cannot properly be tested for efficacy. Our analysis has shown it repeatedly fails to trigger when erratic and irregular (arguably the worst forms) AM occur.

4.81 In summary it is to be questioned why a set of procedures which knowingly miss many forms of adverse character impact and result in minor and irrelevant penalties that permit the intrusive noise to continue are being adopted.

4.82 Averaging noise over an annual basis would also effectively render assessment of the effects of noise character impractical. This does not reflect the intent of the WHO where predictive methods are primarily used to look at and compare general noise exposure.

4.83 **Defra nuisance guidance identifies limitations of ETSU-R-97.** The UK ETSU-R-97 procedures have been recognised as not reflecting impact upon people where UK Defra guidance on investigating nuisances from wind farms reflect this by recognising the lack of usefulness of ETSU-R-97 in that regard. Furthermore ETSU-R-97 recognises this. Despite this it is proposed to adopt procedures following these methods.

4.84 **Recognition the procedures fail to protect communities.** Despite extensive and clear international evidence wind farms commonly introduce noise character that intrudes at very low decibel levels and which the UK ETSU-R-97 procedures ignored, and continue to fail to address, the draft Irish guidelines seek to mimic their flawed and failed procedures. These have now been long exposed as failing to protect communities.

4.85 Almost universally wind farms which cause complaints of nuisance and that are corroborated by independent investigation could show compliance with the proposed planning guidance. Where they are not compliant, extremely minor adjustments of a decibel or two could potentially render them compliant. This level of difference falls within the range of uncertainty in sound level meters and could not be enforced.

4.86 Approach adopted is contrary to science.

4.87 The approach to noise control adopted operates contrary to the science of noise impact. I have already discussed this above but set out some additional points here. In summary:

a) We can apply threshold values to sources such as benign road traffic which mainly impact due to triggering neurons in the brain relating to loudness in isolation. We cannot apply this to noise containing special character which triggers many more and differing neurons. This relates to constant brain surveillance of our environment for threats or the need to apply attention /

action. These lead to unconscious attention grabbing and thus disruption of day to day activities, especially rest and relaxation.

b) Noise with intrusive attention grabbing character intrudes where it is either prominent, dominant or sufficiently alien that it draws attention. The effect of alien and incongruent noise is long recognised. Later when we have adjusted to recognising the alien noise, attention is drawn due to the associated memories of adverse effects with that noise. We therefore sensitise to it. For example, hearing a noise which led to loss of sleep before an important interview would trigger memories associated with the adverse outcome. This noise is not assessible by application of a decibel penalty unless that ensures the noise is primarily masked preventing any trigger. The penalties proposed in the draft procedures do not remotely cause an outcome where they are masked or hidden unlike those applied when using BS4142.

c) There are a wide range of interacting characteristics which intrude for a variety of reasons and applying an average and small penalty to just one category which is broadly identified as AM but in fact the methods miss most forms of AM means it cannot follow the science. Broadly there are three forms of AM and only the regular unchanging form is adequately picked up using the procedure proposed. The procedures underrate or wholly miss the effects of:

- Erratic and irregular AM
- Simultaneous occurrence of whistling and whirring with the AM.
- Occurrence of low frequency noise with the AM which may or may not also modulate.
- The effect of very large variations which can be up to 15dBA on a second by second basis despite the procedures considering such variation is not possible. It is recorded and whilst not common is a startling effect.

- Changes in the character and spectral content of the AM beats on a moment by moment basis such that successive beats exhibit a different pitch or characteristic.
- Changes in impulsivity of AM beats where some rise more gradually and so the rate of change is not so stark and others have distinct impulse content with sudden change.
- Directional effects where different forms of AM arise in different directions.
- The additional underlying roar of general wind farm noise which the AM emerges above. This means there is a contributory industrial type noise that exacerbates the effects of AM in many cases.

4.88 WHO (2018). Environmental Noise Guidelines for the European Region.6

4.89 There is selective reporting of the guidance provided by the WHO 2018 in the draft guidelines. The WHO's precautionary application of an Lden also includes substantial concerns and caveats regarding noise character that the Lden does not cover or address. The Lden precautionary recommendations cannot differentiate locations such as being adjacent a motorway, within a dock or large industrial complex where there are high levels of masking noise. Compare these to a remote rural area where there is no mechanical or industrial noise other than the wind farm. The application of the same limits to both is illogical and contrary to the science of human response to noise. The effects of this cannot be factored into the WHO recommendations and the WHO express significant caution.

4.90 In 2018 the WHO published their updated guidance for Europe for protecting human health from exposure to environmental noise. Whilst the guidelines focus mainly on transportation and leisure noise, they include a section on wind turbine noise. Key points are summarised below.

[6] World Health Organisation (WHO) (2018). *Environmental Noise Guidelines for the European Region.* Copenhagen : WHO

4.91 The 2018 guidelines recommend exposure levels aimed at protecting human health. This includes cardiovascular and metabolic effects, annoyance, effects on sleep cognitive impairment, hearing impairment and tinnitus, adverse birth outcomes, quality of life, mental health and well being. As such, they concern effects of greater consequence than comfort and convenience, harm to amenity or unreasonable interference with the use and enjoyment of land. The latter is, in my understanding, part of the definition of nuisance. Whilst the WHO discussion on impact is helpful for reference, the recommended exposure level should be treated with some caution when considering comfort and convenience or unreasonable interference.

4.92 Due to a lack of high quality evidence, as defined by the WHO, the recommendations on wind turbine noise are conditional and for many of the investigated health effects there was insufficient evidence. However, the WHO has set a recommendation for reducing noise levels from wind turbines below 45dB Lden.[7] It is also noted within the guidelines that below this exposure level there might still be a risk of annoyance. In addition, and of note, the WHO caveats that the descriptors Lden and Lnight may not be appropriate for describing wind turbine noise and this may limit the ability to draw associations between wind turbine noise and health effects.

4.93 The WHO lists several characteristics of wind farm noise that may exacerbate impact compared to the sound energy level alone and why the Lden and Lnight descriptors may not be appropriate.

Wind turbines can generate infrasound or lower frequencies of sound … The noise emitted from wind turbines has other characteristics, including the repetitive nature of the sound of the rotating blades and atmospheric influence leading to a variability of amplitude modulation, which can be a source of above average annoyance (Shäffer et al 2016). This differentiates it from noise from

[7] The Lden is a long term average noise level. It is calculated assuming that there is an equal (or equivalent) level of noise over a whole day. Greater weighting is given to periods where more freedom from noise is expected, evening and night time. It is a descriptor typically used for transportation sources. It can be used to investigate noise dose; however, caution must be exercised when looking at sources such as wind turbine noise where there are specific characteristics to the sound which may cause adverse reaction at lower levels than sources without these characteristics. The Lden cannot describe how the sound environment changes on an hourly, minute by minute or second by second basis.

other sources and has not always been properly characterized. Standard methods of measuring sound, most commonly including A-weighting, may not capture the low frequency sound and amplitude modulation characteristics of wind turbine noise (Council of Canadian Academies, 2015).

4.94 The importance of assessing impacts in context is also raised as a key consideration for wind turbine noise and this accords with other recent editions of guidance (for example BS4142:2014).[8] The difference in human response to wind turbine sound in comparison with other sources, for example transportation noise, is also noted.

Wind turbines... size and type have increased significantly over recent years. As they are often built in the middle of otherwise quiet and natural areas, they can adversely affect the integrity of a site. Furthermore, residents living in these areas may have greater expectations of the quietness of their surroundings and therefore be more aware of noise disturbance... These situational variables and the values and preferences of the population may differ between wind turbines and other sources...

4.95 Whilst the WHO provide a recommendation for prevention of health effects using the Lden value, the guidance also highlights uncertainty with the appropriateness of the descriptor for describing the full nature of impact from wind turbine noise. The WHO guidance reinforces a common theme recurring throughout recent noise guidance and research that context and character play a large part in determining human response to sound. The WHO were unable to determine a separate night time criteria for protecting health from wind farm noise.

4.96 Methods of assessing low frequency noise

4.97 Reference is made to the Defra curve but this is an internal procedure where different time periods of measurement could be applied. Despite this the draft guidance argues against internal measurements. There are various misrepresentations summarised as follows:

[8] British Standards Institution (2014) *BS4142:2014: Methods for rating and assessing industrial and commercial sound*. London: BSI.

a) Internal impact can be very different to external impact due to room dimensions which affect levels.

b) A variety of different internal measurement locations can be utilised giving different results.

c) There will be argument how external levels relate to internal levels. In one case where I used international research on the likely difference as the houses were not built, extensive disagreement still arose.

d) Whilst the Defra method does consider varying low frequency noise it was never derived to address regular second by second low frequency noise including in case where it also exhibits impulse content.

e) When proposing a wind farm it is impractical to measure its effects inside residential property and there are a significant number of variables that affect the results.

f) Alternative external procedures based on detailed research have been developed but are ignored.

4.98 Summary key problems with guidelines as written

4.99 The two most fundamental problems that arise which if adopted as written render the guidelines toothless and formulated to enable serious land use conflicts between wind farms and residential uses:

4.100 Adopting the procedures and an approach first applied in the UK document ETSU-R-97 that assumes impact upon people is as found for benign and anonymous (no related adjacent land use) transport sources despite no supporting evidence. Further that this can be adapted by applying minimal decibel penalties. It is noteworthy the extensive Canadian Health studies has shown human response to wind farm noise is typically equivalent to road traffic noise 16dBA higher. It follows the wind farm noise would need to be about 16dB lower than road traffic levels for equal impact. The procedures do not remotely follow this.

4.101 In adopting language to which there is significant ambiguity and multiple interpretations serves to permit application of the most lenient methods such as long term averaging of background sound, source noise, penalties and low frequency noise. An example would be considering the noise both downwind and upwind. Upwind noise can sometimes be of the order 12dBA lower than downwind. Only the downwind noise may be causing problems but the method would allow the averaging of both.

4.102 Need for listening experience to better understand impacts

4.103 MAS commonly create a listening experience where noise experienced in homes is reproduced to enable parties and the courts to understand how the noise actually experienced impacts residents. In turn this can inform on what is being proposed as permitted by the draft guidelines.

4.104 MAS will happily set this up to inform the Irish Government what the guidelines actually translates to and will permit residential neighbours to have to suffer. As a starting point please visit the MAS website at

https://www.masenv.co.uk/wind-farm-case-study

4.105 The draft guidelines would permit these sources of noise to occur and they would likely comply with the guidelines. This is a case recognised and agreed at court as causing a legal nuisance. It was considered a serious nuisance by those affected.

4.106 Some additional findings;

a) The wording is ambiguous and confused in a manner allowing multiple interpretations and in doing so permit far more noise than might at first appear. Eg. A limit of 43dBA can be interpreted as a long term arithmetic average of 43dBA meaning 50% of the time it could be substantially higher.

b) 3dBA increase is recognised as noticeable but the minimum change permitted here is 7dBA in terms of the average noise over the background LA90 sound level. Stating it as 5dBA by using the LA90 is misleading.

c) Background sound levels of 20-25dBA are commonly accepted but in reality they fall well below 20dBA on a common basis and this often coincides with the worst windfarm noise impact.

4.107 Ambiguity

4.108 There is a plethora of issues with ambiguity including:

a) The process of relating noise limits to wind speed at hub height even though masking noise commonly does not relate to this and human response also does not. We do not tolerate more noise because it is windier.

b) Long term arithmetic averaging of limits. This has arisen due to failure of UK conditions to prevent such a process and a court decision permitting professional judgement / interpretation meaning where wind energy acousticians choose to permit long term averaging of both background sound and turbine noise including when each are high and low due to different meteorological conditions, all the data points are averaged. This completely ignores the original intent of ETSU-R-97 to look at the impact on each individual night and also it no longer maps over time individual periods of high wind farm noise when background sound levels are low. Instead compliance is argued as can be based on very long term averaging as a professional judgement permits this. Taking periods of serious intrusion and averaging them with periods of no or little intrusion leads to compliance even when there are substantial periods of intrusion.

4.109 The issue is that the generation of highly attention drawing and therefore intrusive characteristics which include a variety of forms of amplitude modulation, mechanical noise sources, low frequency sources and irregularity in the noise lead to serious adverse impact unless the noise is sufficiently masked and no longer dominant or prominent.

4.110 The approach adopted in the draft guidelines is to treat the noise as equivalent to a benign, anonymous type source which when containing special character that prevents climatization and habituation and conversely draw attention and cause sensitisation, making it slightly lower in energy addresses the problem. This is perverse. The introduction of the character changes human response

and its loudness is then of limited relevance. Simply put making a loud (in relative terms) and dominant noise slightly less loud but which still disrupts and draws attention unconsciously in a manner you cannot stop it doing because it remains sufficiently dominant or prominent is a barely perceptible improvement.

4.111 There is no basis for adopting such a flawed approach to noise. Whilst this approach is partially accepted in the UK to address failings with the deeply flawed ETSU-R-97 it has not led to any cases where unreasonable and intolerable noise intrusion has been rendered even remotely acceptable. ETSU-R-97 was developed on the basis intrusive attention drawing character other than limited tonality was absent. It was formulated long before a reasoned understanding of the WHO guidelines and its misconstrued approach developed on the basis all noise was more or less acceptable below certain thresholds. Conversely the WHO guideline values were not setting acceptable values but the onset of critical health effects for transport sources devoid of specific characteristics.

4.112 If the UK Government had permitted wind farm development to be undermined through acceptance of the increasingly recognised flaws in ETSU-R-97 it would have had serious consequences for its entire renewable energy programme. It is instructive that in the case of all the wind farm developments considered or demonstrated as causing civil nuisance in the UK all comply with wind industry interpretation of ETSU-R-97 despite widespread evidence of nuisance.

4.113 Simply put, adopting the guidelines as written will lead to continued serious land use conflicts where local residents have abandoned their homes or live in continuous stress with no relationship whatsoever between acceptable noise in the home and the levels permitted by the proposed guidelines. It is instructive the UK ETSU-R-97 guidelines and adaptations for amplitude modulation have not led to a single situation where those affected have been able to use the controls to achieve protection from nuisance.

4.114 It is also instructive recognition of the lack of utility of decibel based controls has progressively led to the abandonment of planning guidance other than in a minor way in the UK based on decibel levels. These only really now remain for minerals developments and wind farms. In the main National Planning Policy Framework

and the Planning Practice Guidance emphasis is placed on the effects upon humans and changes in life style such as having to close windows and not decibel levels. Decibel levels still form valuable controls and will commonly be applied as a backstop control but the inability to set a single value due to the variables in how noise affects people value is now well established. Thus for example two sources of noise and background levels may be the same (e.g. compressor noise) but different limits would be applied because one is in an industrial area where such noise is common but the other a rural area near a major road and so the sound environment is different. Each case has different factors which influence. Thus the WHO Lden value for wind farm noise and adverse health effects rather than on comfort and use of the home is an upper limit that will consider wind turbines in industrial areas and near motorways as well as remote rural areas. The idea this precautionary Lden value of 45dB is a suitable control in isolation in the extremely remote, quiet areas of Ireland which normally widely experience natural sounds and some farming is a perverse interpretation.

