

SUBMISSION ON COOLOO WINDFARM based on Word version of FI Response template

Planning Reference: 323761

Date for Submission: 9th July 2026

Response to FI Submissions: Black Font – Applicants Response, Green Font – Independent Scientific Report, Blue Font – MLavelle Response [Many of the issues raised in the Applicants FI submission were previously raised in my initial submission & have not been responded to.]

1. INTRODUCTION

MKO have been instructed by Neoen Renewables Ireland Limited (the Applicant), to prepare a response to the request issued by An Coimisiún Pleanála (the Commission) on 22nd December 2025 (Third Party and Statutory Bodies Observations) in relation to the live Strategic Infrastructure Development (SID) planning application before them for consideration (ACP Ref: 323761).

The Proposed Project will comprise 9 no. wind turbines with a tip height of 180 metres (m) and will have an estimated **installed capacity** between c.54MW and 64.8MW, located in County Galway (the 'Proposed Project'. The Commission did not request responses to specific observations made to the planning application; rather they invited the Applicant to make a submission in response to both the third-party/prescribed body observations received.

Response from MLavelle: The output from 9 wind turbines does not come close to 50Mw & this SID Application is invalid. The SID Legislation states "OUTPUT" and NOT "CAPACITY". The "OUTPUT" for 9 Turbines is c20Mw. This can easily be checked using SEAI Wind Atlas windspeeds & Manufacturers Power Curves for the specific make & c8m/s windspeed.

The letter of 22nd December 2025 stated that the deadline for submitting a response to the third-party observations and prescribed body observations was 13th February 2026. MKO requested an extension to respond to the third party/ prescribed body observations by email dated 5th February 2026. An extension was granted by the Commission via email on 6th February 2026, until 27th February 2026.

1.1 Overview of the Proposed Project

The Applicant lodged a planning application to the Commission in September 2025 for the Proposed Project as set out in the public notices as follows.

"The proposed development will consist of the provision of the following:

i. 9 no. wind turbines with the following parameters:

- Total turbine tip height of 180 metres;
- A rotor blade diameter of 150 to 162 metres;
- A hub height of 99 to 105 metres;

ii. Permanent turbine foundations, hard-standing and assembly areas;

iii. Underground electrical (33kV) and communications cabling;

iv. 1 no. temporary construction compound (including site offices and welfare facilities);

v. A meteorological mast with a height of 100 metres, security fencing and associated foundation and hard-standing area;

vi. 1 no. new site entrance on the R332 in the townland Lisavally;

vii. 1 no. new access and egress point off the L6056 Local Road in the townland of Dangan Eighter;

viii. 1 no. new access and egress point on to an existing access track in the townland of Dangan Eighter;

ix. 2 no. new access and egress points off the L6301 Local Road in the townland of Cooloo and Lecarrow;

- x. Upgrade of existing site tracks/roads and provision of new site access roads, clear span crossings, junctions and hard-standing areas;
- xi. A new temporary access road from N63 national road and to R332 Regional Road in the townland of Slievegorm to facilitate the delivery of turbine components and other abnormal sized
- xii. loads;
- xiii. Demolition of an existing derelict house and adjacent outbuilding in the townland of Cooloo;
- xiv. Peat and Spoil Management Areas;
- xv. Tree felling and hedgerow removal;
- xvi. Biodiversity Management and Enhancement measures;
- xvii. Site Drainage;
- xviii. Operational Stage site signage; and
- xix. All ancillary apparatus and site development works above and below ground, including soft and hard landscaping.

A 10-year planning permission and 35-year operational life of the wind farm from the date of commissioning of the entire wind farm is sought (other than temporary and permanent works specified above)."

1.2 Terminology

The terminology of project elements used within this report, remains consistent with the terminology used throughout the original planning application documents including the Environmental Impact Assessment Report (EIAR) and is outlined below.

'Proposed Project': Encompasses the entirety of the project for the purposes of this, EIA in accordance with the EIA Directive. The Proposed Project is described in detail in Chapter 4 of the EIAR.

'Proposed Wind Farm': This refers to turbines and associated foundations and hardstanding areas, meteorological mast, access roads, temporary construction compound, underground cabling, peat and spoil management, site drainage, biodiversity enhancement, turbine delivery route (TDR) accommodation works and all ancillary works and apparatus. The Proposed Wind Farm is described in detail in Chapter 4 of the EIAR.

'Proposed Grid Connection': Refers to the 110kV onsite substation, battery energy storage system and 110kV underground cabling connecting to the existing Cloon 110kV substation, and all ancillary works and apparatus. The Proposed Grid Connection is described in detail in Chapter 4 of the EIAR.

'Site': Relates to the primary study area for the EIAR, as delineated by the EIAR Site Boundary in green as shown on Figure 1-1 of the EIAR and encompasses an area of approx. 355 hectares.

'Proposed Wind Farm site': This refers to the portion of the Site surrounding the Proposed Wind Farm but excluding the portion of the Site surrounding the Proposed Grid Connection underground cabling route.

2. RESPONSE TO THIRD-PARTY OBSERVATIONS

There were 221 no. valid observations received on the application including third party observers and prescribed bodies. Table 1 below outlines the common themes identified within the third-party observations and specifies the lead author on the project team responsible for the corresponding response.

Table 2-1 Third Party Observation Themes

Theme	Section Discussed	Lead Author(s) for Response
Planning Policy and Legislation	Section 2.1	MKO
Public Consultation & Community Engagement	Section 2.2	MKO
Land Ownership & Usage	Section 2.3	MKO
Project & Application Details	Section 2.4	MKO
Population & Human Health	Section 2.5	MKO
Biodiversity	Section 2.6	MKO
Land Soils and Geology	Section 2.7	Gavin & Doherty Geosolutions
Hydrology and Hydrogeology	Section 2.8	Hydro-Environmental Services
Noise	Section 2.9	TNEI

Climate	Section 2.10	MKO
Landscape and Visual Assessment	Section 2.11	MKO
Cultural Heritage	Section 2.12	IAC Archaeology Ltd
Traffic and Road Safety	Section 2.13	Alan Lipscombe Traffic Consultants, MKO
Telecommunications	Section 2.14	MKO
Major Accidents and Natural Disasters	Section 2.15	MKO
Decommissioning	Section 2.16	MKO

2.1 Planning Policy and Legislation

2.1.1 Galway County Development Plan Policy

A number of third-party observations referenced the planning policy relevant to the Proposed Wind Farm site. These observations mainly related to local planning policy and specifically to the Galway Local Authority Renewable Energy Strategy 2022-2028 ('the LARES').

The content of these observations was mainly focused on the classification of the portion of the application site being designated as 'Generally to be Discouraged' for wind energy development. These observations questioned the suitability of these lands for the development of wind energy infrastructure given that they have not been classified in a suitable area for this type of development.

Some observers also raised concerns regarding potential conflicts to other policies and objectives within the Galway County Development Plan (GCDP) 2022-2028. These policy and objectives relate to natural heritage and biodiversity, wetland protection, and peatland protection.

Response

As outlined in the Planning Report submitted with the Planning Application, a robust constraints analysis has been carried out in order to determine areas suitable for turbine placement.

[Response from MLavelle: The Windpro software involves inputs of constraints & screenshots of outputs. These were not provided. This Windpro software can provide downstream turbulence measurements & these were not provided.](#)

It is demonstrated through the assessment of the Proposed Wind Farm against the LARES, that the Wind Farm site is suitable for wind energy development. The Proposed Wind Farm site scores well when examined across the opportunity and sensitivity factors set out in the LARES. This assessment is provided in section 7.2.4 of the Planning Report.

It should also be highlighted that the LARES does not specifically restrict applications for wind turbines within Generally to be Discouraged Areas, but rather, they are assessed on their merits on the principle of proper planning and sustainable development. As such and having regard to the policy appraisal in the Planning Report, it is considered that the proposed turbines outside favourable policy areas are consistent with the policies and objectives of the LARES and the GCDP, the principal development is acceptable and therefore it should be assessed on its merits by the An Coimisiún Pleanála.

[Response from MLavelle: The County Development Plan classifies the area as unsuitable & to be discouraged. Anyone can apply for anything. The CDP doesn't exclude development applications. The failure of the Applicant to submit a competent application determines that it is invalid & should be refused.](#)

As part of the Planning Report, a comprehensive assessment of the wind energy capacity was conducted, revealing that there is an insufficient quantum of favourably zoned land to reach the estimated yield in County Galway by 2030. The estimated shortfall exceeds 400MW, falling short of the 1,350 MW total capacity outlined in the LARES. It is for this reason it is critical to examine all viable areas that may be suitable for wind energy following a detailed assessment, and to maximise the potential of sites brought forward for wind energy. Where it can be demonstrated that viable sites outside of the favourable policy areas are suitable for wind energy following detailed assessment, these areas should be considered for wind energy to meet national climate and energy targets.

Response from M Lavelle: There are many alternatives to Windfarms which have not been analysed as part of this application. Urban Wind Turbines to satisfy Local Agenda 21 to satisfy supply at the closest position to demand has not been analysed. Nuclear Power with suitable sites has not been analysed. National Parks have not been analysed. Without such comparative analyses, this application is incomplete.

Reference 2026: Comparative Analysis Of Wind Turbine Blade Design For Urban India: Optimizing Power Generation and Structural Efficiency. Sanskruti Thakur, Atharva Tanpure, Megha Gupta, Anvita Birje. Journal of the Big Data & Artificial Intelligence. Vol. 4 No. 1, pp. 63-83/ 2026. ISSN: 2692-7977. DOI: 10.54116/jbdai.v4i1.75

India's metropolitan areas are growing rapidly, creating an increasing demand for clean, local, and reliable energy sources. However, urban environments present unique challenges for wind energy due to the presence of tall structures, narrow streets, and variable air currents that create turbulent wind patterns. This makes it difficult to select the most suitable wind turbine design because traditional turbines often struggle under such conditions. Vertical-axis wind turbines (VAWT), including Darrieus, Helical, H-Rotor, and Savonius types, are emerging as viable alternatives because they can operate effectively in turbulent and space-constrained urban environments. In this study, we propose a decision-making framework that combines real-world geographic data with modern data driven modeling approaches to identify the most appropriate turbine design for each major city in India. We used the ERA5 reanalysis dataset, which spans 44 years, from 1980 to 2024, to capture realistic wind patterns across the country. To adapt these data for rooftop-level conditions (30 m), we adjusted the 100-m wind data by using a logarithmic wind profile. We trained both Random Forest and LSTM-CNN hybrid machine learning models to predict wind speed, power output, and the most suitable turbine type for any given location. Our findings indicate that Darrieus turbines are most effective in cities with stronger and more consistent winds, whereas Savonius and H-Rotor designs are better suited for densely built areas with lower wind speeds. The LSTM-CNN hybrid model achieved a classification accuracy of 94.8%, which is significantly higher than the 92.4% accuracy of the Random Forest baseline. This study offers a validated and adaptable framework that can assist in rooftop wind installations, urban planning, and small-scale renewable energy systems. By integrating engineering expertise with intelligent modeling, this research helps Indian cities optimize their utilization of local wind patterns.

It is noted in this regard that Galway County Council (GCC) in their report submitted to the Commission conclude that the principle of the Proposed Wind Farm is considered to be acceptable, subject to the assessment of the proper planning and sustainable development.

Response from MLavelle: A submission can be validated by a Local Authority, but that doesn't mean that it is acceptable or in compliance with proper planning & sustainable development, which plainly this submission isn't. It would seem that the Galway County Council report was authored by a recent employee of MKO. This generates an issue in relation of impartiality, where the Planner should have excused herself. It is not permissible to issue a quasi-judicial report, where bias could be an issue.