4.115 Consequences of adopting the new guidelines.

4.116 Much of the differences and reasons why the draft guidelines are discussed below. In the case of the 2006 guidelines, there is the clear argument their age is such the statements which now mislead over wind farm noise arise due to the lack of adequate understanding at the time. This defence could not be said about any guidelines adopted in 2020. Not only are the scientific failings of what is proposed very clear in 2020 but a substantial number of cases have arisen with a large number of actions being pursued where the wind farms that are causing serious problems for residential neighbours may be wholly compliant with the draft guidelines now proposed. A simple test of this can be seen on the MAS Environmental website, in a case accepted at court as causing serious nuisance but wholly compliant with the draft guidelines.

5.0 Background to the assessment of sound and relevant wind farm controls.

5.1 Principles to be applied - Assessment of sound and noise

5.2 Human hearing has been referred to as "the sentinel of senses".[9] Its capacity to respond to information and changes to that information in light, dark, consciousness and sleep is incredibly sophisticated.[9] As noted by Jones et al (2010) it appears that human hearing is obligatory, we cannot help but hear, attend to (specifically or inadvertently) and respond to our aural environment.[9] It is a fundamental human response and dates back to our evolutionary past when certain sounds would have had significant meaning. Many of these basic responses remain engrained and are even exploited, for example in music and film, to elicit emotional response.[10]

5.3 Our environment is made up of many different natural and man made sounds. Human responses to sound combine both physiological responses, i.e. a response to the disturbance of a sound wave moving through the air and through our auditory pathways, and psychological responses. Psychological responses can be influenced by physiological responses, how these responses are processed by the brain and many other subjective factors including non acoustic factors such as attitudes to the sound source.

5.4 The difference between sound and noise is dependent on a number of subjective, personal and situational variables. Subjective responses may be acoustic and non acoustic and can depend on factors such as age, absolute decibel level, character of the sound, time of the day at which the sound occurs, personal attitudes to the sound and historical experiences, the attitudes of those generating the sound, character of the area etc. As defined by others, "sound can be measured by a sound level meter or other measuring system. Noise is

[9] Davis H. Preface. In Stevens SS, Warshofsky F, ed. (1970) Sound and hearing. Netherlands: Time Life Books. Cited in Jones DM, Hughes, RW, Macken WJ. (2010). Auditory distraction and serial memory: The avoidable and the ineluctable. Noise Health. 12:201-209.

[10] For example the lack of wildlife sounds and silence in woodland scenes to indicate danger or the Jaws theme, a low frequency sound increasing in pace and getting louder indicating advancing danger.

related to a human response and is routinely described as unwanted sound, or sound that is considered undesirable or disruptive".[11]

5.5 The distinction between sound and noise at an individual level is subjective. Just as there are different preferences for musical taste the judgement of sound versus noise can vary widely from person to person. This includes differences both in sounds that are considered pleasant and unpleasant but also individual sensitivities to noise, for example hearing thresholds.[12]

5.6 The assessment of whether sound is noise and whether that noise is unreasonable is not always simple but most people will commonly recognise levels and types of noise that they find unpleasant and that materially affect the use of property especially in relation to rest and relaxation.

5.7 There are certain features of sound that are generally considered to increase annoyance and reduce tolerance and these can be treated as exacerbating factors of noise impact. These are mainly features that attract attention, rendering a sound more discernible. They include impulsivity, tonality and intermittency. Steady, continuous, anonymous sounds, for example distant road traffic noise, are generally considered easy to acclimatise to and habituation can arise relatively quickly.

5.8 Sounds that have an identifiable source, impart a particular message, are variable, unpredictable and have specific identifiable characteristics such as a hum or drone are more annoying at lower sound levels than steady continuous sounds. These attention drawing sounds typically spark adverse reaction and ongoing complaints without acclimatisation. In many cases increased sensitivity to the sound source can arise and it is generally accepted that this aspect of sensitisation is a normal and typical response.

5.9 Our brains are constantly analysing and interpreting our sensory environment. As noted in Baars & Gage (2010) "The central role of the auditory perception

[11] British Standards Institution (2014) *BS4142:2014: Methods for rating and assessing industrial and commercial sound*. London: BSI.

[12] With regards to assessment it is generally accepted that those who are hypersensitive to noise are not protected.

system is to extract information from the listening environment in order to determine what is happening around us".[13] Attention can be drawn to sounds voluntarily or involuntarily. It is often involuntary attention that can cause annoyance as this disturbs other tasks to which we are trying to direct our attention. On hearing a loud or unexpected sound we become instantly alert, entering a state of heightened arousal in assessing what the noise was and where it came from. This is also true when there are changes in our auditory environment that perhaps are unexpected or cannot be easily explained. The effect is described by Baars (1997) in relation to the Orientating Response (OR):[14]

Suppose you hear the sound of a refrigerator pump – a series of noise bursts of a certain duration, spectral distribution, onset, offset envelope, location in space, cycle time, and so on. If the sound is not painfully loud, people will tend to lose awareness of it rather quickly, but they will tend to be conscious of the noise again as soon as any parameter of the sound changes: The noise can become louder or softer, the time between the noise bursts can change, the intensity envelope can change, or the noise bursts can just stop. Any of these changes will trigger a new OR, just as we may become aware of the noisy refrigerator as soon as the noise stops. [15]

5.10 Theories relating to our expectations of sound and how we react to and perceive events that do not correlate with our previous experiences have been much discussed in relation to our perception of music. The same basic principles can be applied more generically to sound and noise. Constant sound with little change to volume, pitch / frequency or character will be easily accustomed to and requires little cognitive appraisal or attention. Negative responses are more likely to be associated with unexpected changes in loudness, frequency content and more generally by sounds not behaving in a predictable manner.

[13] Baars, B. & Gage, N.M. (2010). *Cognition, Brain and Consciousness: Introduction to Cognitive Neuroscience*. 2nd ed. Oxford: Elsevier.

[14] The orientating response, or orientating reflex, is a response to a change in an organism's environment usually elicited by novel stimuli.

[15] Baars, J. B. (1997) Contrastive phenomenology, in: Block, N.J. Flanagan, O. and Güzeldere, G. (eds) The nature of consciousness, philosophical debates. Massachusetts: MIT, p. 191

5.11 Furthermore, our previous associations and memory of sound will influence and guide future reactions and interpretations. For example, one night of disrupted sleep due to an irritating mechanical hum may elicit an early adverse response to any future occurrences of the hum compared to the first experience due to the pre existing associations with sleep disturbance. Much of this again relates to the character of the noise and the interpretation of any message imparted by the noise in assessment of noise impact.

5.12 Restful and relaxing environments are typically those with a lack of attention drawing characteristics and with positive associations. For example, music labelled as 'relaxing' typically has a slow tempo with predictable, consonant harmony and minimal melodic, dynamic and harmonic variation. The same is true for relaxing soundscapes, which typically have a higher proportion of natural (biological) sounds such as water running (a predictable, smooth sound) and fewer sources of loud mechanical sounds (impulsive, harsh sounds).

5.13 In seeking rest and relaxation, we are therefore typically searching for 'quiet'. This can have several relevant meanings with respect to noise and sound as described in Andringa and Lanser (2013). 16 Firstly and most simply it can refer to a lack of (or little) noise / sound. Secondly, 'quiet' can also refer to a lack of activity or disturbance, for example the relaxing music with minimal changes in melody / harmony or one simple noise source as opposed to multiple different noise sources. Finally 'quiet' can refer to mind states that are not disturbed or interrupted, i.e. a lack of attention drawing character such as the constant, broadband noise from a fan compared to a mobile phone with a melodic ring tone that keeps ringing.[16]

5.14 Consideration of sound versus noise is not simply limited to level (decibel level / loudness) but specific features of the noise / sound and how they interact with and influence our environment. As noted by van den Bosch et al (2018) "...auditory appraisal is greater than the sum of its decibels... the very definition

[16] Andringa, T.C., & Lanser, J.J.L, (2013). How Pleasant Sounds Promote and Annoying Sounds Impede Health: A Cognitive Approach. *International Journal of Environmental Research and Public Health*. 10 pp 1439-1461

of 'noise' as unwanted sound entails appraisal on the dimension of desirability that has no obvious relation to decibels".[17]

5.15 Notwithstanding the above, the decibel level is commonly used to measure and quantify sound. Whilst it provides a universal measure of sound energy, it should be treated with caution if used in isolation to describe the impact of a sound or noise on the human population.

5.16 The human hearing mechanism is incredibly sophisticated, perceiving sounds from around 0-130 decibels (dB) over a range of 20 cycles a second (Hz) - 20kHz. The human ear can adjust to and be startled by very quiet sounds especially when there is little or no other sound, for example a twig breaking in the countryside at night time. At the other extreme the human ear can perform temporary threshold shifts to adjust the auditory threshold and protect itself from very high and / or sudden exposure to sound (for example a loud rock concert).

5.17 The human ear is more sensitive to certain frequencies, typically between 1kHz and 4kHz (approximately the top two octaves on a piano) as this is an important part of the range of speech. However, when a sound is dominated by lower frequency content, typically below around 200-250Hz, it is also recognised as more intrusive than noise that has a more 'balanced' spectrum and so warrants special attention.[18] The A weighting decibel scale (dB(A)) is used to adjust the absolute sound levels measured to reflect the approximate sensitivities of the human ear, though it is recognised it cannot reflect all elements of the noisiness and intrusiveness of a sound, especially low frequency sounds.

5.18 Sound is most commonly measured in decibels, though there are other means for assessing sound, for example using loudness scales. Some common sound sources and approximate decibel levels are given below. A change of 3dB(A), in

[17] van den Bosch, K. A., Welch, D., & Andringa, T. C. (2018). The Evolution of Soundscape Appraisal Through Enactive Cognition. *Frontiers in psychology*, 9, 1129.

[18] See Leventhall H G. Low frequency noise and annoyance. Noise Health 2004;6:59-72. A balanced spectrum has an accepted fall off in noise level per octave. In an office an acceptable fall of per octave was found to be 5dB / octave. Where there is an excess of low frequency noise this is typically perceived as a 'rumble'. The difference between C weighted and A weighted levels (see glossary for definitions) has also been found to indicate dominance of low frequency noise. If the difference between C weighted and A weighted values is greater than around 20dB then there is a potential for a low frequency problem. Caution should be exercised in low noise environments.

a sound without other change in its content, is just noticeable to most people in an environmental location and an increase of 10dB(A) in the sound level is typically perceived to be twice as loud.

5.19 Some examples of typical decibel levels measured by MAS are given in table 2 below as a guide. However, it is noted that these are decibel levels alone and do not include a description or penalty for character or context of the noise which in reality would contribute to its acceptability / unacceptability.

Table 1: Typical short term decibel levels for common sources of noise[19]

Amplified music in bar	85-88dB LAeq,T
Road traffic - busy dual carriage way, approximately 20m from centre of carriageway	73dB LAeq,T
Light aircraft flying directly overhead	70dB LAeq,T
Restaurant extract fan at 1m	68dB LAeq,T
Skate park average sound level at 6m	61dB LAeq,T
Mixed residential and industrial area, evening ambient sound level (external)	55dB LAeq,T
Open plan office average daytime sound levels	50dB LAeq,T
Urban residential ambient sound level, night time (external)	35dB LAeq,T
Rural night time ambient sound level (external)	25-30dB LAeq,T
Noise in flat from neighbour's TV located in flat directly above. Clearly audible though content (words) not discernible (internal)	23dB LAeq,T
Inside remote rural bedroom, night time (window partly open) ambient sound level	12dB LAeq,T

5.20 Whilst research in to threshold levels for sounds with specific attention drawing characteristics is limited, for example the onset point of annoyance in a given set of circumstances, some basic sound level thresholds have been found for steady continuous sources such as road traffic noise and relating to the onset of critical health effects.

5.21 A long term steady level of noise of approximately 42dB(A) outside a window from transport sources at night is recognised as the point above which there are

[19] Significant variation can arise, for example, music levels in a bar may drop typically to around 80-85dB(A) in cases and external levels will depend on context and time of day.

increasing adverse sleep effects. [20] An impulsive / peak noise of 35dB inside is recognised as likely to cause some sleep disturbance and a maximum level internally of 42dB(A) is recognised as commonly leading to awakenings when there is repeated incidence, especially during periods of lighter sleep. These threshold levels are based on research into sources of noise typically considered benign (e.g. road traffic noise). It follows that there will be sleep disturbance effects, such as lower quality sleep, at some intermediary level where the noise contains specific character.[21]

5.22 Whether or not noise creates annoyance is a matter of degree and depends on the circumstances, for example on matters such as how loud it is, the type and character of the noise, where, when and how frequently it occurs, how long it lasts etc.[22] It follows assessment of annoyance requires consideration of a range of factors and should not focus on one factor, such as decibel level, alone.[23] The assessment of nuisance and annoyance has been guided by case law and considers both subjective and objective judgements. Nuisance can generally be considered a set of circumstances or 'state of affairs' where there are periods of intrusive noise, which is unreasonable and excessive to the extent that they affect the use of enjoyment of a property in a material way. In MAS' experience, and as identified in many judgements, the following factors have been found to influence the assessment of nuisance and annoyance:

[20] This is an Lnight,outside value. See: World Health Organisation (2009) *Night noise guidelines for Europe*. Geneva: WHO.

[21] It is noted that sleep criteria, and indeed many other threshold levels of acceptability, have often been based on transportation sources and it follows that sounds that do not have the same benign, steady, anonymous character are likely to disrupt sleep at lower levels. This is likely a combination of lack of habituation to sounds that are not steady, anonymous etc, to which a listener might actually become more sensitised, and due to attention grabbing characteristics that are not always recognised in traffic noise. For example it is commonly accepted that audible music bass beats at night in a dwelling are unacceptable and likely to disrupt sleep, regardless of level.

[22] Bontoft & Others v East Lindsey District Council 2008 QBD

[23] Noise impact has long been recognised as relating to so much more than its decibel level. I understand a noise can be effectively immeasurable above ambient or background levels and still be a nuisance where it is incongruent and depending on its nature and character (see for example Godfrey v Conwy County BC (2000)).

- character - both of the noise and of the area
- duration
- time of occurrence
- loudness
- message imparted by the noise
- variation in noise over time
- spectral content of the noise
- frequency of occurrence
- regularity / predictability of the noise
- respite from the noise, length / duration of respite
- how easily the noise can be avoided
- impact of the noise on basic needs such as sleep and communication
- cumulative impact of noise intrusions (different noise sources from single or multiple sites)
- the necessity of the noise also in relation to greater society
- decibel level of the noise
- visual or other impacts associated with the noise

5.23 Assessment of impact on the use and enjoyment of premises can relate to both human responses such as annoyance and irritation but also the coping strategies adopted by people and how they try to adapt to the noise. Coping strategies can relate to changes in behaviour including complaining, trying to mask the noise with other sounds, avoiding the noise through leaving the house to find respite, not using gardens, avoiding social events such as family events, keeping windows and doors closed and in extreme cases, moving house. The coping strategies adopted provide evidence of actual outcomes and are not restricted to evidence based on emotional descriptors. These inform extensively on wind farm impact where abandoning homes is higher than for any other noise case we have ever come across.

5.24 I understand that a noise nuisance and annoyance is not only disturbance and adverse impact but that this disturbance and impact is unreasonable, exceptional or excessive in a material way, affecting the use and enjoyment of a property. It is not trivial impact.

5.25 Assessing wind farm noise impact

5.26 Initial assessments of noise impact from a wind farm (once the wind farm is operational) concerns planning approval noise limits. Currently these types of assessment most commonly look only at average noise level (dB), but is just one factor of many that affect perception and impact of sound in an environment.

5.27 In many cases long term averages are considered that do not relate even to the noise level and how it dominates at any moment in time. Thus, it is common for assessments to report the noise level alone often adding comment that at this 'low (sound energy) level' adverse impact cannot arise. This is seriously misleading and indicates a failure to understand noise.

5.28 In these cases, complaints often continue. This should not be surprising given that the factors commonly contributing to the annoyance (i.e. factors outside of the decibel level alone) have not been included in planning assessments. Thus, the conclusion that noise is not capable of being highly intrusive because sound energy levels are low is incorrect. Notably, UK guidance on wind farm noise nuisance recognises the importance of noise character and the limitation of the decibel level.[24]

5.29 Understanding why wind farm noise can cause complaints is related to many of the basic principles of our perception of sound and noise as discussed above. A human perception of sound or noise is relative to our sound environment. Many of the factors that this relative approach includes cannot be described by an absolute decibel level alone. Wind turbine noise intrudes mainly because of the psycho-acoustic characteristics it exhibits, the sensation level of the noise, how dominant or prominent the noise is in the environment, its relative audibility and the extent to which it draws attention. A similar set of principles arise with music noise where mere audibility at night-time, or where impact occurs regularly, is recognised within guidance as unacceptable.[25]

[24] See paragraph 7.13 below for discussion on "Wind Farm Noise and Statutory Nuisance Complaint Methodology" (NANR 277)

[25] The Institute of Acoustics (IoA) (2003) *Good Practice Guide on the Control of Noise from Pubs and Clubs* St Albans: IoA.

5.30 Wind farm noise annoyance.

5.31 Wind farm noise complaints pertain largely to noise annoyance and similar adverse responses, i.e. the noise is not painfully loud but is considered highly annoying, irritating or affects uses of the dwelling such as quiet relaxation. The assessment of noise impact and annoyance is often related to decibel levels and whilst this offers an easy approach to assessment it often oversimplifies the judgements and interacting factors that occur in reality. The WHO (2000) state:

Whilst sound can be measured with the help of acoustical instruments such as sound level meters, the actual extent of noise nuisance cannot be measured in this way. One of the negative noise effects is annoyance. Large-scale population studies show that only one third of noise annoyance can be accounted for through exposure to varying sound levels. Non-acoustical factors, including personal factors such as noise sensitivity, and social factors, can have as much effect as the sound level. [26]

5.32 The WHO use the word "annoyance" to describe a wide range of human responses which go beyond the lay use of this word. The relationship between noise and annoyance is well summarised by Guski et al (1999).[27] In reality, annoyance is likely to be influenced by a combination of acoustic and non acoustic factors. Guski et al (1999) found that annoyance was mainly a result of *"(1) immediate behavioural noise effects aspects like Disturbance and Interfering with intended activities, and (2) evaluative aspects like Nuisance, Unpleasantness and Getting on one's nerves"*. Guski et al (1999) define annoyance as *"a psychological concept which describes a relation between an acoustic situation and a person who is forced by noise to do things he/she does not want to do, who cognitively and emotionally evaluates this situation and feels partly helpless"* [my emphasis].

5.33 These definitions go a long way towards identifying why wind farm noise can be highly intrusive and annoying even at lower decibel levels. By interfering or

[26] World Health Organisation (WHO) (2000) *Noise and Health* Copenhagen: WHO

[27] Guski, R., Felscher-Suhr, U. & Schuemer, R. (1999). The Concept of Noise Annoyance: How International Experts See It. *Journal of Sound and Vibration*. 223(4) pp 513-527

disrupting activities in the home (by attracting attention away from the intended activity) and because of variable and tonal noise characteristics (typically evaluated as unpleasant noise characteristics) wind farm noise satisfies two basic and influential factors associated with annoyance.

5.34 Nuisance (and annoyance) as defined above concerns interference with rest and relaxation. A primary consideration therefore is whether there are features or aspects of the wind farm noise that directly impact this i.e. causing reduced ability to relax, rest and be calm, disrupting 'quietness'. Andringa and Lanser (2013) note the importance of a quiet environment in promoting restorative behaviour (rest, calm etc.) and highlight the detrimental and disruptive affect that annoying sounds can have.[28]

5.35 Andringa and Lanser (2013) use the figure below as a means of describing how the appraisal of our sound environment influences our reaction to that environment, what we feel like as a result and how we respond. The right hand side figure influences the left hand side figure, which in turn influences how we interact with our environment. The left hand side figure shows the relationship between unpleasant and pleasant feelings (horizontal axis) and arousal (deactivation and activation) (vertical axis). This is influenced by our appraisal of the sound environment, shown in the right hand side figure. The horizontal axis shows unpleasant and pleasant sounds and the vertical axis sound 'eventfulness'.

[28] Andringa, T.C., & Lanser, J.J.L, (2013). How Pleasant Sounds Promote and Annoying Sounds Impede Health: A Cognitive Approach. *International Journal of Environmental Research and Public Health*. 10 pp 1439-1461

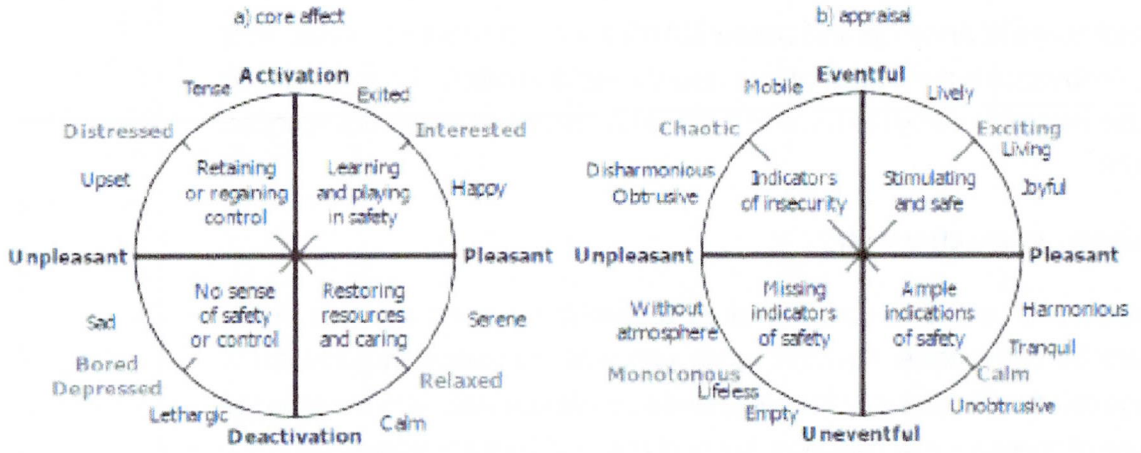


Figure 1: Interaction between appraisal of noise and how this influences emotional experience and arousal

5.36 With respect to wind farm noise, if either of the left hand side quadrants of the appraisal figure (right hand figure) are satisfied then a negative response, such as annoyance, will arise. For example, looking at the top left hand side quadrant, if the wind farm generates sound judged as unpleasant (e.g. loud compared to the underlying sound environment, or highly tonal sound) and eventful or chaotic (e.g. containing many characteristics, intermittent characteristics, unpredictable and changeable characteristics) then this will result in behavioural affects and emotional responses associated with being tense, distressed and upset. It will require more attention thus disrupting other activities by drawing on mental capacity.

5.37 The relationship between the perception of our sound environment and positive / negative feelings and arousal (core affect), and in turn how this can then impact on rest and relaxation (quiet) is described by the authors below:

"...boring sonic environments and sonic environments that contain annoying sounds lack safety indicators or are indicative of potential or actual danger. These environments function as exogenous motivators that force us to be more alert and/or to attend particular sources that then may come to dominate mind-states. Prolonged presence in annoying sonic environments reduces the freedom to self select adaptive behaviour, reduces opportunities for the proactive optimization of long-term needs, and leads to ensuing health effects." *Andringa & Lanser (2013) [my emphasis]*

5.38 The conclusions of Andringa and Lanser (2013) are concordant with Guski et al (1999). Annoyance is generated by interference and disruption of activities in the home and being forced by the noise to behave in a manner that was not intended or sought.

5.39 Wind turbine noise character.

5.40 There are many factors to consider when assessing noise impact. Historically the character of the noise, how this varies with time, frequency and duration of the noise and the character of the area have all been considered relevant to the existence of annoyance or nuisance. Many of these factors are referenced in the way that wind turbine noise is described by those affected.

5.41 Wind turbine noise and AM is commonly described by affected residents in various ways. Some of the descriptions are collated below and show the range of analogies and features attributed to the noise.[29] It is suggested that such a range of descriptions arise due to the alien nature of the noise, which those impacted struggle to try to correlate with other familiar and commonly arising noises in an environment.

[29] These are collated primarily from large wind turbines but many are equally appropriate for small wind turbine descriptors.

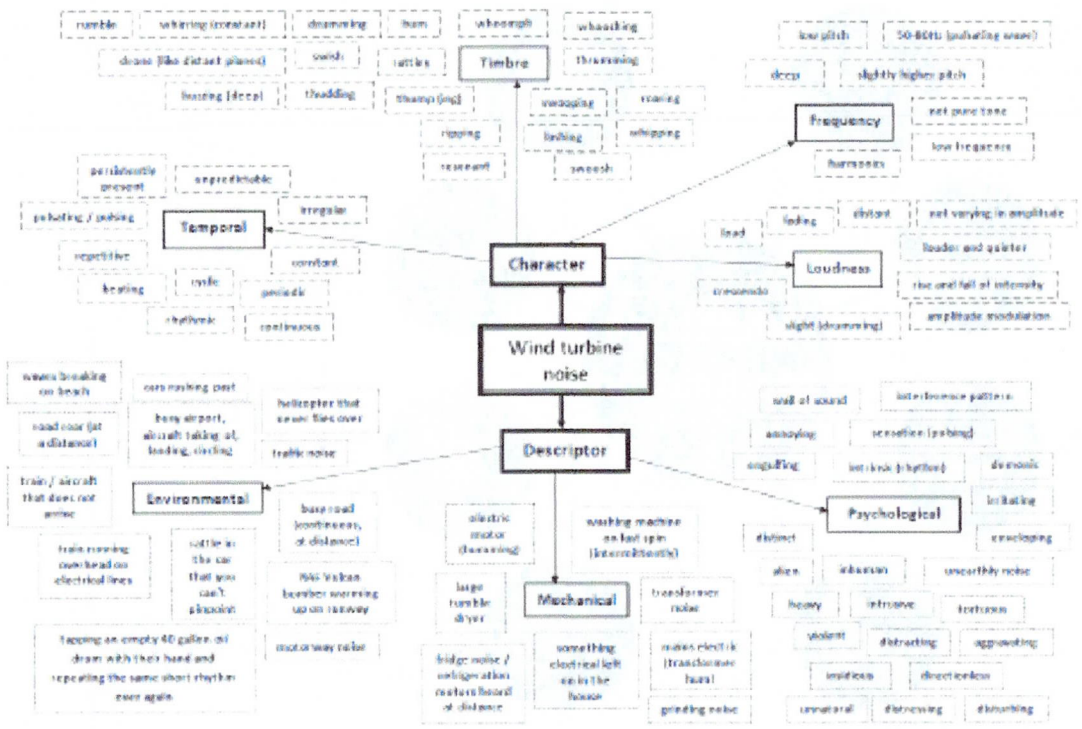


Figure 2: Terms used by affected residents to describe wind farm noise and AM

5.42 Amplitude modulation, which is a major feature of wind farm noise, itself exhibits different characteristics. Categories or types of AM could quite easily form a sub group of wind farm noise characteristics including, for example:

Regular AM where there is little variation or change in the level of AM (this could be linked with the 'repetitive' descriptor often used by those affected).

b) Erratic AM, where there is not a clear periodicity or rhythm but with individual AM peaks (often with a high peak to trough difference) can arise with little warning.

c) Intermittent AM, where the AM comes and goes, fades in and out - this is a fairly common feature.

5.43 The figure below shows some of the factors that can be considered when trying to assess the extent and severity of AM impact.

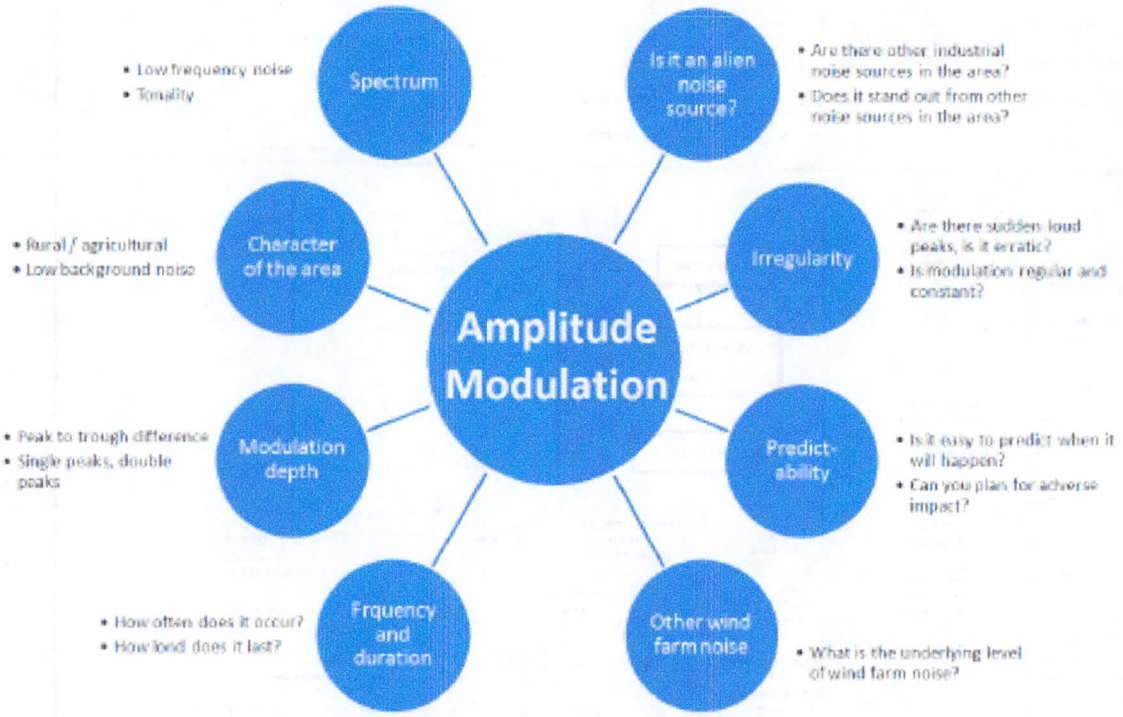


Figure 3: Aspects contributing to AM assessment

5.44 As already discussed, people react differently to sound and noise. Whereas some might not object to a certain level or type of wind farm noise, others clearly do find it intrusive. Why this is so and how it can be explained has been the subject of research but clear conclusions have not always been reached.

5.45 Several studies have found that annoyance is not necessarily related to sound level and that wind farm noise is more annoying at lower levels than other sources of noise.[30,31,32] Pedersen (2007) (2009) listed moderating factors as visual

[30] Yokoyama, S., Sakamoto, S., & Tachibana, H. (2013). Perception of low frequency components contained in wind turbine noise. 5th International Conference on Wind Turbine Noise. Denver.

[31] Pedersen E,. & Waye, K. (2004). Perception and annoyance due to wind turbine noise - a dose response relationship. J. Acoust. Soc. Am. 116 (6) pp. 3460 -- 3470.