An assessment of all relevant policy objectives is provided in the Planning Report which accompanied the application, please see section 7.2 Table 4 of the Planning Report for further detail.

2.1.2 Wind Energy Design Guidelines 2006

A number of third-party observations highlighted concerns with the 2006 Wind Energy Development Guidelines. They consider the guidelines to be outdated and not fit for purpose when it comes to assessing modern wind farm proposals.

Response

As set out in section 2.5.5 of the EIAR, 'Wind Energy Development Guidelines for Planning Authorities' (Department of the Environment, Heritage and Local Government (DoEHLG), 2006) (hereafter referred to as the

2006 Guidelines) remains to be the relevant document in relation to Section 28 of the Planning and Development Act 2000, as amended ('the Planning Act'). In December 2019, The Department of Local Government and Heritage published 'Draft Wind Energy Development Guidelines' (Department of Housing, Local Government and Heritage (DoHLGH) (hereafter referred to as the draft 2019 Guidelines). The draft 2019 Guidelines is an update to the 2006 Guidelines, which were the subject of a 'focused review' undertaken by the Department of Housing, Local Government and Heritage with regards to noise standards, set back distances, shadow flicker, community consultation and community dividend and grid connections.

Response from MLavelle: The applicant has not complied with the draft 2019 or the 2006 Wind Energy Guidelines.

Given the timelines involved in renewable energy project planning applications, an updated draft may be finalised during the project's assessment. It has been demonstrated in the EIAR that the Proposed Wind Farm will be capable of adhering to the relevant standards set out in the draft 2019 Guidelines, based on currently available information.

Response from MLavelle: This is absolute nonsense. The Applicant does not know what the Government Planning Statement will require.

Section 5.2 of the Planning Report outlines how the Proposed Project was designed with regard to the 2006 and 2019 Guidelines.

Response from MLavelle: The applicant has not complied with the draft 2019 or the 2006 Wind Energy Guidelines.

It is noted that planning authorities/ the Commission are not bound to the provisions of the wind energy guidelines, and they can (and do) consider updated standards/requirements/specifications in assessing impacts and the proper planning and sustainable development of the area.

2.1.3 Compliance with SEA, EIA and Habitats Directive

A submission raises concerns regarding the Proposed Projects compliance with the SEA Directive, the EIA Directive and the Habitats Directive.

Response

The Strategic Environmental Assessment (SEA) Directive sets out a procedure that must be undertaken when assessing a plan or programme to which the procedure applies, not planning applications for individual projects. SEA has been undertaken of adopted planning policy at all levels, including the GCDP 2022-2028, the Regional and Spatial and Economic Strategy 2020 – 2030, and the National Planning Framework.

As detailed in Section 1.2 of Chapter 1 in the submitted Environmental Impact Assessment Report (EIAR), the EIAR complies with the EIA Directive 2011/92/EU as amended by Directive 2014/52/EU. In addition, Article 94 of the Planning and Development Regulations 2001 (as amended) sets out the information to be contained in an EIAR, with which the EIAR complies. The Environmental Impact Assessment (EIA) will be undertaken by the Commission, as the competent authority.

The EIAR provides information on the receiving environment and assesses the likely significant effects of the Proposed Project on it and proposes mitigation measures to avoid or reduce these effects. The function of the EIAR is to provide information to allow the Commission to conduct the EIA of the Proposed Project. All elements of the Proposed Project, i.e. the Proposed Wind Farm and Proposed Grid Connection have been assessed as part of the EIAR.

Article 6(3) of the Habitats Directive sets out the requirement for an Appropriate Assessment (AA) of any plan or project that is not directly related to the management of a protected site but is likely to have a significant effect on it. This assessment evaluates the potential implications for the site in light of its conservation objectives. Under Section 177U of the Planning and Development Act (as amended), the legal requirements pertaining to AA set out in Part XAB of the Planning Act, apply to this application for development permission under Section

37E. This application for planning permission is therefore accompanied by an AA Screening Report and a Natura Impact Statement (NIS). The AA will be undertaken by the Commission, as the competent authority.

2.1.4 Project Splitting

Several third-party observations to the Commission raised concerns that the Proposed Grid Connection, inclusive of the onsite 110kV substation and battery energy storage system (BESS) compound and the Proposed Wind Farm are being treated as separate applications. They suggest that the Applicant might be engaging in project splitting, dividing the project into smaller parts to downplay the overall environmental and social impacts.

Response

The Proposed Grid Connection falls within the 110kV SID threshold for electricity transmission infrastructure. As such, the Proposed Grid Connection is not included in this application and will be subject to a separate application to the Commission under Section 182A of the Planning and Development Act 2000, as amended. While the Proposed Project consists of two separate planning applications (one for the Proposed Wind Farm and one for the Proposed Grid Connection), no project splitting has occurred as the entirety of the Proposed Project has been assessed throughout the EIAR.

Section 1.1.1 of the EIAR clearly sets out the approach in relation to the assessment of the Proposed Project. The Proposed Wind Farm and the Proposed Grid Connection (which will be subject to a separate application) have been comprehensively assessed together in the EIAR submitted with the planning application. The EIAR covers the Proposed Wind Farm and the Proposed Grid Connection as a single entity referenced as the 'Proposed Project' throughout the application.

Reference 2024: Quantifying social factors for onshore wind planning – A systematic review. Tsamara Tsani, Jann Michael Weinand, Jochen Linßen, Detlef Stolten. Renewable and Sustainable Energy Reviews 203(2024) 114762. www.elsevier.com/locate/rser

3. Results

3.1. Overview of studies reviewed

Out of the 81 papers reviewed, 44 provided methods for quantifying social factors, while 37 integrated social factors into onshore wind power planning models or potential studies. The years of publication range from 2002 to 2022. The geographical scope of the empirical studies and planning models ranges from the site-specific (23 %), regional (26 %), national (33 %), multi-national (11 %), continental (5 %), to the global levels (1 %). 88.8 % of the reviewed articles analyze case studies in European and North American countries, with Germany being the most studied country (24 % of the articles). The social acceptance of onshore wind turbines has been an important issue in these regions [15,41,52] due to the rapid deployment of wind energy in the recent decades. Social acceptance is often considered a significant barrier to deployment [53].

The analysis shows that 63 % of European studies focus on quantifying disamenities from wind turbines, such as visual impacts, acceptable proximities, noise, and impacts on well-being. In contrast, eight out of twelve studies from North America concentrate on quantifying potential socio-economic impacts as factors affecting acceptance. This difference in focus may suggest a geographical and socio-cultural variation on what is considered an important factor for acceptance.

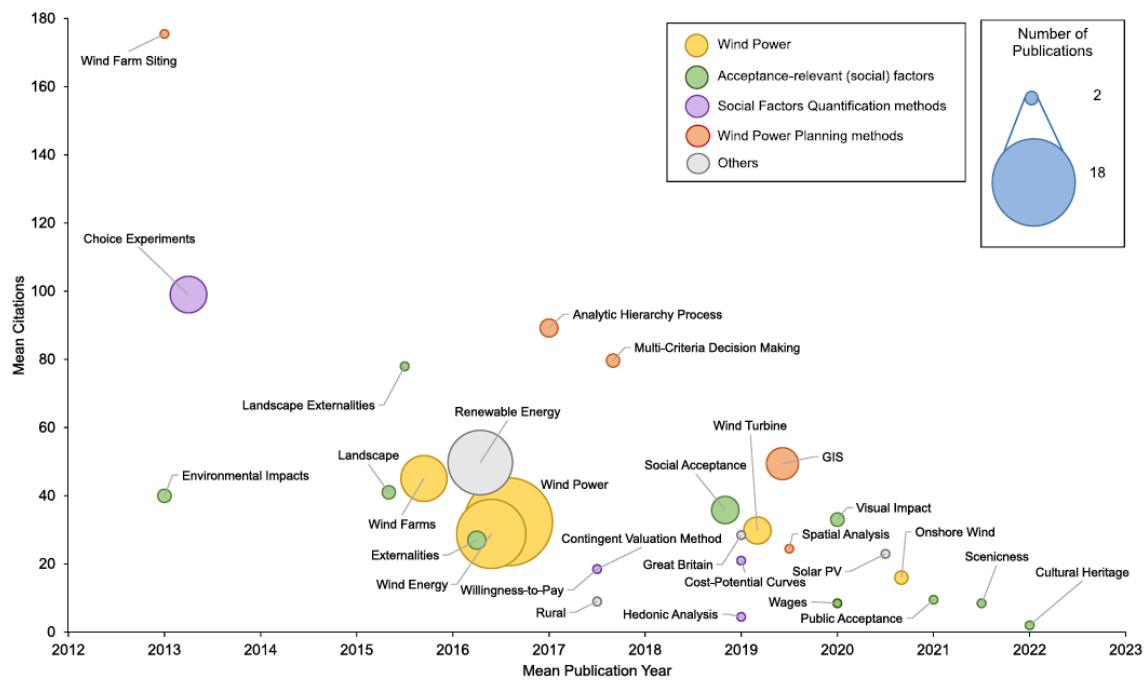


Fig. 3. Keyword trend based on number of publications (shown as bubble size), mean citations, and mean publication year. The mean publication year and mean citations for each keyword is calculated by dividing the sum of publication years or number of citations by the number of publications with the respective keyword. The distribution of keywords' appearances over the years and their number of citations are supplemented in [Supplementary Tables 3 and 4](#)

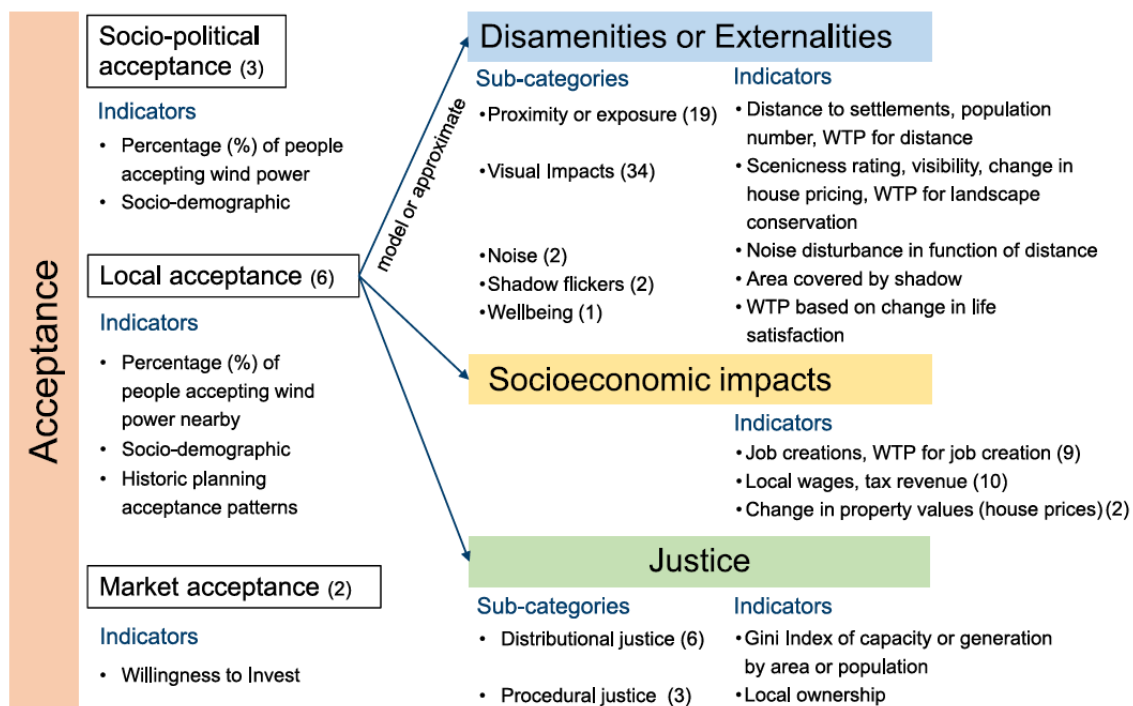


Fig. 4. Classification of social factors and the indicators used to measure factors in the reviewed studies. The figures in brackets represent the number of studies in this review that contained the respective social factors. WTP – willingness-to-pay. Definitions of each category can be found in [Supplementary Table 5](#).