[32] Schäffer, B., Schlittmeier, S., Pieren, R., Heutschi, K., Brink, M., Graf, r., & Hellbrück, J. (2016). Short-term annoyance reactions to stationary and time-varying wind turbine and road traffic noise: A laboratory study. J Acoust. Soc. Am. 139(5) pp2949-2963.

impact, low background sound levels and lack of respite at night time. [33,34] Michaud et al (2016) found that response to wind turbine noise is related to the overall A weighted noise level but that communities are between 11dB and 26dB less tolerant of wind turbine noise than of transportation noise sources.[35]

5.46 Ioannidou et al (2016) focused on analysis of annoyance from AM and confirmed that for sources of AM of a fixed decibel level, modulation depth (peak to trough difference) was the primary determinant of annoyance.[36]

5.47 The research of my colleague Sarah Large at MAS found that differences between types of AM can clearly be heard and that differences in responses are largely a result of AM characteristics rather than sound energy levels.[37] Regularity, irregularity, constancy and repetitiveness were identified as both positive and negative features of AM whereas rhythmic features, low frequency sounds and drones / hums were all consistently identified as annoying. [37]

5.48 It is clear that there are many features of wind turbine noise and any one of these features might draw our attention, including changes within these features. The role that this has in wind farm noise disturbance is described by Gabriel et al (2013) [38]:

...he might wake up with the first peak of AM not knowing this was the reason, but half awake and listening if there might be some "danger". He might identify

[33] Pedersen, E. (2007) Human response to wind turbine noise - perception, annoyance and moderating factors. Göteborg: Göteborg University

[34] Pedersen, E., van den Berg, F., Bakker, R., & Bourma, J. (2009) Response to noise from modern wind farms in The Netherlands. J. Acoust. Soc. Am 126(2) pp. 634-643

[35] Michaud, S. et al (2016). Personal and situational variables associated with wind turbine noise annoyance. *J. Acoust. Soc. Am.* 139 (3) pp. 1455 -- 1466.

[36] Ioannidou, C., Santurette, S., & Jeong, C.H. (2016). Effect of modulation depth, frequency, and intermittence on wind turbine noise annoyance. J. Acoust. Soc. Am 139 (3) p.1241-1251.

[37] Large, S. (2016) A quantitative and qualitative review of amplitude modulation noise from wind energy development. Internoise 2016. Hamburg, Germany.

[38] Gabriel, J. et al. (2013). Amplitude Modulation and Complaints about Wind Turbine Noise. 5th International Conference on Wind Turbine Noise. Denver.

the wind farm as origin of noise with the next "peak" of AM and from now on it might be hard for him to rest or to fall asleep again.

5.49 Character of wind farm noise.

5.50 In contrast to a rural pastoral character, wind farms generate a mechanical and industrial source of noise that characterises the area as one in close proximity of and dominated by commercial / industrial activity. There is usually an overall increase in noise level that saturates the sound environment with broadband sound energy and masks many of the natural sources that would otherwise be heard.

5.51 In addition to the overall increase in sound energy there are additional characteristics associated with industry such as low frequency noise, hums, whines and AM that creates a cacophony of mechanical sound. It is a stark change to the otherwise quiet and tranquil soundscape devoid of such sources until a wind farm operates. It is an incongruous sound that can dominate and dictate the character of the area during day, evening and night and for sustained periods.

5.52 Spectral content of the noise.

5.53 The spectral content of the noise is usually variable and depends on the measurement location (indoors or outdoors) and the range of acoustic characteristics present. In turn these commonly depend on meteorological conditions, the make of turbine, distance and orientation. There are several key acoustic characteristics generated by a wind farm that have a specific spectral footprint. Lower frequency energy is commonly prevalent within the data. This can arise as an overall increase in low frequency energy (broad band) or with some tonality (specific third octave bands creating a humming sound) or with tonality and pulsing (a pulsing hum).

5.54 The presence of low frequency noise and hums / whines / tones is commonly associated with increased annoyance and is likely to make the noise more intrusive at lower levels than a sound of the same sound energy level but absent specific spectral content.

5.55 Regularity / predictability of the noise.

5.56 There is an element of predictability and regularly in wind farm noise impact from a wind farm. Whenever there is wind, there is likely to be impact and this will occur continuously until the wind farm is turned off or the wind drops. However, the level and type of impact is highly unpredictable. AM can arise for short periods or bursts within a longer period of sustained general wind farm noise impact or continuously for several hours at a time. Similarly, low frequency noise can arise briefly as a pulsing hum or for longer periods. No clear pattern to the type of noise impact that will arise is seen and the severity of noise impact is readily variable but apparent. The lack of predictability prevents residents from implementing effective coping mechanisms such as planning social events.

5.57 The impact of the noise on basic needs such as sleep and communication.

5.58 Wind farm noise level is never of a magnitude that would cause speech interference or would likely mask speech or other typical household sounds. However, it is of a level that is clearly audible and could cause annoyance or interference with other sounds and activities. The level and nature of impact is commonly of a type and magnitude that would be expected to result in sleep disturbance.

5.59 Levels of internal low frequency noise measured within bedrooms often exceed the Defra low frequency noise curve. Average internal noise levels also commonly exceed the threshold set for sleep preservation for steady continuous noises, such as road traffic noise. This is often the case as attenuation moving inside can be low. Attention is highly likely to be drawn to the noise of the wind farm due to acoustic features such as pulsing, tonality and AM and this is highly likely to interfere with the return to sleep once awoken.

5.60 Cumulative impact of noise intrusions

5.61 The noise impact from a wind farm can be treated as a whole (a single impact) and this is reasonable for many aspects of the noise. However, the location of different turbines relative to a dwelling can result in what appears to be multiple sound effects arising from different turbines. This particularly relates to AM. The effect of multiple characteristics arriving from different turbines and different

directions will have a cumulative impact on the sound environment and how the sound is perceived, creating an impression of being surrounded by the sound. Localisation of multiple sources also constitutes another aspect of the wind farm noise that will draw attention (making the noise harder to ignore).

5.62 In addition to cumulative noise impacts, there may also be the cumulative impact of shadow flicker and noise. It is not possible to quantify this cumulative effect.

5.63 Annoyance

5.64 Many of the factors discussed above are clear indicators of annoyance. Unlike other sources, for example transportation or industrial noise, the wind farm noise can occur 24/7/365 for as long as there is sufficient wind. Transportation sources would typically reduce at night time and strict controls are typically placed on industrial activity to either limit frequency and duration of intrusive sources or reduce the overall dominance of the noise if it is to occur regularly. Such controls and restrictions are not in place for the majority of wind energy developments. Thus, the wind farm noise is constant and therefore conflicts with day to day living far more so than many other sources of noise.

5.65 The lack of respite and lack of escape from wind farm noise is another factor readily associated with annoyance. A lack of control over an intruding noise or a lack of control over your environment is a common cause of annoyance. Residents have no control over the noise from a wind farm and there are no controls on its operation to the extent that there are no predictable or guaranteed periods of respite. For example, there is no ability to cope with a noise that occurs all night in the knowledge that the next night will not be affected.

5.66 There is commonly a lack of escape from the noise. External amenity areas at dwellings are commonly affected and it readily penetrates residential buildings leading to no where to escape it except leaving the area. When inside the wind farm noise remains clearly audible and dominant with windows open in most cases. In many cases aspects of wind farm noise are also audible indoors with the windows shut. As such, to escape entirely from the noise residents must leave the dwelling or generate a source of masking noise within the dwelling. The lack of control and extreme coping responses needed remove autonomy of

residents' actions and living within their own home. This is highly likely to lead to annoyance.

5.67 There are many other factors of annoyance discussed including common explanatory themes that arise throughout discussion papers on noise annoyance. If a sound attracts attention, if it is incongruous with the sound environment absent the specific sound, if the sound is much louder than other pre-existing sound sources then annoyance can be expected to arise. Such factors commonly arise in the case of wind farm noise. Multiple acoustic characteristics generated by a wind farm will attract attention for that reason alone.

5.68 A mechanical / industrial wind farm source of noise is an alien sound in an otherwise quiet, rural soundscape. Most wind farms generate substantial increases in sound energy above pre-existing background and ambient sound levels for significant periods but this is lost with averaging times when they do not.

5.69 Guski et al (1999) found that annoyance was mainly a result of "(1) immediate behavioural noise effects aspects like Disturbance and Interfering with intended activities, and (2) evaluative aspects like Nuisance, Unpleasantness and Getting on one's nerves".[27] The evaluative aspect of any wind farm noise commonly fits with annoyance, nuisance, unpleasantness and 'getting on one's nerves' responses.

5.70 Andringa and Lanser (2013) highlight the importance of 'quiet' in a sound environment. A level of quiet is needed to promote restorative behaviour. The presence of a quiet or restorative environment is marked by aural cues as to the safety of the environment. It would normally include aural cues such as wildlife sounds, birdsong.[39] These sounds are commonly masked or subsumed within wind farm noise and as such the wind farm noise works against aural cues that promote rest and relaxation.

[39] Natural sounds are typically considered with safety and lack of danger. For example, the sound of a forest or jungle will suddenly be silenced by the presence of a predator. This effect is commonly used in film scoring to indicate imminent danger or cause for concern.

5.71 There is a clear case for expected heightened annoyance with most wind farms for multiple reasons. Empirically there is a significant increase in noise and this is accompanied by acoustic character (multiple features) that attract attention and render the noise more annoying, harder to ignore. Qualitatively the noise conflicts with periods when residents would expect greater freedom from noise. It conflicts with and disrupts periods of sleep. There is a lack of control over the noise, lack of respite from the noise and limited escape from the noise. The combination of all of these factors commonly result in a state of affairs where it is expected residents to be highly annoyed. This arises at the levels which would comply with these draft guidelines.

5.72 This submission is by me based on my analysis of the draft guidelines but is extensively informed by much of the research and analysis of criteria, especially included in Part 2 that has previously been prepared by Sarah Large.

Mike Stigwood
Director and Lead Environmental Health Consultant
MAS Environmental Ltd.

19th February 2020

The assessment of potentially actionable noise impact

By Daniel Baker, Senior Environmental Health Practitioner, MAS Environmental Ltd and Mike Stigwood, Director and Lead Consultant, MAS Environmental Ltd.
(Reviewed by Professor Andy Smith, Director, Centre for Occupational and Health Psychology, School of Psychology, Cardiff University)

This article considers elements of noise impact; independent, or only partially reliant on the decibel level. It relates to sources of specific sound from one premises affecting another that is potentially 'actionable' in law.

One example of actionable noise in the UK is noise emitted from premises that is prejudicial to health or a nuisance regulated by a local authority.[1,2] Consideration is given to non-acoustic and situational factors ('context') and how they affect the perception, interpretation and reaction to actionable sound at the individual level.

Main image: Sound waves that are disruptive, alien, unwanted, occurring in the wrong place, at the wrong time or otherwise in an unexpected way (context), are usually considered noise

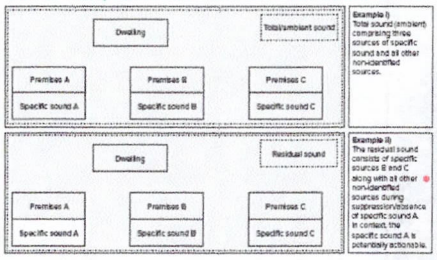
When is sound noise?

In air, sound is an aural sensation caused by pressure variations. The pressure variations are waves of energy. Sound is the human perception of those pressure waves via the hearing mechanisms located within the ear as interpreted by the brain. The pressure variations are transmitted via the middle ear (air), inner ear (fluid) and converted into nerve impulses mainly within the cochlea. The nerve impulses are detected and interpreted by the brain.

The perception of a sound, whether desired or unwanted will depend on a wide range of acoustic and non-acoustic factors, memories, associations, sensitivity and expectation. Sound can have positive psychological connotations such as a songbird reminding the

"The perception of a sound, whether desired or unwanted, depends on a range of acoustic and non-acoustic factors, memories, associations, sensitivity and expectation."

Actionable/specific sound within the acoustic environment



Above: Figure 1

listener of nature. This provides a positive association with the acoustic environment. Where sound waves are disruptive, alien, unwanted, occur in the wrong place, at the wrong time or otherwise in an unexpected way (context), is usually considered noise.

Categories of noise and description of sound in context

In England, the Department for Environment, Food and Rural Affairs (DEFRA) within the Noise Policy Statement for England (NPSE) 2010 recognises noise as falling into three categories:

- 'environmental noise' which includes noise from transportation sources
- 'neighbour noise' which includes noise from inside and outside people's homes; and,
- 'neighbourhood noise' which includes noise arising from within the community such as industrial and entertainment premises, trade and business premises, construction sites and noise in the street"

Noise affecting sensitive locations such as dwellings can fall into any of the categories both externally and/or internally. The total (ambient) sound encompasses all categories of noise. Sources of actionable noise most commonly fall into the 'neighbour' and 'neighbourhood noise' category. The specific sound is emitted from a specific source and usually identifiable by the receiver within the acoustic environment as to where it emanates from and what it is caused by. The total, specific and residual sound is illustrated in Figure 1 above.[2]

In Figure 1, example i shows a dwelling juxtaposed with premises A, B and C. The premises operate independently, and each emit a specific sound respectively, also as A, B and C. The grey area represents the total sound comprising all sources near and far. In the context of example ii, premises A emits a specific sound of noticeably different character. Premises B and C along with all other non-identified sources of sound within this example acoustic environment contribute to the residual sound, as observed when the specific sound from premises A is suppressed. The occupants of the dwelling consider the specific sound emitted from premises A to be unwanted (noise) and intrusive within the context of a residential receiver. Depending on the context and different approaches to analysis in each of these two examples, the specific sound can be considered as part of the residual sound or as specific sound that is intrusive and unwanted at the residential receiver. 'Context' can therefore have widespread interpretation and application.

The term 'context' is increasingly used within environmental management and noise assessment. A wider definition suggests context is *"A set of physical (geographical, topographical, meteorological, and structural), social, psychological, cultural, situational conditions, relevant to determine a particular individual or collective behaviour, attitude, emotion toward an environmental stressor"*[4] in relation to noise, the International Organization for Standardization (ISO) considers that context concerns the interrelationships between person, activity and place in space and time through auditory sensation, interpretation of that sensation and response.[5] Thus, generally, noise should not be considered in isolation but in the context of wider situational factors. However, for actionable noise those affected and regulators are often less concerned with factors such as wider societal benefit when assessing noise and focus on how it affects the individual based on the circumstances of impact.[6,7]

Situational factors and psychological reaction

Noise is commonly defined as unwanted sound or sound without value. Noise may arise in a variety of situations from a dripping tap, someone else's loud telephone conversation, an intruder alarm or sound including unusual or otherwise irritating features that disrupt thought processes. Conversely, the greater our mental effort or concentration on a task, the less attention we pay to other stimulants such as noise. As a result, noise disrupts activity such as relaxation and rest to a greater extent than activities requiring higher concentration. For example, undertaking manual work tasks, concentrating on an important telephone call or cutting a hedge.

The term 'noise' introduces a subjective (emotionally based response) element to the individual's decision of whether a sound is wanted or unwanted. It is normally an unconscious response. It is important to note, whether a sound is noise and whether that noise is expected or annoying is dependent upon the circumstances/situational factors in which sound is received. For example, a relatively quiet dripping tap may be thought of as not too annoying but can prevent/disturb sleep if audible in a hotel bedroom at night when it is otherwise quiet. Likewise, an objectively loud audible intruder alarm sounding on the streets of towns and cities during the day may cause little annoyance to a transient listener but with the same sound energy level can become a serious annoyance when repeatedly malfunctioning at 2am in a residential neighbourhood. 'Noise annoyance' can be defined as negative feelings of dissatisfaction, displeasure, disturbance or irritation caused by a specific sound.[8]

A loud telephone conversation of another passenger can be very annoying when trying to relax, read or concentrate on a long train journey. The speech content and use of language is likely to continuously trigger attention. However, the person making the call is less distracted by the noisy environment around them as they are concentrating on the call. These aspects of annoyance are far less determined by the decibel level other than in relation to audibility and possibly dominance, but by the constituents of the sound (character, message imparted to an inadvertent listener etc.) and how they are perceived (expectation, level of interruption etc.) in context.

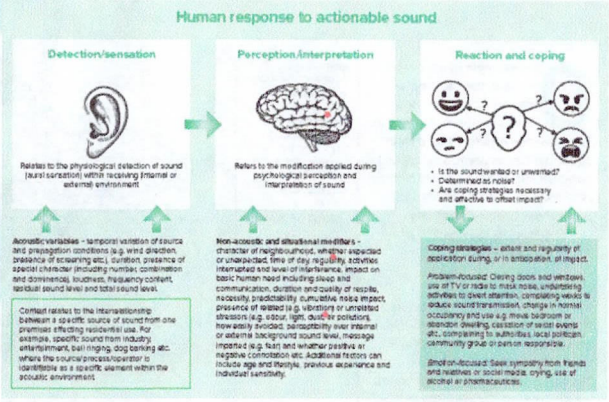
The likelihood a sound is considered noise and will cause annoyance is multifactorial. The individual interpretation and reaction includes modifiers such as attitude/perception of the source and source operator, attitude to the message imparted, necessity to community life, perception of control over the specific source, individual sensitivity and sensitivity to any specific characteristics present that grab attention i.e. disrupt rest, relaxation or activities requiring concentration. This is shown diagrammatically in Figure 2 below.

Figure 2 shows the detection/sensation, perception/interpretation and reaction/coping at the individual level.[9] Sensation relates to the physiological detection of sound and acoustic variables. Perception/interpretation refers to modification due to non-acoustic and situational factors applied during the psychological processing of sound within an internal or external environment. Non acoustic factors can arise from unconscious or conscious responses. Reaction follows psychological processing and modification to determine whether the sound is wanted or unwanted. Problem-focused or emotion-focused coping strategies may then be applied which are multidimensional and situation specific.[10] Coping strategies can be maladaptive, for example, the use of alcohol to sleep during repeat noise exposure. This form of maladaptive coping can lead to unintended adverse health outcomes. The aim of coping strategies is to counteract adverse impact arising from exposure to the noise stressor, usually in a way that disrupts desired lifestyle the least.

Interpretation also depends on related memories, for example, if a particular activity (neighbour's party) led to disturbed sleep at an important point in lifetime then any related memories to noise from that neighbour could trigger emotive responses relating to the historical experience. One example would be a party affecting sleep the night before an exam and such recurrence is likely to more readily trigger negative response.

The specific sound arising from industrial/commercial use is likely considered wanted by staff or those associated with the business as it informs on operations and imparts a positive (economic) message. However, it can be considered unwanted by residents when received in the context of a home environment where there is no equivalent positive message or perceived benefit.

Below: Figure 2



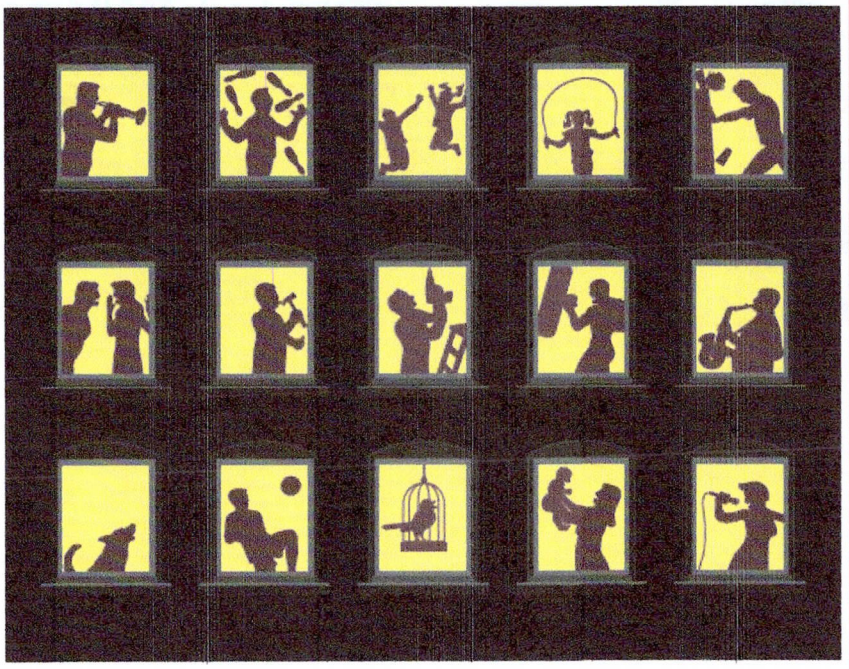
The aural experience will also depend on the condition of the ear and especially the inner ear which changes with age, exposure to excessive noise (sustained or sudden) and natural/genetic variation. Age introduces changes into this evaluation of noise both in terms of physiological and psychological changes where loss of hearing capacity due to presbycusis means generally there is less recognition of higher frequency intruding sounds.[11,12] Conversely the increased range of memory of different sounds, voices of individuals and exposure to societal experience introduces greater causes of distraction where attention is unconsciously drawn. Thus, a young child will recognise and be drawn by a parent's voice but not attracted by a wide range of sounds it has little experience of and therefore memory of. This has been demonstrated with smoke alarms where children who have not experienced the alarm may sleep through it but those trained to respond and treat the noise as a sign of danger (imparts a message) or is based on a known voice will more readily awaken.[13]

Cognition and habituation

Unlike other environmental stressors such as light, noise cannot be 'shut out' physiologically by the body.[14] However, habituation to some forms of noise does occur when the message interpreted by the brain is determined as not presenting a risk of the need for fight or flight (psychological and physiological stress response) such as road traffic noise. Humans typically habituate to noise that does not impart a message of concern. Similarly, a noise may not trigger psychological stress responses as there is no perceived threat but nevertheless draws attention because it triggers unconscious responses such as recognition of the noise and what it represents.

Humans are continuously and unconsciously listening. Humans aurally observe the environment for threat even when asleep which may trigger awakening in response to salient, sudden or loud sounds. This appears a natural response meaning it is difficult to prevent either awakening where the brain perceives a response may be needed, or attention when awake for example, triggering a memory such as from a known voice. Equally, alien and unrecognised sounds will trigger attention and awakening as the brain will be seeking input from all senses in a conscious state to determine its source and, whether it carries a threat or other message. These responses do not require loudness but sufficient recognition or degree of unconscious concern to trigger awakening. As a result, PS4

14. For example, where eyes are exposed to high levels of light the eyelids can close and the iris constricts. There is no alternative or comparative mechanism for aural protection albeit it is understood there is a physiological mechanism of dampening to muscles connected to bone within the ear in response to sudden loud noises e.g. the middle-ear reflex/stapedius reflex.



Below: Sources of actionable noise most commonly fall into the 'neighbour' and 'neighbourhood noise' category

awakenings and distraction when awake arising from alien, unwanted or disliked sounds is not directly related to its loudness and more a factor of its detection, perception (audibility) and identification (interpretation) whether conscious or unconscious. An observer's auditory impression of the relative strength or intensity of the sound is less relevant once identified in a particular situation and humans do not normally relate to them in terms of their loudness in such cases. This is recognised in particular by the courts in nuisance cases.

Other effects include the 'irrelevant speech effect' which is an example of an effect that doesn't depend on the intensity of the noise. The irrelevant speech effect is the finding that performance on immediate serial recall tasks is impaired by the presence of background speech, even though the background speech is completely irrelevant to the task.[6]

In cases of continuous or constant noise exposure, for example distant road traffic noise, habituation occurs reducing adverse response at the individual level. However, in cases of repeat exposure to actionable noise, sensitisation occurs where the message causes increasing alertness or alarm due to the absence of physical or emotional coping.[6,7] The determination of sound as noise, depends upon which type of response is triggered, whether we habituate to it and thus the negative response reduces and the consequence of the response such as awakening, disruption or activity, negative or positive interpretation.

As the disruption of brain activities by noise is an unconscious process, we cannot prevent its effect. It can be reduced by concentrating on the task we do not want disrupted but in turn this requires increased mental focus altering cognition. This in turn is a higher level of alertness and concentration which is not conducive with relaxation and rest. Thus, in the presence of noise on a train we will more readily be able to focus and respond to a message from a work colleague but when at home reading a novel for relaxation, will less likely be able to maintain the relaxation we are seeking to achieve.



Below: Sound can have positive psychological connotations such as a songbird reminding the listener of nature

Noise impact on humans

There are generally two categories of sound source. The first are commonly classified as anonymous sources such as road, rail and aircraft. They are anonymous as we do not unconsciously associate them with a particular person or operator. Thus, when heard they less often draw our attention. They are normally present daily without exception and thus become embedded in memories that do not trigger the need for conscious response.

Sound from transportation is generally considered unwanted and defined 'environmental noise' by national noise policy,[8] impact is primarily related to energy dose and physiological effects of a high level of continuous sound energy causing sleep disturbance, annoyance and triggering hormone type responses. Adverse health effects from transportation noise (anonymous) arise primarily relative to their decibel level and transportation type causing impact (rail/road/air). It can be time specific such as where activity only arises at certain times, for example holiday traffic or operations of a port relating to ferry times, in most cases adverse impact follows a dose-response relationship and daily impact where an increasing decibel level of exposure increases the incidence of adverse health outcomes. A systematic review of evidence by the WHO (2018) identified different trigger levels for air, road and rail traffic.[9] Health effects including but not limited to annoyance and sleep disturbance are recognised to impact at certain trigger/onset levels of sound energy where a stepwise change occurs in the percentage of a population adversely affected.

Environmental noise affects everyone in society to varying degrees. Transportation noise can include special characteristics that require consideration e.g. low frequency noise from aircraft and reaction is influenced by non-acoustic and situational factors. One outcome is the development of different guideline levels for aircraft, road traffic and rail noise as provided in the WHO 2018 and the necessity for individual evaluation. There is a recognisable benefit of transportation sources, socially, for mobility and movement of goods. It is long recognised humans tend to habituate to low levels of distant or localised road traffic noise over time as it does not threaten safety (impart a message of danger) or trigger a flight or flight psychological stress response and is present virtually every day with no related adverse outcome (depending on context). It is noise that is ubiquitous within society, benign in terms of threat, acceptable as a social norm and characteristics to the point it does not normally draw attention or directly relate to some other stressor. Such sources are not normally actionable in law and complaints do not result in direct regulatory action. Exceptions do occur such as a very noisy exhaust on a motorbike and military flying.

The second category is effectively actionable noise. This sound and its circumstances of impact typically contain acoustic and non-acoustic characteristics. Non-acoustic factors, generally, are considered to be all factors other than sound level alone which contribute to noise annoyance and similar effects.[10] This can include a wide range of sources such as music or noise from an industrial site associated with a particular identifiable activity, process or operator. If the responsible person (individual or business) can be identified it is more likely the resulting impact will be perceived as noise by the receptor. Related memories will increasingly be set down as the noise is experienced and reinforce negative responses increasingly over time. Sound with this character unconsciously draws attention associating adverse response with the source, process and person or organisation responsible. As a result, non-acoustic factors associated with the source add to impact (interpretation) and psychological stress caused by the noise (reaction) resulting in the application of coping strategies.

The source recognition and unconscious response, to the process or person responsible, become more readily identified in the brain resulting in increased sensitisation and drawing of attention. Over time, improved recognition develops in the same way a musician recognises faults with their instrument and a conductor recognises what part of the orchestra is at the wrong tempo or dominance. Heightened sensitivity is a normal human reaction following repeat exposure and should not be confused with individuals who may exhibit 'over-sensitivity', generally, to noise i.e. hyperacusis. This leads to a general principle that humans tend to habituate to environmental/transportation noise but sensitise to noise with attention drawing character or that imparts an adverse message. Important parameters include lack of controllability, unpredictability and where a noise is considered unnecessary. Intermittent (non-continuous) noise can have a greater effect on reaction due to the modification attributable to these non-acoustic and situational factors.

Impact from actionable noise with specific acoustic characteristics is determined more by non-acoustic factors such as regularity, times of occurrence, duration and quality of respite periods, message imparted and how individuals interpret it, character of the neighbourhood and what activities are affected. Audibility, dominance, attention grabbing, regularity, duration, times of occurrence and what is disturbed are important non-acoustic and psychoacoustic factors. One example is music bass beat from specific premises where music emissions are regularly audible. Regardless of decibel level, when observed inside the home they are widely recognised as unacceptable. Even when infrequently occurring at night it is recognised as unacceptable as it will disturb sleep. It does so not because of its decibel level but due to the detection and interpretation by the receiver and human responses which trigger awakening or impede mechanisms which lead to the onset of sleep. In the case of bass beat within music, there are two primary effect multipliers including the low frequency content and regular modulation. There are generally multiple reasons for increased human response including expectation and message imparted (speech). In such cases assessment is based on the acoustic characteristics, the mechanisms by which it intrudes, when it occurs and its frequency and duration along with other non-acoustic factors. Other acoustic factors are also important and can include the spectral distribution, and changes in level along with the duration of such sound energy levels.

Relationship of noise character and loudness or sound energy level

The World Health Organization (WHO) attribute only one third of noise annoyance to the decibel level with non-acoustic factors demonstrating greater importance. Whether noise causes adverse or significant adverse impact depends on several factors as recognised in the UK courts in nuisance cases including how loud it is in relative terms, what sort of noise it is, where, when and how regularly it occurs, how long it lasts and its frequency/spectral content. Numerous other factors are also relevant.

Difficulty arises when trying to relate impact causing adverse psychological human response to sound energy level. Whilst loudness is a clear factor and is processed by different neurons to those triggering attention or emotional responses, the relevance and importance of loudness compared to factors such as attention drawing character in the home is less well researched. The latter relates more to its audibility and dominance rather than loudness.

It is generally recognised within planning policy and noise guidance, [10]

18. Exceptions exist where it is necessary for transportation to be heard for safety reasons e.g. train horn but it nevertheless remains unwanted by exposed residents. Especially as many cases are avoidable but is convenient or financially beneficial to the operator. However, it would likely be considered noise when focussed in a home environment to a residents living close to a crossing and many complaints arise.
19. For example, those at a late-night party enjoying themselves at the cost and disregard of others losing a night's sleep.
20. Determined through experience of both authors and feedback from the training of local authority officers responsible for the investigation of noise complaints and enforcement.