2.1.5 Unauthorised Development

A submission raised concerns surrounding unauthorised development on the Proposed Wind Farm site.

Response

The Applicant is not aware of any presence of unauthorised development within the Proposed Wind Farm site. GCC, as stated in their PA report, did not identify any enforcement cases relating to the site.

2.2 Public Consultation & Community Engagement

Several third-party observations to the Commission have regard to the description of the Proposed Project in the planning application and submitted Environmental Impact Assessment Report (EIAR).

Observations are made under the following themes:

- Community Consultation & Engagement with Local Community Bodies
- Public Notice in Newspaper

2.2.1 Community Consultation & Engagement with Local Community Bodies

Concerns have been raised suggesting there was a lack of community consultation process undertaken as part of this project. Submissions have claimed that there was a lack of meaningful public engagement, with insufficient information, and ineffective communication, leading to community consultation that is not in line with the draft 2019 Guidelines.

Response

A Community Engagement Report is included as Appendix 2-2 of the EIAR, which outline the steps that the Applicant has taken since project inception to ensure transparent community engagement through all phases of the project to date. This report has been prepared in line with the requirements as set out in the Draft Revised Wind Energy Development Guidelines (December 2019) – Community Engagement.

From early 2023 and over the course of 2024, there was ongoing communication between members of the local community and the project Community Liaison Officer (CLO), representing the project developers. This communication took place predominantly via email and phone and was predominantly concerned with the same themes that had been encountered earlier in the consultation process, such as visual and noise impact, property prices, etc. As a period of time had passed since the public information event in 2024, updated information was issued via post to the wider community in September 2025. The details provided included the full description of the Proposed Project seeking planning permission, as well as a map of the final layout of the Proposed Wind Farm.

The Applicant has engaged and consulted with the local community from an early stage of the preplanning phase of the Proposed Project. This process of community engagement has proven highly valuable as a means of identifying the key concerns of the local community in relation to the Proposed Project, and the issues raised by local residents during the consultation process have informed and shaped the project proposal in several ways.

The Proposed Project will provide a direct and prolonged economic benefit to the communities surrounding the site through the Community Benefit Fund, and through employment opportunities during the construction process. The Applicant is committed to maintaining the strong community engagement approach throughout the post-application stage and, if planning permission is granted, will continue to consult with and be available to residents through the construction and operational lifespan of the Proposed Wind Farm.

As detailed in Appendix 2-2 of the EIAR, as part of the community consultation process, the CLO met/contacted a number of GAA representatives from clubs in the area around the Site. Such GAA clubs included Killkerrin-Clonbern GAA and Mountbellew GAA in Co. Galway. Information pack drops by the CLO provided details to a number of National School principals in the surrounding area.

These included Briarfield National School, Cooloo National School, Barnaderg National School and Lavally National School, Co. Galway.

In addition to the Public Information Event held in January 2024, a meeting was arranged via the CLO with Moylough Community Council in February 2024. In advance the Community Council submitted a list of questions to the Applicant which had been gathered from members of the Community Council.

The questions were all answered and issued back to the community council prior to the meeting taking place. All questions were discussed at the meeting and answers were uploaded to the project website.

Assurance was given to the Community Council that further questions would be welcome and encouraged the committee to remain in contact.

The Applicant has made meaningful engagement with the local community a primary consideration of the Proposed Project through face-to-face, written, telephone and online contact and the community consultation

process has been effective, open and transparent which they are committed to through the construction and operation of the Proposed Wind Farm.

2.2.2 Public Notice in Newspaper

Several third-party observations to the Commission raised concerns over the publishing of statutory notices for the application within the Irish Examiner newspaper and not the local paper (Tuam Herald) which was ineffective at reaching the local population.

Response

As per the requirements for SID applications, statutory notices were advertised for the application prior to lodgement within a local paper (Connacht Tribune) and national paper (Irish Examiner). The Connacht Tribune is an approved newspaper by GCC.

In addition to these advertisements and measures outlined in Section 2.2.1 above and detailed in Appendix 2-2 of the EIAR, updated information was issued in September 2025 via post to the wider community prior to the lodgement of the application. The details provided included the full description of the Proposed Project seeking planning permission, as well as a map of the final layout of the Proposed Wind Farm.

2.3 Land Ownership & Usage

In a number of third-party observations to the Commissions, the issue of landowner consents was raised regarding lands that would be required for the Proposed Project. Submissions made reference to landowner consent for trimming roadside bushes along the R332 Regional Road for access to the Site, and the lack of landowner consents provided for the laying of the Proposed Grid Connection cabling.

Response

As shown in Figures 15-18 and 15-19, the swept path analysis for turbine delivery vehicles entering into the Site at Access Junction 1 shows turning radii at this location. The analysis highlights the land take, visibility splays, and field boundary removal in order for the delivery of turbine components to enter the Site. The over-run area required will result in the removal of hedgerows and the maintenance of hedgerows for visibility splays. As outlined in Section 4 of Appendix 15-2 Traffic Management Plan (TMP), bushes/shrubs on the southern side of the [R332]* will be trimmed in order to maximise forward visibility at the proposed construction site entrance. It is estimated that the proposed trimming along the roadside will achieve 140m of forward visibility. The land directly across the road from the proposed site entrance, where roadside trimming will be conducted, is within the control of the Proposed Project and a landowner consent letter has been acquired for the planning application.

Response from MLavelle: This means that hedge trimming can not occur outside of this area under the control of the applicant & can be contested & blocked.

*It is acknowledged that an incorrect reference was made to the R328 in the mitigation measures outlined in Chapter 15 Section 15.1.10 of the EIAR and Section 4 of the TMP included as Appendix 15-2. See Section 2.13.5 of this response document below. The text above has been amended to correctly reference the R332.

As outlined in Section 1.1.1 of Chapter 1: Introduction and Section 2.1 of Chapter 2 of the submitted EIAR as part of the planning application, the Proposed Grid Connection is an integral part of the Proposed Project and is assessed in this EIAR, however, it will be subject to a separate, future application. The future, application for consent for the Proposed Grid Connection will be made to the Commission in accordance with the provisions of 182A of the Planning and Development Act 2000, as amended. The Proposed Grid Connection was assessed but not applied for as part of the planning application for the Proposed Wind Farm. For the purposes of an environmental impact assessment, landowner consents are not required. **In the future planning application for the Cooloo grid connection, landowner consents will be acquired where necessary and included in that application. It is noted in this regard that grid connection works carried out in the public road by a statutory undertaker do not require a letter of consent, as outlined by Art. 22(g)(ii) of the Planning and Development Regulations 2001 (as amended).**

Response from MLavelle: The Dromada Windfarm Case in 2023 determined that the grass verge is private property as is the setback areas in front of houses. The applicant would have to lay any ducting in the metalled part of the public road. However, the absence of statutory undertaker involvement/ownership with this application determines that the applicant cannot rely on that.

2.4 Project & Application Details

Several third-party observations to the Commission have regard to the description of the Proposed Project in the planning application and submitted Environmental Impact Assessment Report (EIAR).

Observations are made under the following themes:

- Proposed Grid Connection
- Proposed Wind Farm Export Capacity
- Project Design
- Application Documents

2.4.1 Proposed Grid Connection

Several third-party observations including the Barnaderg Cooloo Windfarm Action Collective CLG (hereafter referred to as the Collective) queried the details of the Proposed Grid Connection within the application and sought clarification on details of the grid connection agreement with regards to consent, assessment and maintenance of permanent infrastructure.

Response

As noted above in Section 2.1.4, the Proposed Grid Connection is not included in this application and will be subject to a separate application. The future planning application for the Proposed Grid Connection will include for an onsite substation, BESS and grid connection that will connect the Proposed Wind Farm into the national grid. As detailed in Chapter 4 Section 4.10 of the EIAR, following decommissioning of the Proposed Wind Farm at the end of its operational life, certain components of the Proposed Grid Connection including the underground electrical cabling route, onsite substation will remain in place as it will form part of the electricity grid under the ownership and control of the ESB and EirGrid.

Response from MLavelle: The Dromada Windfarm Case in 2023 determined that the grass verge & to centre of road is private property as is the setback areas in front of houses. The public road is a Right-of-Way to pass over the surface. However, the absence of statutory undertaker involvement/ownership in the applicant's application determines that the applicant cannot rely on that.

2.4.2 Proposed Wind Farm Export Capacity

A number of third-party observations regard the stated export capacity of the Proposed Project, with claims that the output of the Proposed Wind Farm will be less than 50MW and therefore the application does not meet the SID threshold.

Response

As noted in Section 1.4 of Chapter 1 Introduction, the Proposed Wind Farm would have a combined maximum generating **capacity** of between 54 to 64.8 MW. The exact generating **capacity** of the installed turbine will be designed to match the wind regime on the Site and will be determined by the selected manufacturer. Regardless of the final selected turbine model, it can be confirmed that the Proposed Wind Farm will have a total **output** in excess of 50MW meeting the relevant threshold set out in the Seventh Schedule of the 2000 Act.

Response from MLavelle: This statement is simply untrue.

The brochure "**capacity**" is not the same as "**output**".

"**Output**" is based on annual wind speed as outlined on SEAI Wind Atlas in association with Power output curves from the Windfarm Turbine manufacturer. For 8m/s one finds that the output is c2.2Mw per turbine & NOT the Brochure Capacity of 6.2Mw.

This is similar to purchasing a Ferrari F1 Grand Prix motor car with top speed over 200kph for rural road driving in Ireland & demanding that the speedlimit should be raised to reflect the Ferrari's top speed.

It is clearly nonsense and the output for this application is for $9 \times 2.2\text{Mw} = 19.8\text{Mw}$ & far lower than the 50mw threshold.

This is an invalid application.

The Applicant engaged with the Commission under the provisions of Section 37B of the Planning Act as to whether the Proposed Project would meet the thresholds of the Seventh Schedule of the Planning Act. A letter received from the Commission dated the 19th September 2025 stated that under Section 37B (4)(A) that it is the opinion of the Commission that the Proposed Project falls within the scope of the paragraphs 37A(2)(a) and (b) of the Act. This confirmed that the Proposed Project constitutes SID and therefore the planning application should be made directly to the Commission. The determining factor considered relevant for the Proposed Project meeting the relevant threshold set out in the Seventh Schedule of the 2000 Act, was in relation to the **power output** in Megawatts (MW) of the Proposed Wind Farm.

Response from MLavelle: The law in relation to SID Threshold of 50Mw states “**output**”. The applicant is responsible for misleading the Commission through the usage of “**capacity**”. This application does not meet the 50Mw threshold for **power output**. Thus it is invalid.

2.4.3 Project Design

A number of third-party observations claim that the location of the proposed turbines do not comply with the 2006 or 2019 Wind Energy Development Guidelines with regards to minimum separation distances between turbines.