"It is generally recognised within planning policy and guidance, that once there is a high sound energy dose in an environment the tolerability of additional noise is reduced particularly where it has attention drawing character."

that once there is a high sound energy dose in an environment the tolerability of additional noise is reduced particularly where it has attention drawing character.[21] It should be recognised quiet environments generally experience increased incongruity by intruding noise particularly where they are not expected. However, in a loud and cacophonic sound environment, low levels of additional noise may not increase attention disruption as there is already a wide range of ongoing attention-grabbing sounds triggering greater attention on tasks in order to avoid disruption. In that instance, the brain is flooded by such effects leading to more complex human responses including potentially a general increased unconscious avoidance of exposure.

Consider an evening environment impacted by a loud relatively steady roar of road traffic at levels of 65dBLAeqT but with additional music noise emissions from an adjacent entertainment facility that is just audible. The music may increase adverse impact even when only just audible due to the total dose. Compare that to a busy vibrant city centre location with the same average noise level but composed of multiple sources.[20] Imposing the same music in this cacophany/sound environment is less likely to intrude due to the saturating cacophony of sounds.

The brain receives separate stimuli in terms of loud noise from multiple sources and has to determine directionality but also elements drawing attention and whether the sound contains a message e.g. threat. So the louder a noise that draws attention the more it will disrupt even higher mental focus except this could change having regard to the context and complexity of the sound environment. Complex sound environments may affect discernibility of some minority sounds. Simply put, in environments with underlying anonymous noise not drawing attention the louder it is the more it would disrupt not just rest and relaxation activities but those in a workplace. In complex sound environments the noise is likely to disrupt and intrude at lower loudness levels, but the intruding noise may not trigger the same complex responses as these aspects of cognition are already in a state of stimulation.

The total level of sound can potentially be important, therefore, in situations where the total sound is high due to all sources near and far and where the specific sound forms one of many individual sources (low signal to noise ratio). Less attention is drawn to a single element of the acoustic environment and impact is more related to the continuous and high levels of noise plus the presence of any individual acoustic features and available coping subject to the complexity of the ambient sources. However, when considering the specific sound in areas of low noise, a high signal to noise ratio relative to the residual sound or background masking sound and minimal competing attention-grabbing character, it can make the sound incongruent focusing attention on that single element. In sound environments that impose a high dose but are not *primarily dominated* by a single continuous transport source, a more complex relationship can arise. Where community noise includes a range of attention drawing sources, for example the cacophonous sound environment described above, this can make assessment of any individual source complex. More research is required as the various contributing factors and their importance remain unknown although it is considered these general principles are supported.

Conclusion

For actionable noise, a noise assessment should consider factors such as audibility and dominance whether internally or externally, frequency and duration, the times it occurs and activities affected, the nature and character of the sounds that unconsciously draw attention and those other factors discussed above in relation to this type of noise. Additionally, impact will vary depending on what human activity is affected. If the noise cannot be escaped from anywhere within the dwelling, this would impact far more than a scenario where it only affects limited rooms used in a limited way such as bathrooms.

Whilst not considered here, audibility and dominance are not necessarily as simple as emergence above background and ambient sound levels, but this is clearly a factor.

In many cases of impact, the decibel level is insufficient to determine whether a specific sound is considered acceptable particularly where certain acoustic and non-acoustic characteristics are present. Whilst pressure variations in the air are a form of energy that can be measured using scientific instruments the reaction to sound is predominantly psychological. This includes within both source noise and residual and background sound environments. The assessment of actionable noise requires more than an understanding of acoustics particularly as knowledge and research into noise with special or specific characteristics is limited. It is possible complex noisy environments may exhibit a greater tolerability of additional characterful noise than less complex quieter environments and is an area for future research.

There are too many variables to provide precise levels or decibel ranges to such influencing factors, but we can draw reasonable conclusions. For example, where a noise is both loud and attention drawing, it does not become acceptable by simply reducing its loudness when still above the point it continues to draw attention. The latter element is less related to loudness and more related to the acoustic characteristics or message imparted by that noise which do not disappear until it is no longer discernible.

When undertaking noise impact assessments, it should be remembered noise falls into distinct categories and the resulting level of annoyance or stress increase can be dependent on a variety of acoustic, non-acoustic and situational factors independent of the decibel level. Dominance, audibility, noisiness and attention drawing elements need to be analysed along with all the other factors discussed such as message imparted, frequency and duration but which can be further complicated by the constituents of the existing sound environment. Other factors such as additional environmental stressors within the receiving locale are also important.

21 For example, when considering context in BS4142:2014+A1:2019 Methods for rating and assessing industrial and commercial sound. London: BSI. Reference to 'absolute level' within online planning noise guidance. See https://www.gov.uk/guidance/noise--2 accessed 20/12/19.

References

1. Environmental Protection Act 1990 Section 79(1) (g) and (8).
2. Refers specifically to the 'nuisance' limb of statutory nuisance under section 79(1) (g).
3. Based on Figure 1 from Dzhambov A, Gjestland T and Lercher P. Review: Challenges of the Use of Sound Emergence for Setting Legal Noise Limits. International Journal of Environmental Research and Public Health 2019, 16, 4517;page 3.)
4. Lercher P, 2019. Combined Transportation Noise Exposure in Residential Areas. In: Nriagu, J (Ed.) Encyclopaedia of Environmental Health. Elsevier Vol 1, pp626-712.
5. BSI, 2014. BS ISO 12913-1:2014 Acoustics – Soundscape. Part 1: Definition and conceptual framework.
6. The wider societal, economic and environmental (sustainable development) considerations would be relevant when considering land use planning applying the NPSE 2010.
7. Baker D. Author's response to comment on "Application of noise guidance to the assessment of industrial noise with character on residential dwellings in the UK". D Baker 93 (2015) 99-96. Journal of Applied Acoustics. Vol. 145, February 2019, Pages 25-26.
8. Guski, D. Annoyance Caused by Exposure to Road Traffic Noise: An Update. Journal of Environmental Psychology Volume 21, Issue 1, March 2001, Pages 105-120.
9. Based on Figure 1 from Baker D. Preliminary evaluation of the relative importance of acoustic, non-acoustic and context related factors in reactions to noise at the individual level. Proceedings of Inter noise 2017 27-30 August Hong Kong. Pp 4501-4512.
10. Mark G and Smith A. Coping and its Relation to Gender, Anxiety, Depression, Fatigue, Cognitive Difficulties and Somatic Symptoms. Journal of Education, Society and Behavioural Science 25(4): 1-12, 2018; Article no.JESBS.41904.
11. Wiley T et al. Aging and High-Frequency Hearing Sensitivity. Journal of Speech Language and Hearing Research, Volume 41, 1061-1072, October 1998.
12. Wiley T et al. Changes in Hearing Thresholds over 10 years in Older Adults. Journal of the American Academy of Audiology, 2008 April, 19(4): 281-371
13. Smith G, Chaumbhath T and Sjolangard M. Effectiveness of a Voice Smoke Alarm Using the Child's Name for Sleeping Children: A Randomized Trial. The Journal of Pediatrics. February 2016, Vol. 205, Pages 250-256.
15. Farley L, Health I, Albritton D and Surprenant. Irrelevant speech effects and sequence learning. Memory & Cognition. 2007, 35 (1), 156-165.
16. Cooper S, 2018. The inaudible soundscape of a wind farm. Proceedings of Euronoise 2018, 27-31 May, Crete, pp 2383-2390.
17. Relates to investigations and situations of actionable noise investigated by the author's and as debated in various noise nuisance cases.
18. World Health Organization, 2018. Environmental Noise Guidelines for the European Region. Copenhagen: World Health Organization Regional Office for Europe.
22. Findall I-H, Wittur U. Non-acoustical factors in noise management at Heathrow airport. Noise & Health [serial online] 1999 [cited 2019 Nov 6];1:27-44. Available from: http://www.noiseandhealth.org/text.asp?1999/1/3/27/31715
23. Stigwood M. Diminishing reliability of the application of Standards on Environmental Noise in the UK. Proceedings of Inter noise 2017 27-30 August Hong Kong. Pp 4489-4500.
World Health Organisation, 2000. Technical Annex – Local Authorities Health and Environment.
24. Baars BJ and Gage N, 2010. Cognition, Brain and Consciousness: Introduction to Cognitive Neuroscience. Second Edition. Oxford: Elsevier

Advertising feature

Secondary glazing enriches Art Deco revival of Hatfield's most iconic building



The Comet Hotel is at the junction of the Barnet by-pass with St Albans Road in Hertfordshire, close to the Selectaglaze office and factory.

Formerly known as the Ramada Hatfield, the Comet's multimillion pound refurbishment, which began in 2017, is now complete. A new three storey extension block annexed to the rear of the hotel has added a further 52 rooms, which reflects and enhances the silhouette of the heritage building. This new extension is shared with a student residential development.

In addition, the hotel has also opened its own independent restaurant, 'Element Bar & Kitchen'. A replica of the Comet Racer, mounted on a 20ft high pylon stands tall outside the hotel.

The hotel had retained the building's original Crittal sash windows, but this did not provide the required level of noise insulation to a number of the guest rooms, restaurant and function spaces.

To remedy this, St Albans-based Selectaglaze installed 104 secondary glazed units. The secondary windows were made bespoke to ensure the best fit and included four different systems, specific to the project's needs. All units were finished in white to match the original external windows.

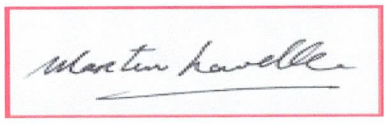
The new secondary glazing to this Hatfield landmark will help lower energy bills and afford the guests a good night's sleep, and those visiting the hotel will be guaranteed a pleasant experience.

Hotel refurbishments are often fast-track projects requiring close cooperation between client, contractor and specialists. Selectaglaze has wide experience of working in buildings up to Grade I Listed and offers a technical advisory service and specification advice to ensure correct interface with other trades.

Established in 1966, Royal Warrant Holder Selectaglaze is the leading specialist in the design, manufacture and installation of secondary glazing and will be exhibiting at Future Build 2020 from 3rd – 5th March 2020.

For further information, please contact Selectaglaze on **01727 837271**
Email: enquiries@selectaglaze.co.uk
Visit: www.selectaglaze.co.uk

Signed:…



Martin Lavelle, BE.
24th June 2026

APPENDIX I – COMMUNITY STATEMENT REGARDING PUBLIC CONSULTATION

Community Statement Regarding Public Consultation
Proposed Tirawley Wind Farm Development – ACP Ref. PAX16.324258

Purpose of this Form

The purpose of collecting these signatures is to document concerns from local residents regarding the lack of adequate public consultation and public awareness in relation to the proposed Tirawley Wind Farm Development (ACP Ref. PAX16.324258).
This form will be submitted to An Coimisiún Pleanála as part of a formal objection to the proposed development.

Data Protection Statement

The personal information provided on this form (including name, address, and signature) is being collected solely for the purpose of supporting a submission to An Coimisiún Pleanála regarding the proposed Tirawley Wind Farm Development (ACP Ref. PAX16.324258).
The information will only be used in connection with this submission to An Coimisiún Pleanála and for no other purpose.
By signing this form, you consent to your information being included as part of the submission to An Coimisiún Pleanála.

Concern Regarding Lack of Public Communication/Consultation

This form records concerns from local residents regarding the level of public consultation and public awareness associated with the proposed Tirawley Wind Farm development.

Resident Statement

I declare that I was not adequately informed, consulted or made aware of the proposed Tirawley Wind Farm development,

- No door-to-door consultation took place with any resident within my home
- There were no leaflets etc distributed to our home
- The only public information event known to us the residents took place in June 2023, in Ballina, over 25km away.
- This event was poorly advertised and not sufficiently brought to the attention of us the local residents.
- Residents further understand that the June 2023 event related to a different proposal involving approximately 31 turbines and not the current proposal now under consideration.

I respectfully request that An Coimisiún Pleanála take these concerns regarding public consultation and community awareness into account during the assessment of the application.

No	Full Name	Address/Eircode	Signature	Date	
1	Geraldine McManus	Lissadrone Ballycastle, Mayo F26 RX92	G McManus	28/05/26	
2	Jacqueline Brady	Lissadrone F26 EC97		28/5/26	

3	Edward Farrell	F26 DW96	Edward Farrell	28/5/26	
4	Mary Keating	F26 W8FC	[illegible]	28/05/2026	
5	Teresa Fagan	F26 KD74	Teresa Fagan	28-5-26	
6	Jan Ath Murrally	F26 CH74	[illegible]	28/05/26	
7	Erika Bodnar	F26 HY68	[illegible]	28/05/26	
8	Bernadette Barkley	F26 K85P	[illegible]	28 5 26	
9	MARION SALT	F26 XGY4	Marion Salt.	28/5/26.	
10	GRETTA BYRNE	F26 WV05	Gretta Byrne	28/5/26	
11	FRANK CARDEN		[illegible]	28/5/26	
12	Ann Carden	F26 P7Y7	[illegible]	28/5/26	
13	STEPHEN MEANY	F26 PO3E	Stephen Meany	28/5/26	
14	Brendan McDonnell	F26P6RO	Brendan McDonnell	28/5/26	
15	Reynagh Murphy	F26FHP5	Reynagh Murphy	28/5/26	
16	Carmel Gallagher	F26 AOWO	Carmel Gallagher	28/5/26	
17	Liam Boyd	F26D271	LIAM BOYD	28-5-26	
18	Bernie Boyd	F26D271	BERNIE BOYD	28/5/26	
19	Sarah Boyd	F26D271	Sarah Boyd	28/5/26	
20	SEANO GRADY	F26X2YP	Seano Grady	28-5-26	
21	GEORGE O GRADY	F26X489	George O Grady	28-5-26	
22	Emily Golden	F26 Y2C4	E Golden	28-5-26	

23	Francis Healy	F26 H4CA	Francis Healy	28/5/26	
24	Lisa Tighe	F26 W7EF	L Tighe	28-5-26	
25	Noel Tighe	F26 W7EF	N Tighe	28 May 26	
26	Patricia Kelly	F26 A2K3	P. Kelly	28.5.26	
27	Vincent Kelly	F26 A2K3	Vincent Kelly	28.5.26	
28	PHIL BOWZELL	F26 D9F5	[illegible]	28/5/26	
29	GERARD BOYD Gerard Boyd	F26 X291	Gerard Boyd	28-5-26	
30	Edel Boyd	F26 X291	Edel Boyd	28/5/26	
31	Marie McLoughlin	F26X6K5	Marie McLoughlin	28/5/26	
32	ANTJE KELLER	F26T9T0	Antje Keller	28/5/26	
33	VINCENT MUNNELLY	F26T9T0	Vincent Munnelly	28/5/26	
34	Noel IIUFFY	F26NW25	Noel Iluffy	28.5.2026	
35	Patrick Kearney	F26V4X2	Patrick Kearney	28.5.2026	
36	SEAN MC HALE	F26RW90	[illegible]	28/5/2026	
37	Andrew Kyrillou	F26 N9P5	A Kyrillou	28/5/26	
38	Marie McLoughlin	F26X6K5	Marie McLoughlin	28/5/26	
39	Anne Walker	F26 C5R3	Anne Walker	28/05/26	
40	Susan Tighe	F26 HK20	Susan Tighe	28/05/26	
41	Dermot Reilly	F26 FN2R	[illegible]	28/05/26	
42	John Reilly	F26 FY88	John Reilly	28/05/26	

43	Muriel Collins	Muriel Collins	F26C5FC		
44	Ann Loughney	Ann Loughney	F2CC5F4		
45	Noel Donnelly	Noel Donnelly	F26P6R3		
46	Teresa Donnelly		F26P6R3		
47	John F Cassey	Ross Lodge / Lillale F26HX77	F26HX77		
48	MARTIN NEALON	CARRICKARM CARROWMORE	F26YW98		
49	KEVIN NEALON	CARRICKARM CARROWMORE	F26YW98		
50	Kathleen Lynn	Ballygarry.	F26HR26.		
51	Matthew Lynn	Ballygarry	F26HR26		
52	Catherina Gardner	CARROWMORE Ballycastle	F26V186		
53	Thomas Gardner	CARROWMORE Ballycastle	F26V186		
54	ROBERT BOYD	Robert Boyd	F26 X291		
55	DOLORES BOYD	Dolores Boyd	F26 X291		
56	PAUL TIGHE	Paul Tighe	F26A061		
57	MARTIN TIGHE	Martin Tighe	F26A061		
58	GERARD HEALY	LISSADRONE F26RX92	Gerard Healy		
59	CARMEL GALLAGHER	BARNHILL F26AOWO	Carmel Gallagher		
60	FRANK GALLAGHER	BARNHILL F26AOWO	Frank Gallagher		
61	ANDREW CLARKE	CASTLETOWN F26Y4X5	Andrew Clarke		
62	ELAINE HARRISON	CASTLETOWN F26 Y4X5	Elaine Harrison		

63	Breeda Murphy	Farmhill Kinvara F26RSC9	B Murphy	6/06/26	
64	PETER MURPHY	FARM HILL RINKUN F26 RSC9		6/6/26	
65	CHRIS REES	THE GLEBE LACKEN HILL F26WK2X		6/6/26	
66	Una Rees	The Glebe Lackenhill, Ballycastle	Una Rees	6/6/26	
67	Ramsey Thompson	CARROWMORE-LACKEN F26WD	H RAMSEY THOMPSON	6/6/26	
68	A.M. THOMPSON	F26X9WD " "		6/6/26	
69	FRANCES Duggan	" "		6/6/26	
70	PAULA DUGGAN	" "	Paula Duggan	6/6/26	
71	CAITLIN THOMPSON	" "	Caitlin Thompson	6/6/26	
72	Theresa Melody	Killogeary, Carrowmore-Lacken	T. Melody	6/6/26	
73	Lacken	Castletown Lacken		6/6/26	
74	Gabrielle Kiernan	Castletown Lacken	Gabriel Co	6/6/26	
75	Carol O'Donnell	Beltra, Carrowmore Lacken	C O'Donnell	6/6/26	
76	Monica McGee	Killogeary Carrowmore Lacken	M. McGee	6/6/26	
77	Seamus Bourke	Rathlacken Carrowmore-Lacken	Seamus Bourke	20/6/26	
78	Tadhg Jackson	Lissadrone Carrowmore-Lacken	Tadhg Jackson	24/6/26	
79	David Faye	Beltra Carrowmore Lacken	D. Faye	24/6/26	
80					
81					
82					

No	Full Name	Address/Eircode	Signature	Date	
	Mary Walsh	Ballycastle F26 XH98	Mary Walsh	11/6/26	
	David Walsh	Ballycastle F26 XH98		11/6/26	
	Deg Kiernan	Kilbride Ballycastle F26 EW86		11/6/26	
	Terra Kiernan	Kilbride Ballycastle F26 EW86		11/6/26	
	Andrew Tighe	Carrowmore Ballycastle	A Tighe	11/6/26	
	Annmarie Tighe	Main Street, Ballycastle Mayo	AMTighe	11/6/26	
	Joe Tighe	Main Street, Ballycastle, Mayo	STighe	11/6/26	
	Patrick Tighe	Ballymacdaugh Ballycastle	Patrick Tighe	11/6/26	
	Anne Tighe	Ballymacdaugh Ballycastle	Anne Tighe	11/6/26	
	Kate Tighe	Sea Road, Ballycastle	Kate Tighe	11/6/26	
	Patrick Tighe	Lisbrin, (Scald) Ballycastle	Patrick Tighe	11/6/26	
	Geraldine Connor	Crott Ballycastle	Geraldine Connor	11/6/26	
	Michael O'Neill	Carrowmore Ballycastle	M O'N	11/6/26	
	Jason O'Neill	Carrowmore Ballycastle	Jason O'Neill	11/6/26	
	Raymond Tighe	Carrowmore Ballycastle	Raymond Tighe	11/6/26	
	Carole Tighe	Carrowmore Ballycastle	Carole Tighe	11/6/26	
	Ray Tighe	Carrowmore Ballycastle	Ray Tighe	11/6/26	
	Harriett Mc Garry	Kilbride Ballycastle	Harriett McGarry	11/6/26	
	Declan Tighe	Kilbride Ballycastle	D Tighe	11/6/26	

No	Full Name	Address/Eircode	Signature	Date	
	MATTHEW KEANE	F26 P8E2	Matthew Keane	2/6/26	
	Audrey Keane	F26 PCE2	Audrey Keane	2/6/26	
	Jacqui Keane	F26 F3P3	Jacqui Keane	2/6/26	
	SEAMUS KEANE	F26 F3P3	Seamus Keane	3/6/26	
	Aidan Flannelly	F26 C9V2	A. Flannelly	21/6/26	
	Sean FLANNELLY	F26 W3X9	S. Flannelly	21/6/26	
	David Flannelly	F26 A2Y4	David Flannelly	21/6/26	
	ann marie Flannelly	F26 A2Y4	ann marie Flannelly	21/6/26	
	Louise Fogarty	F26 X96V	Louise Fogarty	23/6/26	
	Padraigh Fogarty	F26 X96V	Padraigh Fogarty	23/6/26	
	Jacqueline Collins	F26 X9N4	Jacqueline Collins	23/6/26	
	Emer Collins	F26 F1W1	Emer Collins	23/6/26	
	Michael Collins	F26F1W1	Michael Collins	23/6/26	
	K MURRAY	F26X6X3	K MURRAY	23/6/26	
	Clive Flannelly	F26 W8FC	Clive Flannelly	23/6/26	
	Jackie Jackson	E26 EC97	Jackie	23/6/26	
	BRIAN JACKSON	F26 EC97	Brian Jackson	23/6/26	
	JAMES JACKSON	F26 EC97	J. Jackson	23/6/26	
	CORMAC JACKSON	F26 EC97	C Jackson	23.6.26	

No	Full name	Address / Eircode.	Signature	Date.	
83	Brian Jackson	F26EC97	B Jack	12/6/26	H84
84	TADHG JACKSON	F26 EC97	T Jackson	12/6/26	H 84.
85	Mattie Jackson	F26RP79	M Jackson	2/6	26 H84
86	Breege Jackson	F26 RP79	B. Jackson	2/6	2026 H11
87	Michael Jackson	F26 RP79	M Jackson	2/6/	26 H11
88	Maggie Jackson	~~Fe~~ F26 RP79	M Jackson	12/6/26.	H11
89	Roisin Jacks	F26 RP79	R Jackson	2216126	H11
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	name	Signature	Eircode.	Phone.	
203	Cecil	Jackson	F26 V443	086	329 7709.
204	MAULA	FOX	F26 0434	085	1745540.
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APPENDIX J – COMMUNITY DECLARATION OF SUPPORT

LACKEN BALLYCASTLE COMMUNITY LANDSCAPE PROTECTION GROUP

COMMUNITY DECLARATION OF SUPPORT

Tirawley Wind Farm Development – Planning Reference PAX16.324258

The undersigned residents, landowners, businesses and stakeholders confirm that they support the submission made by the Lacken Ballycastle Community Landscape Protection Group to An Coimisiún Pleanála in relation to the proposed Tirawley Wind Farm development.

The signatories agree with the concerns, evidence, findings and conclusions contained within the Group submission, including concerns relating to residential amenity, landscape and visual impacts, archaeology and cultural heritage, biodiversity, tourism, traffic and road safety, water resources, community wellbeing, and the cumulative impact of wind energy developments across North Mayo.

The signatories support the position that the proposed development does not represent proper planning and sustainable development and should not be granted planning permission.

Many of the signatories may also have submitted individual observations to An Coimisiún Pleanála. This declaration is provided as additional evidence of support for the Community Group submission.

No.	Name	Address / Townland	Eircode (Optional)	Signature
1	Susan Tighe	Carrowmore, Ballycastle	F26HK20	Sus- Tighe
2	Chris Rees	Lacken Hill, Ballycastle	F26WK2X	[illegible]
3	Una Rees	Lacken Hill, Ballycastle	F26 WK2X	Una Rees
4	ANTJE KELLER	BELTRA, Lacken	F26T9T0	Antje Keller
5	VINCENT MUNNELLY	BELTRA LACKEN Vincent Munnelly	F26T9T0	Vincent Munnelly
6	ANDREW CLARKE	Castletown Carrowmore Lacken	F26Y4X5	Andrew Clarke
7	Elaine Harrison	Castletown Carrowmore Lacken	F26Y4X5	[illegible]
8	Brede Murphy	Farmhill Kinion	F26R5C9	B. Murphy
9	[illegible]	FARMHILL KINION	F26 R569	[illegible]
10	Gabriell Mitchell	Castletown	F26R6X4	[illegible]

Page 1 of ____

Date of Collection: 21/6/2026

Data Protection Statement

Personal information collected on this form will be used solely for the purpose of demonstrating support for the submission of the Lacken Ballycastle Community Landscape Protection Group to An Coimisiún Pleanála in relation to Planning Reference PAX16.324258. The information will not be used for any other purpose.

Contact Details

Lacken Ballycastle Community Landscape Protection Group

Email: lackenballycastleclpg@gmail.com

LACKEN BALLYCASTLE COMMUNITY LANDSCAPE PROTECTION GROUP

COMMUNITY DECLARATION OF SUPPORT

Tirawley Wind Farm Development – Planning Reference PAX16.324258

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No.	Name	Address / Townland	Eircode (Optional)	Signature
1	GERALDINE MCMANUS	LISSADRONE F26RX92	F26RX92	G McManus
2	GERARD HEALY	LISSADRONE	F26RX92	Gerard Healy
3				
4				
5				
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8				
9				
10				

Page 2 of 2

Date of Collection: 24/6/26.

Data Protection Statement

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Lacken Ballycastle Community Landscape Protection Group

Email: lackenballycastleclpg@gmail.com

APPENDIX K – CARROWMORE HOUSE

* Earliest record of Carrowmore House 1732 *
Protected Building Ref 0190.

A VISITOR AT CARROWMORE

Submission from Robert & Heather Bowke.

In 1732 Mrs. Mary Pendarves, then a widow, came to Ireland as the guest of Anne Donnellan, and for part of the time stayed at Killala with Anne's brother-in-law, Robert Clayton who was then the Bishop of Killala. On her return to England she settled in Gloucestershire, where she became part of a circle which included the Kirkham sisters of Stanton and the Wesley brothers, then at Oxford.

Following the quaint custom of the eighteenth century in using nicknames which permitted a degree of familiarity in what was a very formal age, she became Aspasia to John Wesley's Cyrus. That he fell in love with her is certain; some think he may have proposed to her. After their Oxford days she and the Wesleys never met again, because she disapprived of religious enthusiasm.

In 1744 Mary Pendarves returned to Ireland as the second wife of Patrick Delany, for whom her influential friends had obtained the Deanery of Down. They lived at Delville in Glasnevin (the site now occupied by the Bon Secours Hospital). One of their friends was Jonathan Swift of St. Patrick's. She was present at the first performance in Fishamble Street of Handel's Messiah. After Patrick Delany's death she returned to England, where after some years George III gave her a pension, and a grace and favour house at Windsor.

On June 21st 1732, while staying at Killala, she wrote to her sister Anne Dewes:

> Today we dined at one Mr. Palmer's (Carrowmore House), a gentleman that lives a mile off, the only very agreeable neighbour we have; he is a very good sort of man, has a handsome fortune, his wife a civil, gentle, agreeable woman; they were married some time and had no children, at last she had one son, which is so great a darling and so much spoiled, that I believe she'll repent of her wishing so earnestly as she did for a son. He is a fine boy, has great vivacity (the more likely to prove her plague); we had a very fine dinner; she played once very well on the harpsichord, but has left it off, and I am in hopes she will lend us her harpsichord as she has no use for it herself; we have staid longer than we intended.

They apparently stayed even longer, and on July 4th she wrote to the same sister:

> Last Monday our family and Mr. Palmre's met on a very agreeable expedition. We were in all twenty; we left home about eleven, and went four mile in coaches and chaises, then we all mounted our horses, and went to a place called Patrick Down, seven mile from Killala. The

road is all the way by the seaside, over vast cliffs, such as you have seen about Mr. Basset's in Cornwall. We had no prospect from the downs where we stood, but the main ocean; about a mile from the cliffs, that are of an immense height, is a rock which formerly was joined, I beleive, to the part where we stood, for it seemed to be the same height; grass grows upon it, and there is the remains of a wall; it is so perpendicular that no one could climb it. The day was just so windy as to make the waves roll most beautifully, and dash and foam about the rocks. I never saw anything finer of the kind; it raised a thousand great ideas; oh! how I wished for you there! it is impossible to describe the oddness of the place, the strange rocks and cavities where the sea had forced its way. For our feast there was prepared what here they call a "swilled mouton", that is, a sheep roasted whole in its skin, scorched like a hog. I never eat anything better; we sat on the grass; had rock for our table; and though there was great variety of good cheer, nothing was touched but the mouton. The day was very agreeable, and all the company in good humour.

Note - Patrick Down is Downpatrick Head on the Mayo coast. Mr. Basset was the nephew and heir of Mary's first husband, Arthur Pendarves.

They were still in Killala in August, and on August 27th she wrote:

Last Tuesday our family and the Palmers went to a place called Kilcummin, not very unlike Down Patrick, but nearer to us; the day was very fine, the sea in a great agitation; we had a magnificent entertainment, with a rock our table, and rocks for seats, where we had a full prospect of the sea in all its glory, and were shaded from the wind. We were exceedingly merry, no one of the company seemed to want anything to complete their pleasure, except myself. I fell into my usual reveries, which are now so well understood, that I am indulged in them. We returned home well satisfied with our entertainment.

Mrs. Delany's collected correspondence was originally published in six volumes in 1861-62, under the title "Autobiography and Correspondence of Mary Granville, Mrs. Delany". The editor was Augusta Hall, Lady Llanover, who was a great-granddaughter of the Anne Dewes to whom most of them were addressed.

A selection of the Irish letters has recently been published by the Friar's Bush Press, under the title "Letters from Georgian Ireland". The Editor is Angelique Day.

- **Céide Fields a neolithic site at in County Mayo, Ireland, containing the oldest known stone-walled fields in the world – dating back nearly 6,000 years.**

- **The following map easily shows the many sites of The Wild Atlantic Way route – that will be impacted by this proposal. The significant impact to a small population of local families has not been adequately outlined in the planning application. A small population is disproportionately affected by this proposal. There is other space in Ireland where there would be less impact – is the reason an economic one – who will provide the infrastructure maintenance of roading for this new development? This has not been addressed.**



Source: https://www.northmayo.ie/

4. **Environmental and Ecological Concerns**

The site includes sensitive habitats such as blanket bogs and areas with ecological significance under the Habitats Directive. The large volumes of peat to be extracted and the disturbance to these habitats could have long-term detrimental effects on biodiversity and peatland restoration efforts.