Response

It is noted that both the Wind Energy Development Guidelines for Planning Authorities (Department of the Environment, Heritage and Local Government (DoEHLG), 2006) (hereafter referred to as the 2006 Guidelines) and Draft Wind Energy Development Guidelines (Department of Housing, Local Government and Heritage (DoHLGH), December 2019) (hereafter referred to as the draft 2019 Guidelines) outline that **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** to ensure optimal performance and account for turbulence and wake effects.

Response from MLavelle

Seven times the Rotor Diameter is $7 \times 162 = 1,134\text{metres}$. Using the Grid references provided & Pythagorean Theorem, we find that separation distances are as outlined below ranging from 520.2, 535.7, 592.8, 606, 611.7 in Column 9. These measurements indicate gross non-compliance with 2006 Wind Energy Guidelines & draft 2019 Guidelines & will create far greater noise to adjoining properties. It is simply not possible to fit 9 Turbines onto this site in compliance with the Guidelines.

The Separation distances between turbines do not comply with 2006 Guidelines or 2019 Draft Guidelines in order to squeeze extra turbines into the site. Providing Grid references for Wind Turbine locations does not allow the normal Citizen to assess separation distances. Failure to provide turbine setback distances determines failure to achieve noise levels below 30dba in low noise areas.

Turbine No.	Easting Coordinate	Difference	Square	Northing Coordinate	Difference	Square	Sum of Squares	Sq root of sum of squares
1	555297			747613				
2	555608	311	96721	748030	417	173889	270610	520.2
3	555563	-45	2025	748640	610	372100	374125	611.7
4	556167	604	364816	748591	-49	2401	367217	606.0
5	556198	31	961	749183	592	350464	351425	592.8
6	555648	-550	302500	749699	516	266256	568756	754.2
7	555568	-80	6400	750508	809	654481	660881	812.9
8	556986	1418	2010724	749348	-1160	1345600	3356324	1832.0

9	556813	-173	29929	749855	507	257049	286978	535.7
3	555563			748640				
5	556198	635	403225	749183	543	294849	698074	835.5
3	555563			748640				
6	555648	85	7225	749699	1059	1121481	1128706	1062.4
5	556198			749183				
8	556986	788	620944	749348	165	27225	648169	805.1

Further to this, the 2006 Guidelines and draft 2019 Guidelines note that the principle of the minimum separation distances should be respected in regard to permission for wind energy development granted on an adjacent site.

Response from MLavelle: Hypocrisy. They blatantly don't respect the minimum separation distances. Furthermore, it is totally unsatisfactory to present wind turbine locations as 6-figure grid coordinates for the normal person. The separation distances between turbines should have been provided.

There are no proposed, permitted, or operational wind farms within 5km of the Proposed Wind Farm site. The nearest turbine is over 7.8km to the west (permitted Cloonlusk Wind Farm). As such, the Proposed Wind Farm **achieves the minimum separation distance from adjacent wind energy developments** as outlined in the 2006 Guidelines and draft 2019 Guidelines.

Response from MLavelle: The separation distance refers to turbines in a windfarm & not geographical distance to other windfarms. The statement that the proposal achieves the minimum separation distance is not true.

The Proposed Wind Farm was developed to take account of all the constraints and facilitators onsite including their associated buffer zones as described in Chapter 3 Section 3.5 of the EIAR and the separation distance required between them. The turbine layout for the Proposed Wind Farm was also informed by the results of noise and shadow flicker assessments as they became available.

Response from MLavelle: The separation distance refers to turbines in a windfarm & this application does not take account of these constraints. The statement that the proposal takes account of "the required separation distance" is not true. The Windpro software input constraints, including separation distances could have been provided in screenshots, together with Wake turbulence downwind. This lacunae was not provided & that determines that this application should be refused.

2.4.4 Application Documents

A third-party observation notes that there was an error on the application website in viewing the NIS document. One other third-party observation notes that a hyphen is missing from the reference to the 'observations' web page on the Commission's website (<https://www.pleanala.ie/enie/observations>) on the newspaper notice published in the Irish Examiner.

Response

The issue in viewing the NIS via the application website has since been resolved. The NIS was available for online viewing via the Commission's website during the public consultation period. It is also noted that hard copies of the application, including the NIS, were available for viewing/ purchase at the offices of the Commission and the local authority, GCC, during the public consultation period.

It is accepted that a printing error leading to the missing hyphen in the web page address exists on the newspaper notice published in the Irish Examiner. The site notice and newspaper notice in the local paper do not have this issue. It is noted that the website link, without hyphen, still directs to the Commission's website where the 'observation' webpage can be easily navigated to.

2.5 Population & Human Health

2.5.1 Shadow flicker

Several third-party observations relate to the potential for shadow flicker impacts from the proposed turbines on nearby residential receptors. The submissions state the size and scale of the proposed turbines would cause shadow flicker to occur on houses, schools and community facilities in the wider area. Several of the submissions relating to shadow flicker claim the Wind Energy Development Guidelines (2006) are outdated and insufficient for assessing the impacts of modern wind farms given the taller turbines that are being proposed now compared to when the Guidelines were originally published in 2006. One submission claims that the list of modelled properties is incomplete and omits dwellings.

[Response from MLavelle: The Competent Health Authority for Ireland is the HSE. The HSE state that the 2006 Guidelines are outdated & this reflects the competent WHO position as well. Any Planning Inspector that ignores this situation does so at his/her own risk as outlined in the Carraig Hill Windfarm JR, where Public Safety was determined by Justice Humphries to be the responsibility of the Decision Taker \[ACP Inspector\]. Any future proceedings under Health & Safety Legislation is under the Criminal Code, when negligence is an issue.](#)

Response

As outlined in Section 5.2.3 in Chapter 5 of the EIAR, there are several factors which determine the frequency and strength of any potential shadow flicker impacts from turbines. Those factors include:

1. Whether the sunlight is direct and unobstructed or diffused by clouds
2. The presence of intervening obstructions between the turbine and the observer
3. How high the sun is in the sky at a given time
4. Distance and bearing i.e., where the property is located relative to a turbine and the sun
5. Property usage and occupancy
6. Wind Direction, i.e., position of the turbine blades
7. Rotation of turbine blades

The current guidance in Ireland for shadow flicker is derived from the 2006 Guidelines and the 'Best Practice Guidelines for the Irish Wind Energy Industry' (Irish Wind Energy Association, 2012). The 2006 Guidelines threshold recommend that shadow flicker at neighbouring offices and dwellings within 500 metres of a proposed turbines should not exceed a total of 30 hours per year or 30 minutes per day. The 2006 Guidelines are currently under review. In 2019, the DoEHLG the draft 2019 Guidelines included recommendations that "no existing dwelling or other affected property will experience shadow flicker as a result of the wind energy development subject of the planning application and the wind energy development shall be installed and operated in accordance with the shadow flicker study submitted to accompany the planning application, including any mitigation measures required. "

In accordance with the 2006 Guidelines, the Shadow Flicker Study Area for the shadow flicker assessment is ten times the rotor diameter – which comes to a 1.62km buffer from all proposed turbines.

As detailed in Chapter 5 Section 5.2.3.5 of the EIAR there are 218 no. third party properties (referred to 'Sensitive Receptors') located within 1.62 km of the proposed turbine locations. The Shadow Flicker software modelled 218 no. Sensitive Receptors for potential shadow flicker impact. Of these, a total of 171 no. Sensitive Receptors are theoretically predicted to experience shadow flicker. The Shadow Flicker Study Area and Sensitive Receptors locations are shown in Figure 5-3 of the EIAR.

The proposed mitigation measures stated in Chapter 5 Section 5.10.3.2.7 of the EIAR, which will be employed at the potentially affected properties to ensure that the current 2006 Guidelines are complied with at any property within the Shadow Flicker Study Area. The same mitigation measures also demonstrate that the proposed turbines can be operated in accordance with the shadow flicker requirements of the draft 2019 Guidelines, i.e. zero shadow flicker occurrences, should they be adopted as currently proposed, while the planning application is being determined. The mitigation measures include both screening measures, such as planting of vegetation, and wind turbine control measures.

[Response from MLavelle: Will the turbines be turned off for an hour after dawn & an hour before sunset for all days?](#)

As stated in Section 5.2.3 of the EIAR, all turbines installed on-site will comply with the daily and annual shadow flicker recommended thresholds of 30 minutes and 30 hours, respectively as set out in the 2006 Guidelines. However, the proposed turbines can be brought in line with the draft 2019 Guidelines shadow flicker recommendation through the use of turbine control software, should this draft guidance be brought into effect.

[Response from MLavelle: This suggests that compliance won't be provided unless forced by new Guidelines or Planning Statement.](#)

2.5.2 Construction Impact

A number of third-party observations refer to the potential impacts of the construction phase on the receiving community. The impacts referenced in the observations include:

1. Increased Traffic Levels
2. Traffic Disruption
3. Environmental Contamination

Response

It is acknowledged that the construction of any large-scale project, including the Proposed Project, will cause some level of impact and disruption on local road users particularly in the construction phase.

The traffic impact assessment, outlined in Chapter 15 of the EIAR, has used traffic count survey data, site surveys, Transport Infrastructure Ireland guidance documents, and Department of Transport recommendations. In Section 15.1.2 of Chapter 15, the receiving environment and road network is described as are the proposed delivery and haul routes. In Appendix 15-2, a project-specific Traffic Management Plan (TMP) has been prepared that sets out traffic management measures that the Applicant will commit to provide during the construction stage of the Proposed Project. The primary objective of the TMP is to minimise the disruption to local road users whilst the Proposed Project is under construction. Section 6 of the TMP states the 'General Traffic Management Measures' being proposed. Measures include engagement with local people regarding traffic related matters, a dedicated Traffic Management Coordinator, an out of hours emergency number, pre- and post- construction condition survey, and re-instatement works. It is outlined that a detailed TMP will be finalised and confirmatory detailed provisions in respect of traffic management agreed with the Roads Authorities, GCC and An Garda Síochána prior to construction works and turbine delivery commencing on Site. Contact will be maintained with the Roads and Traffic Section of GCC throughout the construction phase. The Applicant will rectify any damage caused to the pavement on the existing road network that may arise from any temporary works due to the turning movement of abnormal loads as set out in Section 15.1.12.5. The protection of the environment is a priority during all phases of the Proposed Project. The construction phase will see the use of a number of materials from fuel to concrete as various components of the Proposed Project are built. The use of such materials gives rise to potential impacts to the local environment if there are no controls, best practice construction methodologies or mitigation measures in place. As part of the EIAR assessment, a robust Construction and Environmental Management Plan (CEMP) (Appendix 4-5), a Peat and Spoil Management Plan (Appendix 4-2), mitigation measures in relation to environmental and hydrological protections, health and safety measures, and best practice work methodologies are proposed which will prioritise environmental protection. In Sections 4.6.4, 4.6.5, and 4.6.6 of Chapter 4, the proposed drainage design measures are outlined which are intended to minimise run-off from construction activities into nearby watercourses, and the control of the collected run-off across the Site. Figure 4-26 illustrates the various drainage infrastructure that will be utilised as part of the Proposed Project.

The CEMP describes further all the measures that will be utilised to protect the receiving environment and watercourses. Section 3 of the CEMP outlines the Environmental Management areas that have been considered as part of the assessment which includes protecting water quality, dust control and waste management. Section 4 of the CEMP describes the implementation of the Environmental Management proposals, and it details who will be responsible for each aspect across the construction phase. Section 7 and 8 of the CEMP states the mitigation and monitoring proposals, respectively, that will be adhered to for the duration of the construction, operation and decommissioning phases of the Proposed Project. Listed in Chapter 18 is the full schedule of all proposed mitigation and monitoring proposals across all areas of the EIAR

which are intended to reduce in so far as possible the potential impacts from the Proposed Project on the receiving environment.

2.5.3 Community Impact

Two third-party observations noted the high energy electricity costs that Ireland is experiencing compared to the rest of Europe. The observations claimed that despite the high level of wind energy deployment in Ireland, Irish consumers still are paying amongst the highest amounts in Europe for electricity bills. Furthermore, the observations argue that the Cost of curtailment is being passed on to consumers through rise in electricity bills, making the Proposed Project unsustainable given the high prices being charged.

A number of third-party observations highlight property devaluation as a concern resulting from the Proposed Project being proposed near their homes.

Several third-party observations claim that the Community Benefit Fund of the Proposed Project is “vague, unenforceable and worthless”, there is “no binding, transparent agreement” and that the fund is therefore unreliable. One observation claims that the developer is not legally required to provide a Community Benefit Fund beyond RESS participation.

Response

Ireland is experiencing high energy bills due to a number of factors that include historical underinvestment in the national grid, high inflationary periods post COVID-19 and the War in Ukraine, and a lack of electrical interconnectors to the UK and Europe. Wind energy developments in Ireland help to reduce costs to the consumer through the production of indigenous, clean and renewable energy. In its Annual 2025 Report, Wind Energy Ireland stated that Irish wind farms provided one third of the island’s electricity last year – amounting to 13,364GWh of clean electricity being exported to the national grid. Within the review, a comparative study undertaken in December 2025 found that the average price of electricity on days with the least amount of wind energy was €148.55 per Megawatt hour compared to days with the most amount of wind energy, the average price was €76.41. In a cost analysis study by Baringa Partners published in January 2025, it was found that renewable energy saved Irish consumers €840 million between 2000 and 2023. The study found that the displacement of fossil fuels by renewable energy in Ireland avoided the need to burn €7.4 billion worth of gas and coal between 2000 and 2023, including almost €4 billion since 2021.

Response from MLavelle: This again is not true. The actual cost of dispersed rural windfarms require grid investments in the €billions. This cost is not included by Wind Energy Ireland in their Reports. Wind Energy also ignores the duplication requirement cost for alternative energy when the wind isn’t blowing. Wind Energy also gets payments through curtailment payments. This “saving” is fictional. Any independent analysis would show no savings. This is unmitigated greed at the expense of the citizen.

date	Curtailment Cost	date	Curtailment Cost	date	Curtailment Cost
incl UAEC		incl UAEC		incl UAEC	
01/01/26	€ 320,960	01/02/26	€ 780,000	01/03/26	€ 5,900,000
02/01/26	€ 3,212,400	02/02/26	€ 1,700,000	02/03/26	€ 1,900,000
03/01/26	€ 1,630,400	03/02/26	€ 4,900,000	03/03/26	€ 980,000
04/01/26	€ 1,073,440	04/02/26	€ 1,000,000	04/03/26	€ 780,000
05/01/26	€ 3,813,120	05/02/26	€ 3,500,000	05/03/26	€ 2,000,000
06/01/26	€ 800,000	06/02/26	€ 1,800,000	06/03/26	€ 1,000,000
07/01/26	€ 1,200,000	07/02/26	€ 150,000	07/03/26	€ 2,700,000
08/01/26	€ 150,000	08/02/26	€ 150,000	08/03/26	€ 2,100,000
09/01/26	€ 1,100,000	09/02/26	€ 150,000	09/03/26	€ 780,000
10/01/26	€ 1,600,000	10/02/26	€ 150,000	10/03/26	€ 4,600,000
11/01/26	€ 6,800,000	11/02/26	€ 1,600,000	11/03/26	€ 8,700,000
12/01/26	€ 2,800,000	12/02/26	€ 150,000	12/03/26	€ 10,000,000

Wind curtailment refers to the dispatch-down of wind for system-wide reasons where the reduction of any and all wind generators would alleviate a problem that has occurred. In its 2023 Curtailment and Constraint report, Eirgrid stated that approximately 1,663GWh or 10.7% of produced wind energy was curtailed on the island. Curtailment forces the national grid to rely on back-up fossil fuel sources for electricity production which are often more expensive production forms than wind energy.

Concerns have been raised about the potential for the Proposed Wind Farm to have adverse effects on the value of properties of local residents. This issue has been thoroughly addressed in Section 5.6.1 of Chapter 5 of the EIAR. As outlined in the EIAR, the only Irish study, a 2023 working paper by the Centre for Economic Research on Inclusivity and Sustainability (CERIS), suggests a potential 14.7% decrease in property values within 1km of a turbine. However, the study is based on a small sample of 225 houses and acknowledges that no significant price reductions were found beyond 1km, with any observed effects diminishing over time. Given its limited dataset and working paper status, further research is needed before drawing firm conclusion. Extensive research in the United States provides a broader perspective. The 2009 and 2013 studies by the Lawrence Berkeley National Laboratory (LBNL) analysed thousands of home sales near wind farms and found no measurable, consistent impact on property values. A 2023 study published in Energy Policy reported temporary value decreases post-announcement but found these effects faded once the wind farms became operational. In the UK, studies commissioned by RenewableUK (2014) and Climate Exchange (2016) concluded that wind farms do not have a consistent negative impact on property prices. Instead, county-wide market trends drive local house prices rather than the presence of wind farms. Overall, the existing body of research, particularly large-scale, peer-reviewed studies, does not support claims that wind farms significantly devalue nearby properties in the long term. While localized impacts may occur in specific cases, the evidence suggests these effects are not widespread or long-lasting, with house prices instead reacting negatively to the expectation of likely impacts and construction, but these prices recover during the operational phase. Furthermore, the placement of wind turbines near residential dwellings is not a new occurrence. The project design fully complies with the recommendations outlined in best practice guidance for wind energy developments in Ireland, specifically meeting the 4x tip height setback distance for the protection of residential visual amenity as set out in the draft 2019 Guidelines.

Response from MLavelle: The statement that the “overall existing body of research, particularly large-scale, peer reviewed studies does not support claims that wind farms significantly devalue nearby properties in the long term” is untrue. The following references prove that research proves such a devaluation. Quoting Reports from 2009, 2013 & 2014 is nonsense. They are historic when turbines were far smaller & related to central USA, which is largely unpopulated.

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.

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 is 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.

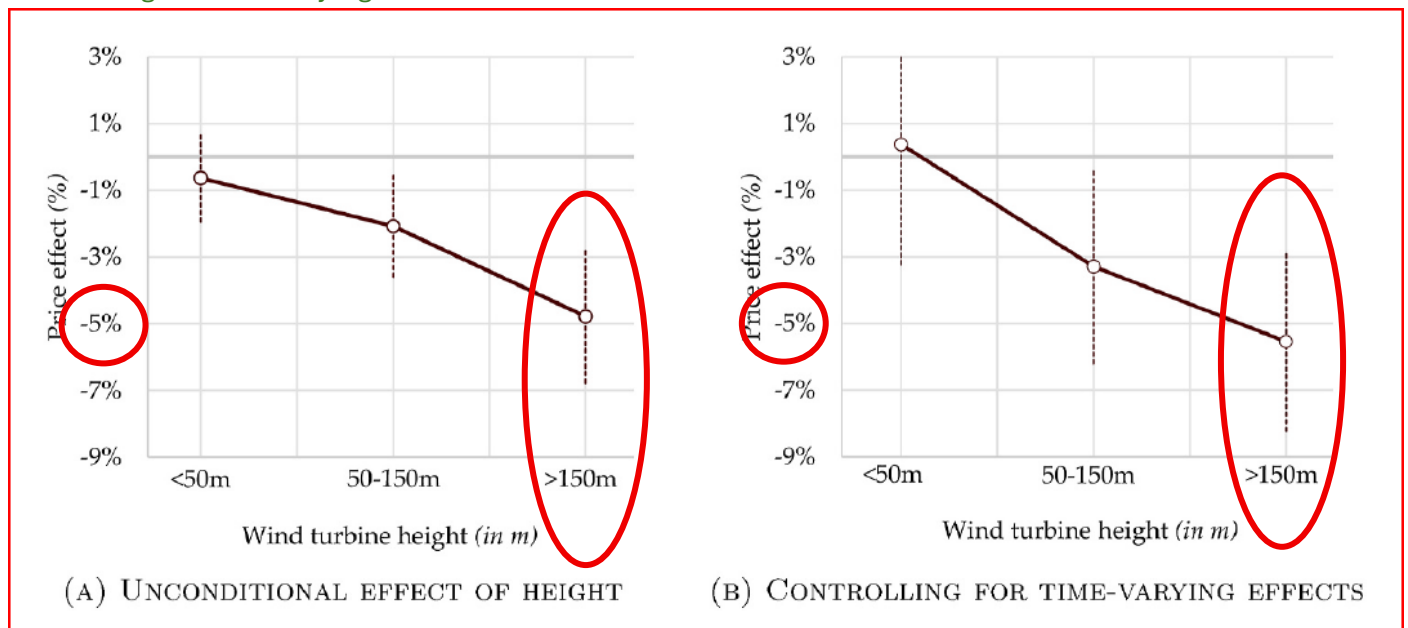


Fig. 4. Price effects for different turbine heights

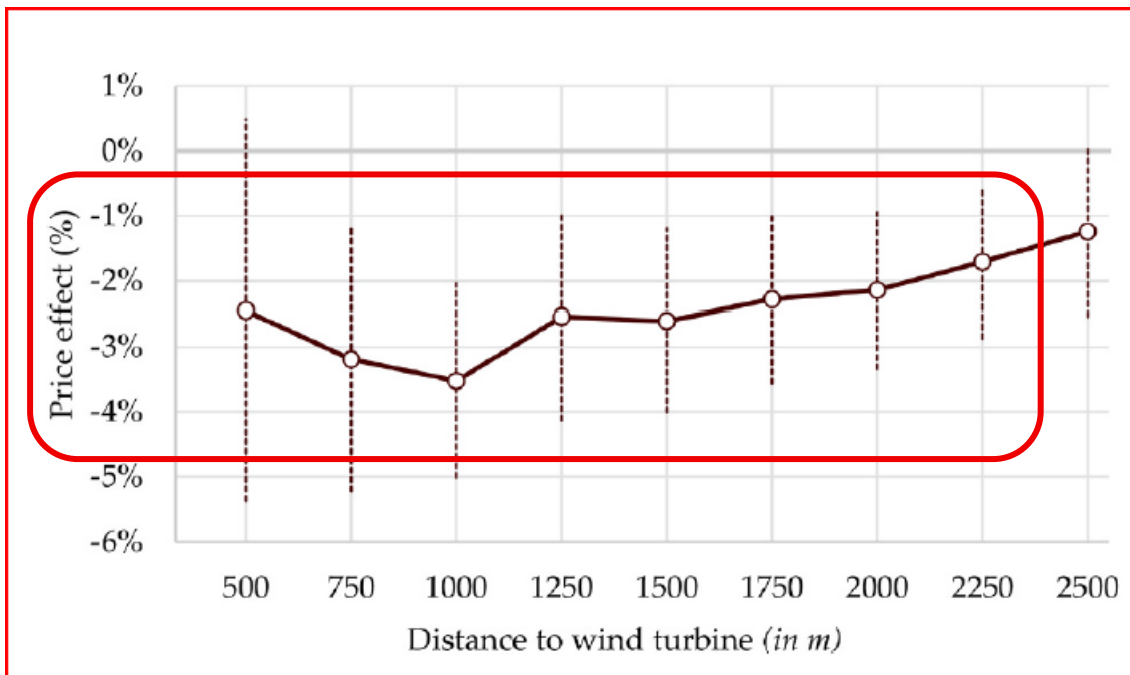


Fig. 5. Wind Turbines: Price effects at different distances (1985–2019)