(Reference: Appendix 1.6 Community Engagement Report, Pages 13-14; Planning Statement, Pages 69-71)

Please note also that this development is in direct opposition to the requirement of Ireland to adhere to the Habitats Directive (Directive 92/43/EEC) posing a risk that our Nation will continue to fail in its obligation as a member state. Please outline why this legislative framework has not been adequately considered in the planning of this project.

5. **Traffic Infrastructure Impact and Palmerston Bridge**

6.

The construction phase will bring significant disruption to the local road network due to the delivery of abnormal loads and turbine components. The existing roads will require widening and modifications that will impact local traffic flow and road safety. The scale of this impact has not been adequately mitigated in the proposal.

There has been no costings made to the ongoing, increased maintenance of this upgraded infrastructure.

(Reference: EIAR Chapter 17 - Traffic and Transport, Pages 6-10; Appendix 1.6 Community Engagement Report, Pages 11-12)

Of particular significance to us is the effects on the modifications and traffic accessing and crossing Palmerstown Bridge, DOONAMONA, MAYO.

If Buildings of Ireland were consulted on this project and impacts.

With the following in mind,

- conservation status of the species
- the acknowledged presence of suitable habitat and,
- recorded winter roosting activity within the study area,

We are not satisfied that sufficient scientific data has been provided, what is provided does not demonstrate adequate protection and mitigation in respect to this important habitat.

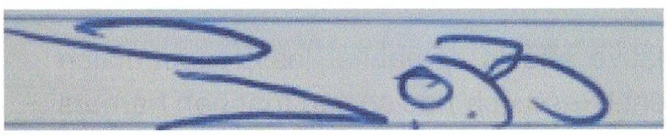
Are there robust studies, that establish the applicants view that impact on Hen Harrier Habitat is not significant? The proposed development will not adversely affect the hen harrier population. A precautionary principle should therefore apply.

In conclusion, I submit that the proposed Tirawley Wind Farm project is not appropriate for this location due to the significant negative impacts on our Gaeltach and traditional way of life, residential amenity, local landscape, ecology, infrastructure, and the negative impacts to our growing Tourist economy, I urge An Coimisiún Pleanála to refuse permission for this
because of the significant risk it poses to our community and to our standing in the wider European Union. It poses a threat to outstanding areas of Heritage and potential UNESCO sites.

Please don't hesitate to contact me if you would like to clarify any of my submission.

Please consult with our family on this project and I am highlighting now to you that we have no record of an attempt to consult with us at Doonfeeny Upper and surrounding townlands.

Go raibh maith agaibh



Jackie O'Boyle Langan

Ph: +353 86 352 2442

Ref: https://www.buildingsofireland.ie/buildings search/building/31301417/palmerstown-bridge-doonamona-co-mayo

7. **Gaeltach, Community and Socio-Economic Issues**

Gaeltacht – disproportionate impact on a small indigenous population of Ireland.

Údarás na Gaeltachta - there is no visible consultation with the population that live to the values and tenants of the local culture – please advise if there was any consultation in our indegenious language. ***Please provide evidence of Irish language translations of planning documents and reports.***

While I acknowledge the need for renewable energy and some regional economic benefits, the socio-economic impact on sustainable family farms and local amenities is concerning. The proposal does not sufficiently address the community's needs or provide clear, direct benefits to our community and our visitors. The proposed community benefit package remains vague and unconvincing.

(Reference: Appendix 1.6 Community Engagement Report, Pages 7-14)

8. **Cumulative Impact and Strategic Considerations**

The project overlaps with areas where other developments are planned or existing, increasing cumulative environmental, visual, and infrastructural pressures. The scale and height of modern turbines, as noted by Mayo County Council, raise questions about the suitability of this site compared to previous assessments.

(Reference: Mayo County Council submission, EIAR Chapter 17,

Pages 9-10) 9. **Impact on Hen Harrier Habitat**

I am also concerned about the cumulative effects of habitat loss, construction disturbance and operational displacement. Research has shown that hen harriers may avoid otherwise suitable habitat in the vicinity of operational turbines, resulting in a reduction in available

foraging area. The application does not appear to adequately assess or mitigate this displacement effect.

Case: 324258 J Langan 220626

Mr Jackie O'Boyle Langan
ROSE COTTAGE
DOONFEENY UPPER
BALLYCASTLE
CO. MAYO
F26 K4D6

22 June 2026

The Secretary
An Coimisiún Pleanála
64 Marlborough Street
Dublin 1
D01 V902

Re: Objection to the Proposed Tirawley Wind Farm Strategic Infrastructure Development Objection Submission to An Coimisiún Pleanála

Re: Planning permission for the construction of Tirawley Windfarm consisting of 16 no. wind turbines, a permanent 110kV substation, 110kV underground cable and grid connection, and ancillary development in the townlands of Ballymurphy, Ballynaleck, Barnhill Lower & Upper,
Barroe, Billoos, Carn, Carrickanass, Carrowmore, Castlelacken Demesne,
and other townlands in County Mayo.

Case Number: PAX16.324258

Dear Sir/Madam,

Thank you for your attention to this matter.

By way of introduction my name is Jackie Langan, my family has owned land in the areas of Doonfeeny Upper, Killerduff, Ballyknock and Killena for generations.

This letter specifically refers to the impact of the development to our residence Rose Cottage at Doonfeeny Upper. My brother and I own this property. The other land is

owned by my brother.

Case: 324258 J Langan 220626

All of this land will the proximity to the proposed Tirawley Wind Farm project, submitted by Constant Energy Limited, to formally lodge my objection to this Strategic Infrastructure Development application.

While I am fully cognisant of the need for Ireland to provide sustainable energy for our nation. My family is opposed to the construction and development of the Tirawley Wind Farm. I would like to emphasise that I have considered his development in as objective a way as possible.

This development poses significant and irreversible risks to the local environment, biodiversity, residents and visitors alike.

The proposal

- threatens critical habitats for protected species including the Hen Harrier, • substantial habitat removal including over 4 km of hedgerow,
- it will have serious visual impact
- It will severely impact on Ballycastle's position on the Wild Atlantic Way and affect Tourism and our growing market as a destination for Artist in the internationally renowned Ballinglen Museum of Art & Gallery.
- traffic disruption and pressure to maintain upgraded roading infrastructure in a fragile and historic location.

There has been inadequate community consultation. We have not been approached or sent any information, as affected landowners, about this development. Please revert with a record of consultation, if any, in relation to this development to landowners in Doonfeeny Upper.

These issues, coupled with shortcomings in the Environmental Impact Assessment Report, the inadequately addressed issues raised in the planning stage by Mayo County Council justify a refusal of permission for this project.

Having reviewed the public information provided and engaged with the community consultation materials, I wish to raise the following concerns:

1. **Residential and Property Impact**
   The proposed wind turbines are located close to existing homes. Despite the stated 540m buffer, the visual impact, noise pollution, and potential shadow flicker effects will significantly disrupt our residential amenity and quality of life. There is also a genuine concern about the likely devaluation of property

prices due to proximity to large-scale industrial turbines.
(Reference: Appendix 1.6 Community Engagement Report, Pages 7-13)

2. **Site Suitability and Landscape Impact**

The location has been described as scattered and not suitable for a development of this scale. The area includes sensitive landscapes, visible from the Wild Atlantic Way and other designated scenic routes, which would be adversely affected by this wind farm. The visual intrusion on the unique coastal and rural landscape is unacceptable
and contrary to the policies outlined in the Mayo County Development Plan regarding landscape protection and visual amenities.
(Reference: Mayo County Council submission, EIAR Chapter 17 - Traffic and Transport, Pages 9-10; Planning Statement, Pages 69-71)

3. **Local Tourism & related economic affects**

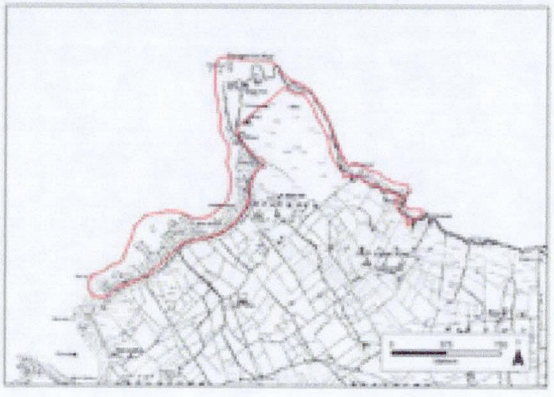
This development will adversely affect the local economy that has a growing and established international and local Tourist infrastructure. There has been substantial investment in a new Coastal Greenway that is due to be constructed soon. There are outstanding features in our landscape that will be substantially affected by the visual impact of this development – including and not limited to:

- **Dun Briste – Downpatrick Head – a hugely significant Geological Site of National Importance. (NHA)**
- **Ref:**
  https://gsi.geodata.gov.ie/downloads/Geoheritage/Reports/MO050_Down patrick_Head.pdf

AN COIMISIÚN PLEANÁLA
LDG- _____
ACP- _____
24 JUN 2026
Fee: € _____ Type: _____
Time: _____ By: _____







Case: 324258 J Langan 220626

Source: *Hennessy et al. 2014 (revised 2019). Geological Survey Ireland.*

- **as well as a culturally historical site and is Integral to the identity of Irish people still living here and our International Irish Diaspora – making it an often-visited site.**

- **The amenity value of this site will be lost with the construction of the wind turbines. This has not been adequately addressed in the planning application.**

Case: 324258 Martin Langan 150626

Mr Martin
Langan ROSE
COTTAGE
DOONFEENY
UPPER
BALLYCASTLE
CO. MAYO
F26 K4D6

The Secretary
An Coimisiún
Pleanála 64
Marlborough Street
Dublin 1
D01 V902

Mariolangan@gmail.com **Ph: +353 87 918 9900**

15 June 2026

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This letter specifically refers to the impact of the development to our residence Rose Cottage at Doonfeeny Upper. My sister and I own this property. The other land is owned by my brother.

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- traffic disruption and pressure to maintain upgraded roading infrastructure in a fragile and historic location.

There has been inadequate community consultation. My husband co-owns our residence with his sister. They have not been approached or sent any information, as affected landowners, about this development. Please revert with a record of consultation, if any, in relation to this development to landowners in Doonfeeny Upper.

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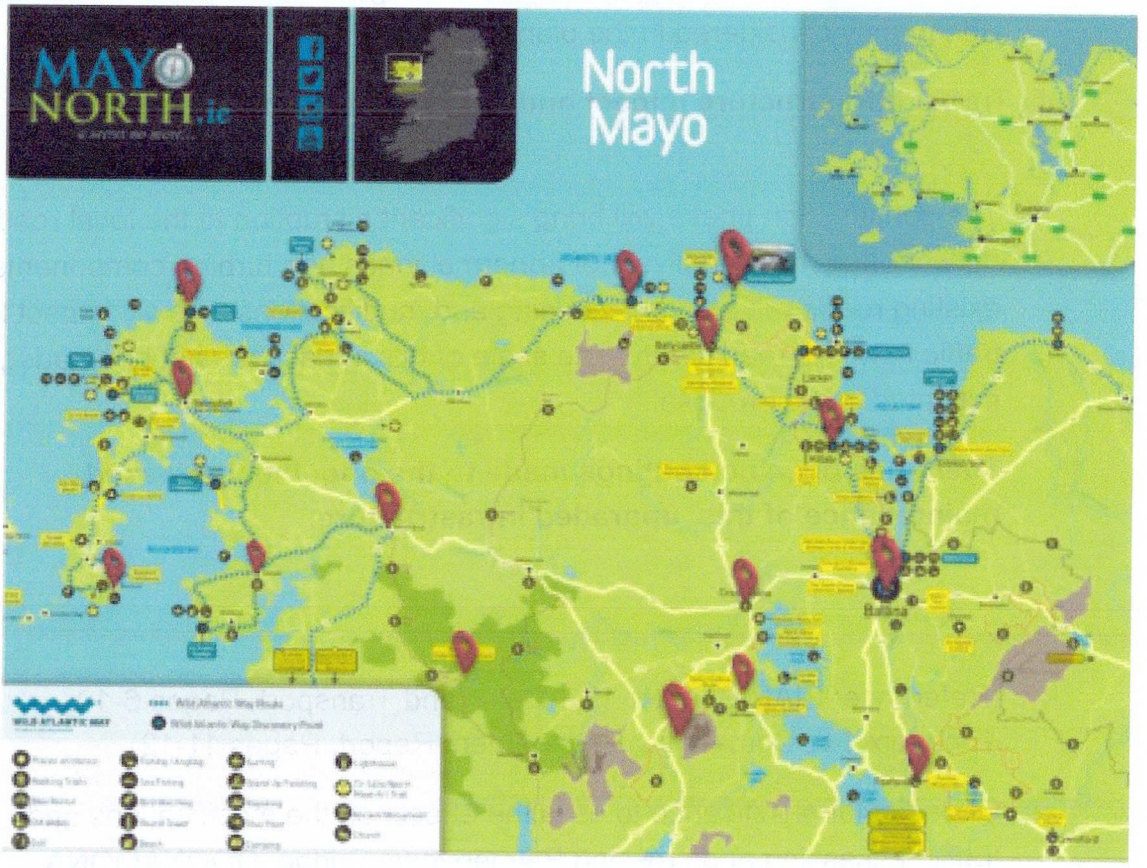

Source: https://www.northmayo.ie/

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Ref: https://www.buildingsofireland.ie/buildings search/building/31301417/palmerstown-bridge-doonamona-co-mayo

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While I acknowledge the need for renewable energy and some regional economic benefits, the socio-economic impact on sustainable family farms and local amenities is concerning. The proposal does not sufficiently address the community's needs or provide clear, direct benefits to our community and our visitors. The proposed community benefit package remains vague and unconvincing.

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I am also concerned about the cumulative effects of habitat loss, construction disturbance and operational displacement. Research has shown that hen harriers may avoid otherwise suitable habitat in the vicinity of operational turbines, resulting in a reduction in available
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With the following in mind,

- conservation status of the species
- the acknowledged presence of suitable habitat and,
- recorded winter roosting activity within the study area,

We are not satisfied that sufficient scientific data has been provided, what is provided does not demonstrate adequate protection and mitigation in respect to this important habitat.

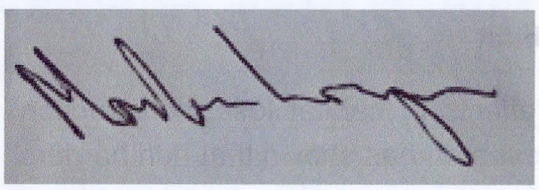
Are there robust studies, that establish the applicants view that impact on Hen Harrier Habitat is not significant? The proposed development will not adversely affect the hen harrier population. A precautionary principle should therefore apply.

In conclusion, I submit that the proposed Tirawley Wind Farm project is not appropriate for this location due to the significant negative impacts on our Gaeltach and traditional way of life, residential amenity, local landscape, ecology,infrastructure, and the negative impacts to our growing Tourist economy, I urge An Coimisiún Pleanála to refuse permission for this because of the significant risk it poses to our community and to our standing in the wider European Union. It poses a threat to outstanding areas of Heritage and potential UNESCO sites.

Please don't hesitate to contact me if you would like to clarify any of my submission.

Please consult with our family on this project and I am highlighting now to you that we have no record of an attempt to consult with us at Doonfeeny Upper and surrounding townlands.

Go raibh maith agaibh



Mr Martin Langan

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APPENDIX L – ADDITIONAL LETTERS FROM RESIDENTS