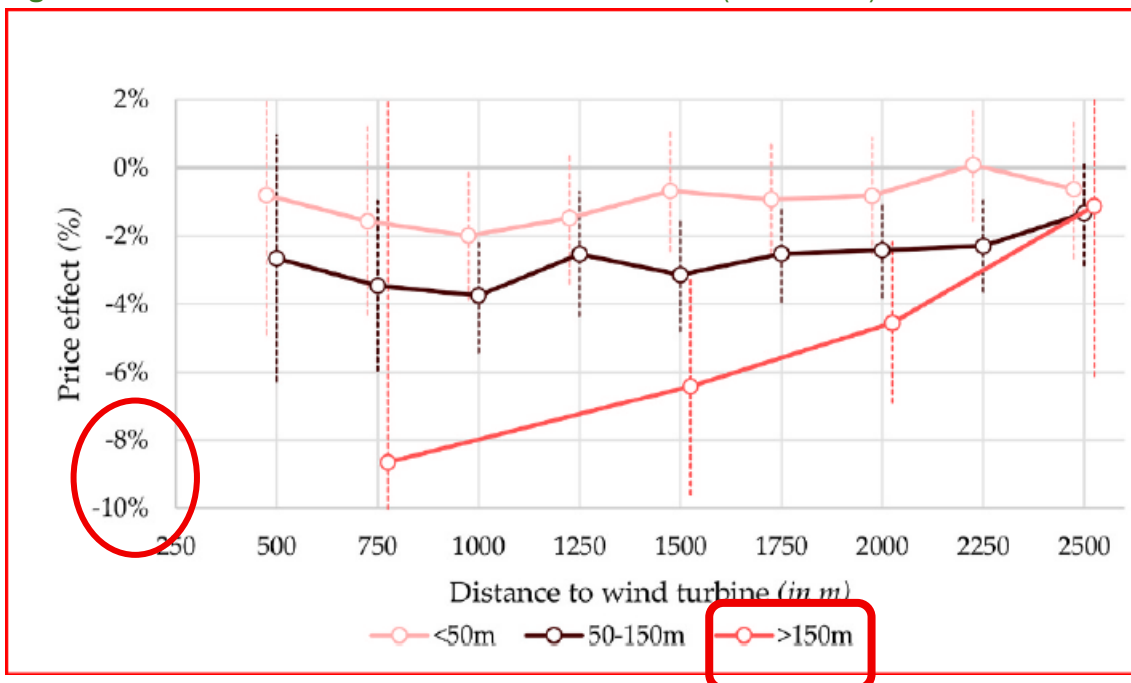


Fig. 6. Distance and wind turbine height

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 learning 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 learning 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 learning 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%.

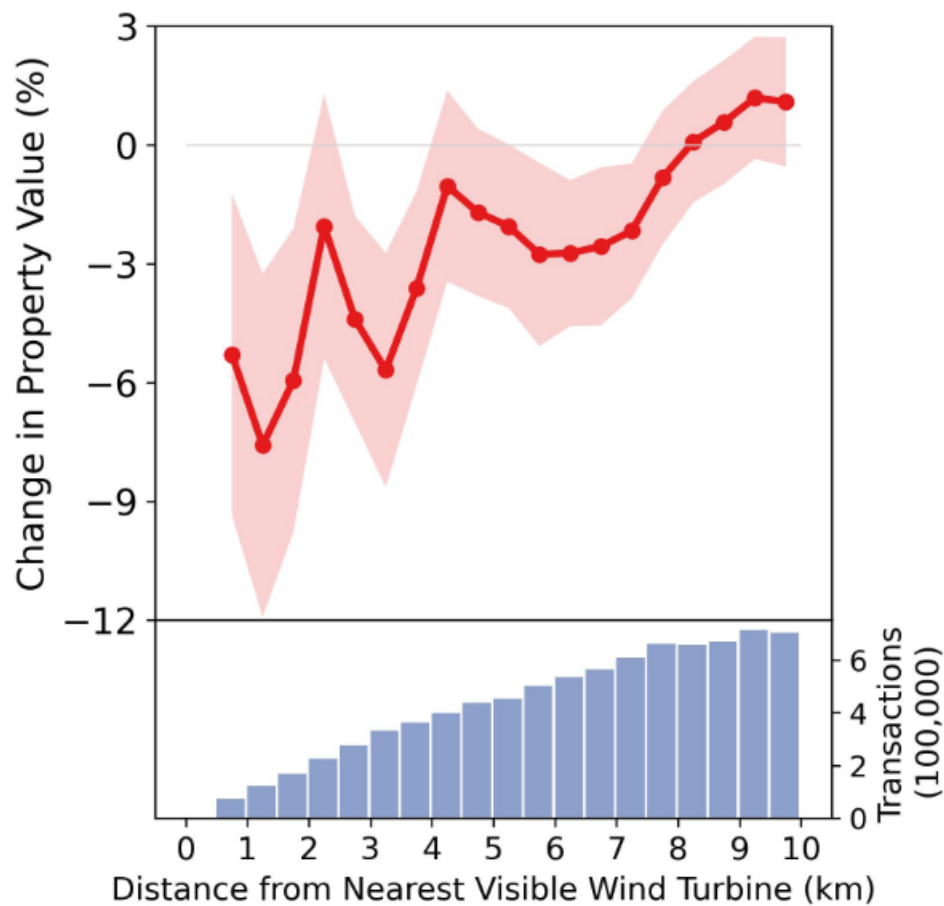


Fig. 2. Effect of wind turbine visibility on property value by distance. The effect of wind turbine visibility on property values for different distance bins. Each distance bin represents a 500-m range, determined by the distance from the nearest visible wind turbine. Red dots indicate estimated coefficients, 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 ($\approx$ 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 ($\approx$ 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.”

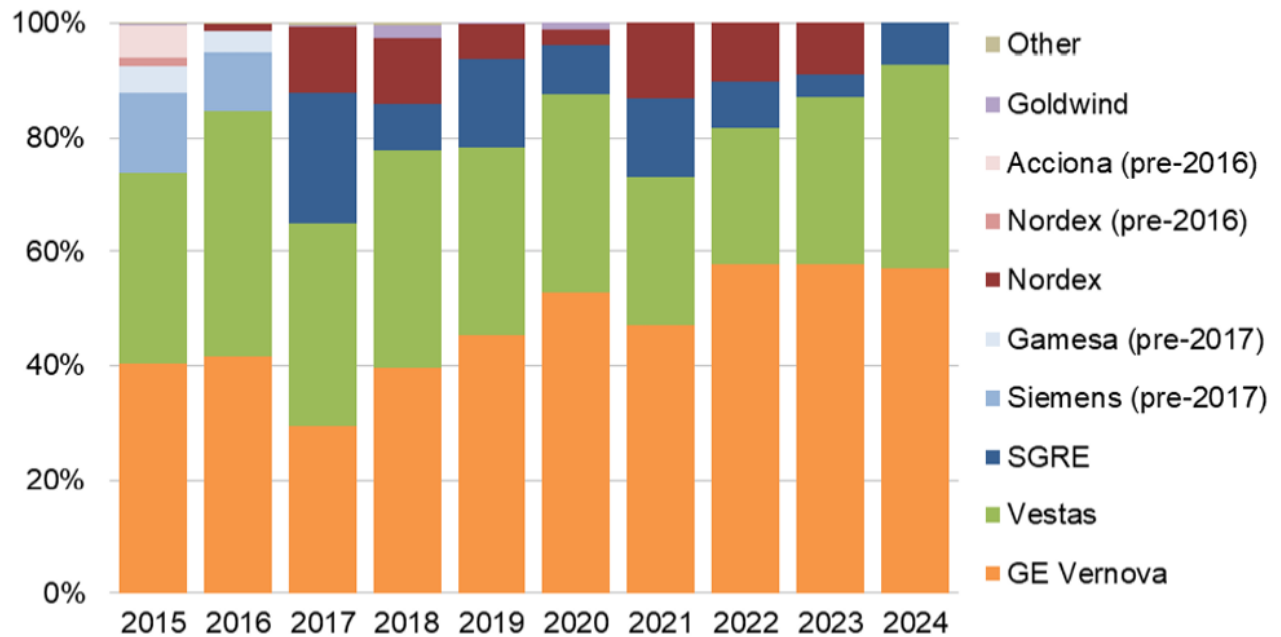
Reference 2024 : Commercial wind turbines and residential home values: New evidence from the universe of land-based wind projects in the United States, Eric J. Brunner, Ben Hoen, Joe Rand, David Schwegman. Energy Policy Volume 185, February 2024, 113837.

<https://doi.org/10.1016/j.enpol.2023.113837>

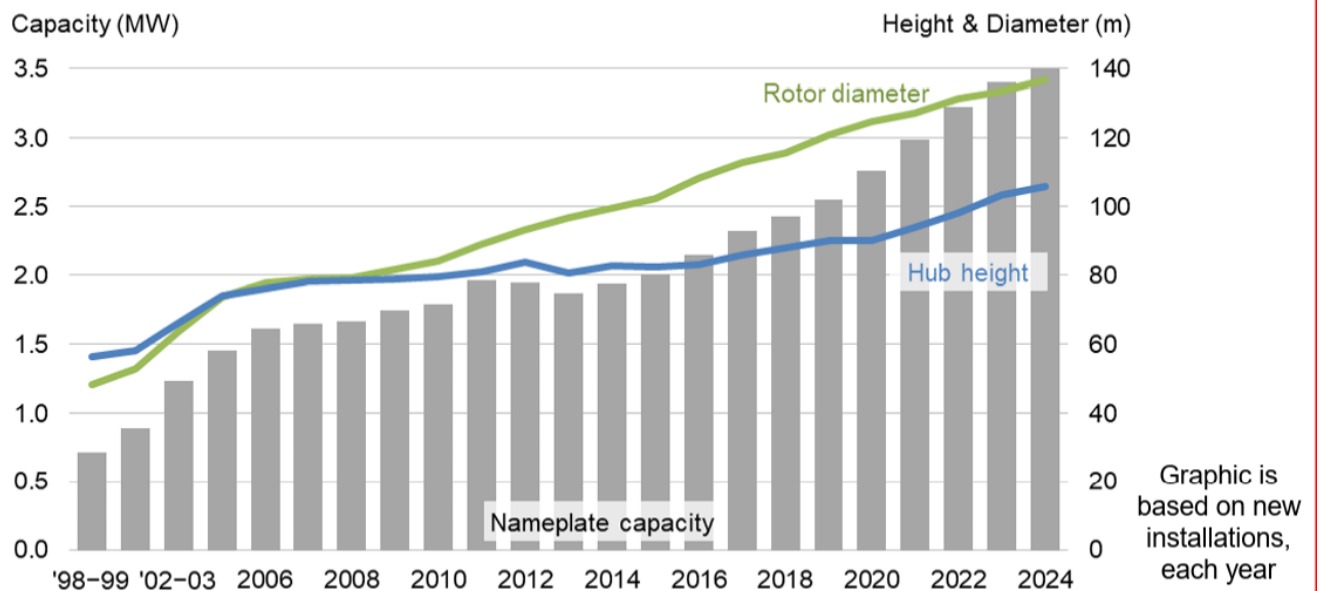
We examine the impact of proximity to land-based commercial wind turbines on residential home values in the United States using data on the universe of commercial wind turbines and residential property transactions from 2005 to 2020. Using event study and difference-in-differences identification strategies 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.

Annual U.S. market share of wind turbine manufacturers by MW, 2015–2024: GE market share = 58% in 2024

U.S. Market Share by MW

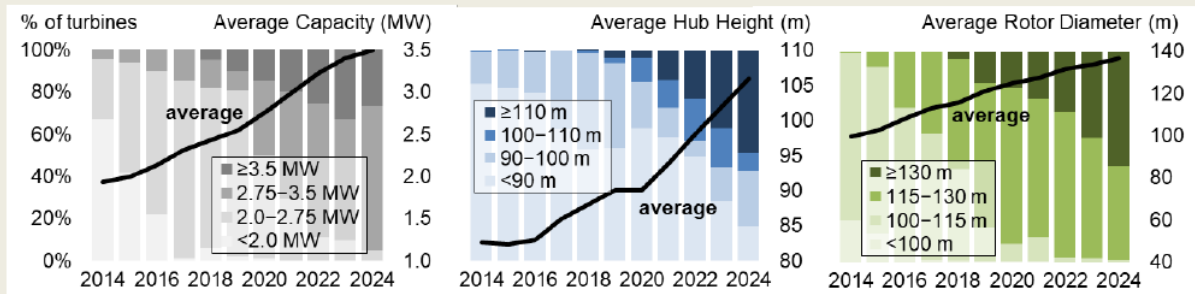


Average turbine capacity (3.5 MW in 2024), hub height (106 m in 2024), and rotor diameter (137 m in 2024) for land-based wind, over time

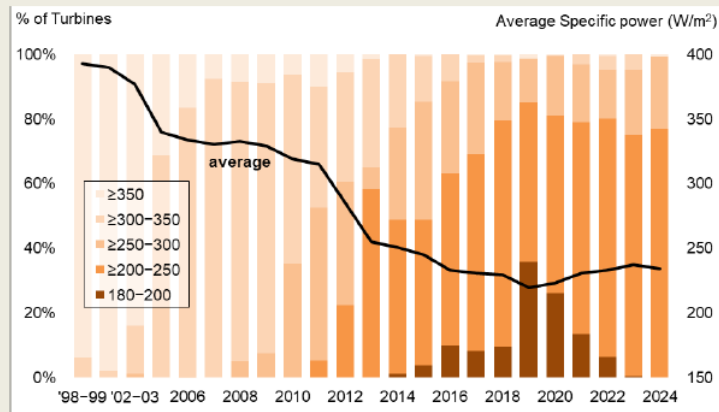


Note wind turbines in 2010 had a Capacity of 2Mw, Hub height of 80m & Rotor diameter of 85m. The height to the tip of the wind turbine would have been $80 + 42.5 = 122.5\text{m}$. The present application is for a 6.2Mw capacity with a tip height of 185m. These are not comparable. The 2016 scenario for Scotland is similar. Comparing property prices from 2009, 2013, 2014 is irrelevant to present day sizes.

Trends in turbine nameplate capacity, hub height, rotor diameter and specific power

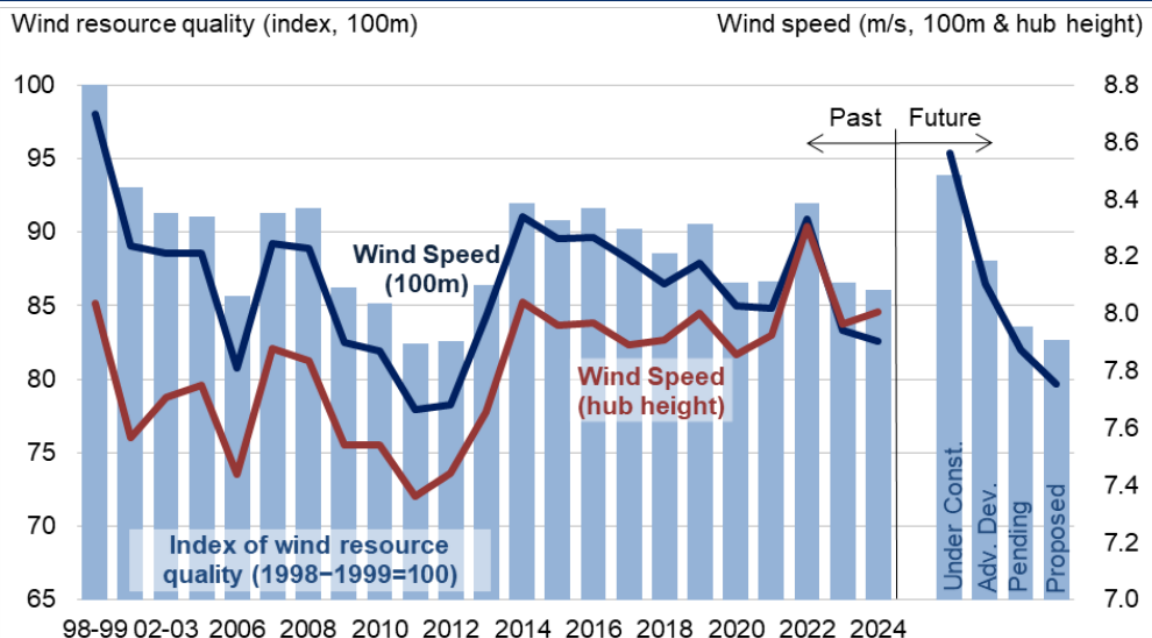


Specific power: turbine capacity divided by swept rotor area; lower specific power leads to higher capacity factors, as shown later



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**

<i>Application of these estimated losses to the client's property value is: Niyol Wind Farm Loss to Property Value Estimate</i>			
<i>Total assessed value</i>		<i>impact</i>	<i>value loss</i>
<i>Properties within the footprint</i>	<i>\$6,948,960</i>	<i>-35%</i>	<i>--\$1,405,051</i>
<i>Properties 1-mile outside of the Footprint</i>	<i>\$4,014,430</i>	<i>-22%</i>	<i>-\$1,528,771</i>
			<i>-\$2,933,822</i>

Stated in Section 4.9.3.2 of Chapter 4 in the EIAR, the Renewable Electricity Support Scheme (RESS) is a Government of Ireland initiative that provides support to renewable electricity projects in Ireland. RESS is a pivotal component of the Programme for Government and the Climate Action Plans 2021, 2023, 2024 and 2025, and is a major step in achieving Ireland's target of at least 80% renewable electricity by 2030. One of the key objectives of RESS is to provide an Enabling Framework for Community Participation through the provision of pathways and supports for communities to participate in renewable energy projects. The RESS Terms and Conditions, published by the Department of Communications, Climate Action and Environment make some high-level provisions for how this type of benefit fund will work. Any project which wants to export electricity to the national grid must abide by these broad principles. Based on the current RESS guidelines it is expected that for each megawatt hour (MWh) of electricity produced by the wind farm, the Proposed Project will contribute €2 into a community fund for the first 15 years of operation of the Proposed Wind Farm. If this commitment is changed in upcoming Government Policy, the fund would be adjusted accordingly.

Should the Proposed Project be developed under RESS, it would attract a community contribution in the region of approx. €300,000/year for 15 years for the local community, totalling €4.5 million. The value of this fund would be directly proportional to the electricity generated by the wind farm. Under current terms and conditions of RESS, the following would be required for Proposed Wind Farm:

- 1) Direct payments – to those living closest to the Site. A minimum €1,000 payment per annum for houses within 1km of the Proposed Project;
- 2) Energy Efficiency – up to 40%/year would be available for the development of energy/sustainability initiatives to benefit people living in the local area. This is to be provided to not-for-profit community enterprises.
- 3) Administration costs - a maximum of 10% of this fund to be made available for the administration and governance costs of the fund.
- 4) Support for local groups – the remainder would be available for local groups, clubs and not for profit organisations that provide services in the local area. This would include services for the elderly, local community buildings, and the development of sporting facilities such as allweather playing pitches etc. The Community Benefit Fund will be under the control of a development fund working group which will represent both the close neighbours of the Proposed Wind Farm and the nearby communities.

The Proposed Project will have additional community benefits separate to the Community Benefit Fund. As outlined in Section 5.10.2.2.2, the construction phase of the Proposed Project will require approximately 100 employees over the course of an 18-24 months construction phase period. The Proposed Project will give rise to employment opportunities as a result. The Proposed Wind Farm will result in an influx of skilled people into the area, bringing specialist skills for both the construction and operational phases that could result in the transfer of these skills into the local workforce, thereby having a long-term positive effect on the local skills base. Up-skilling and training of local staff in the particular requirements of the wind energy industry is likely to lead to additional opportunities for those staff as additional wind farms are constructed in Ireland. The operational and decommissioning phases of the Proposed Wind Farm will also see employment opportunities arise.

[Response from MLavelle: This report states 3 jobs. The rest of this paragraph is fiction. A corner shop would generate more employment than this proposed development. A corner shop would have value to a local community.](#)

The injection of money in the form of rental income to the landowners who are participating in the Proposed Wind Farm where a rental agreement has the potential to result in an increase in household spending and

demand for goods and services in the local area. This would result in local retailers and businesses experiencing a long-term positive impact on their cash flow. This will have a long-term slight positive indirect effect.

Response from MLavelle: This is untrue. The temperature drop from the Wake microclimate effects will decrease crop growth & will effect cattle & increase house heating costs. etc. The farmers were not informed of these losses.

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).

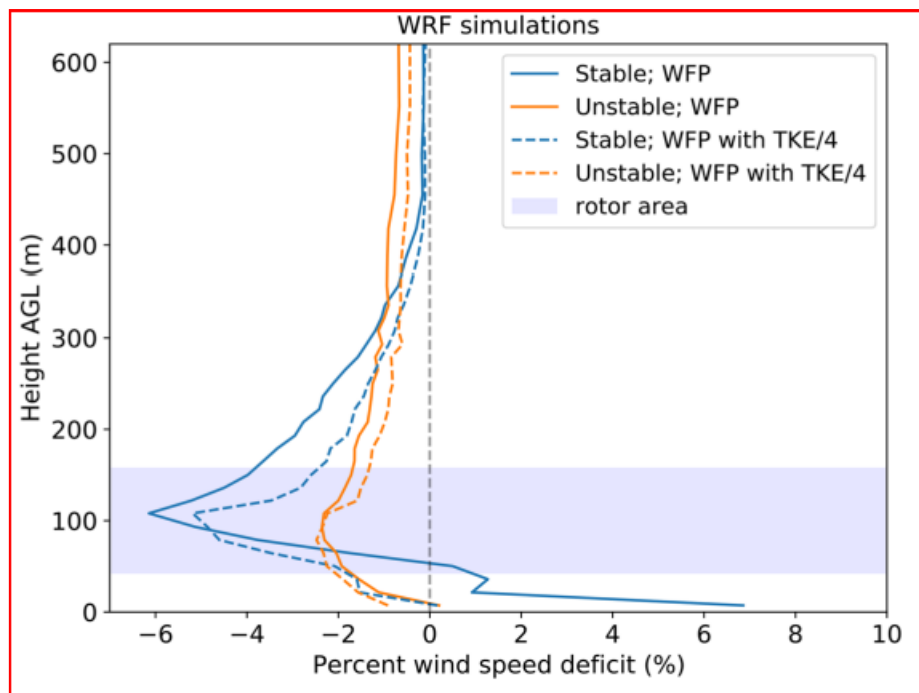
*As for impacts on vegetation, **our results showed decreased vegetation for most wind farms**, especially those large farms. However, positive and insignificant impacts were observed as well. The decreased vegetation is mainly caused by the construction of wind farms and the associated land cover changes, 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, u_0 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.

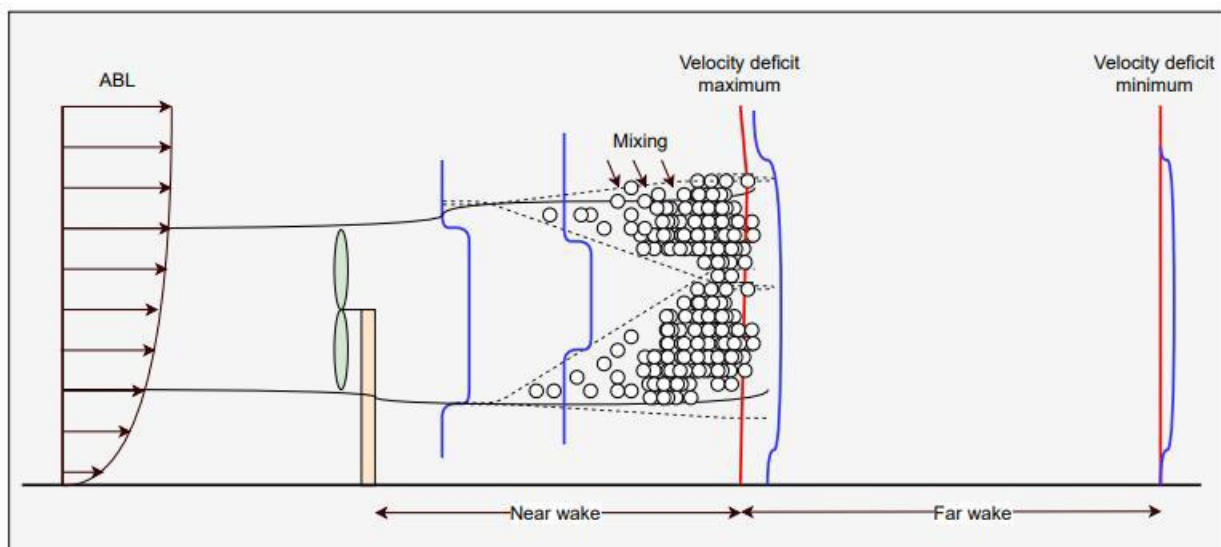


Figure 9. The velocity profile behind WT [85].

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, u_0 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.

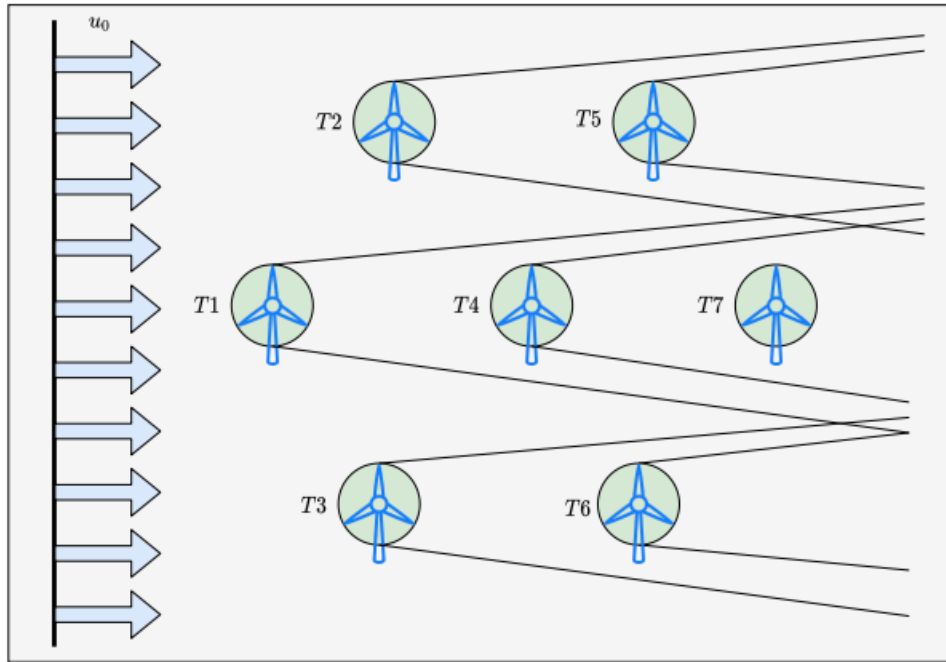
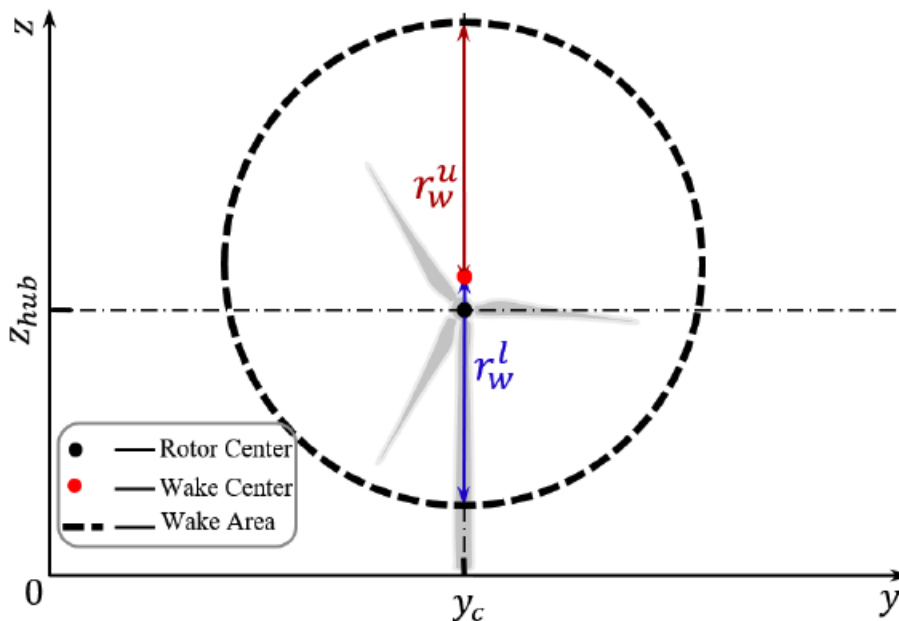


Figure 10. Wake effect in a wind farm (WF) [73].

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 Meteorological 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.

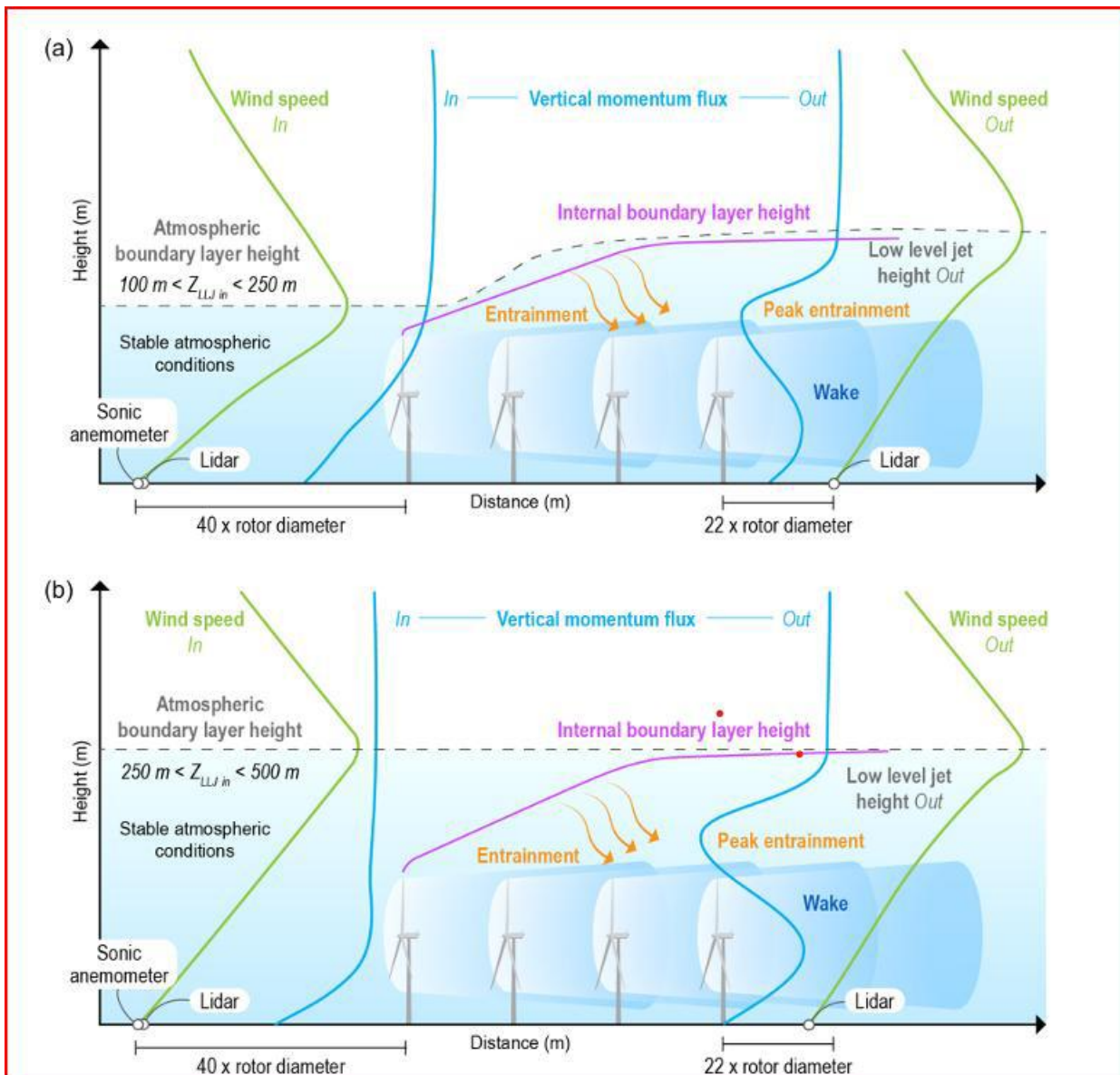
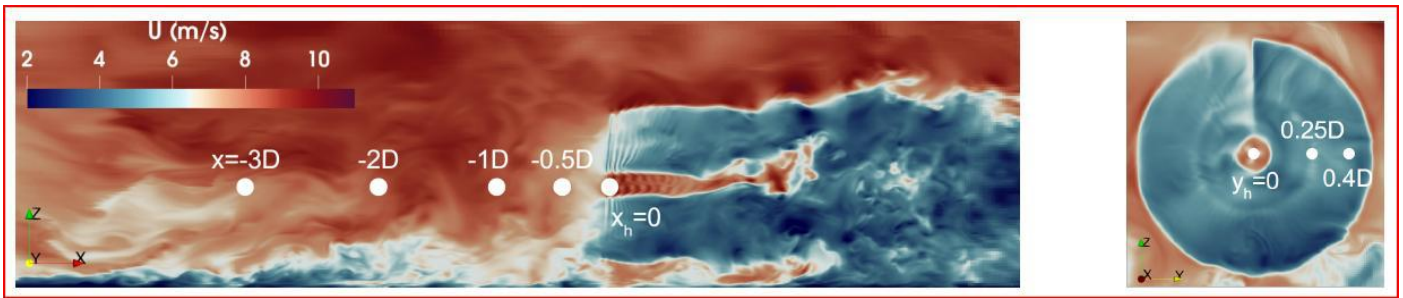


Figure: Schematic of the impact of LLJs on a wind farm boundary layer when (a) $100\text{m} < Z_{LLJ} < 250\text{m}$ and (b) $250\text{m} < Z_{LLJ} < 500\text{m}$.

Reference 2025 : Turbulence Distortion Matters in Predicting Inflow Turbulence Noise of Future Wind Turbines. Ozgur Yalcin, 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. **Therefore, 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

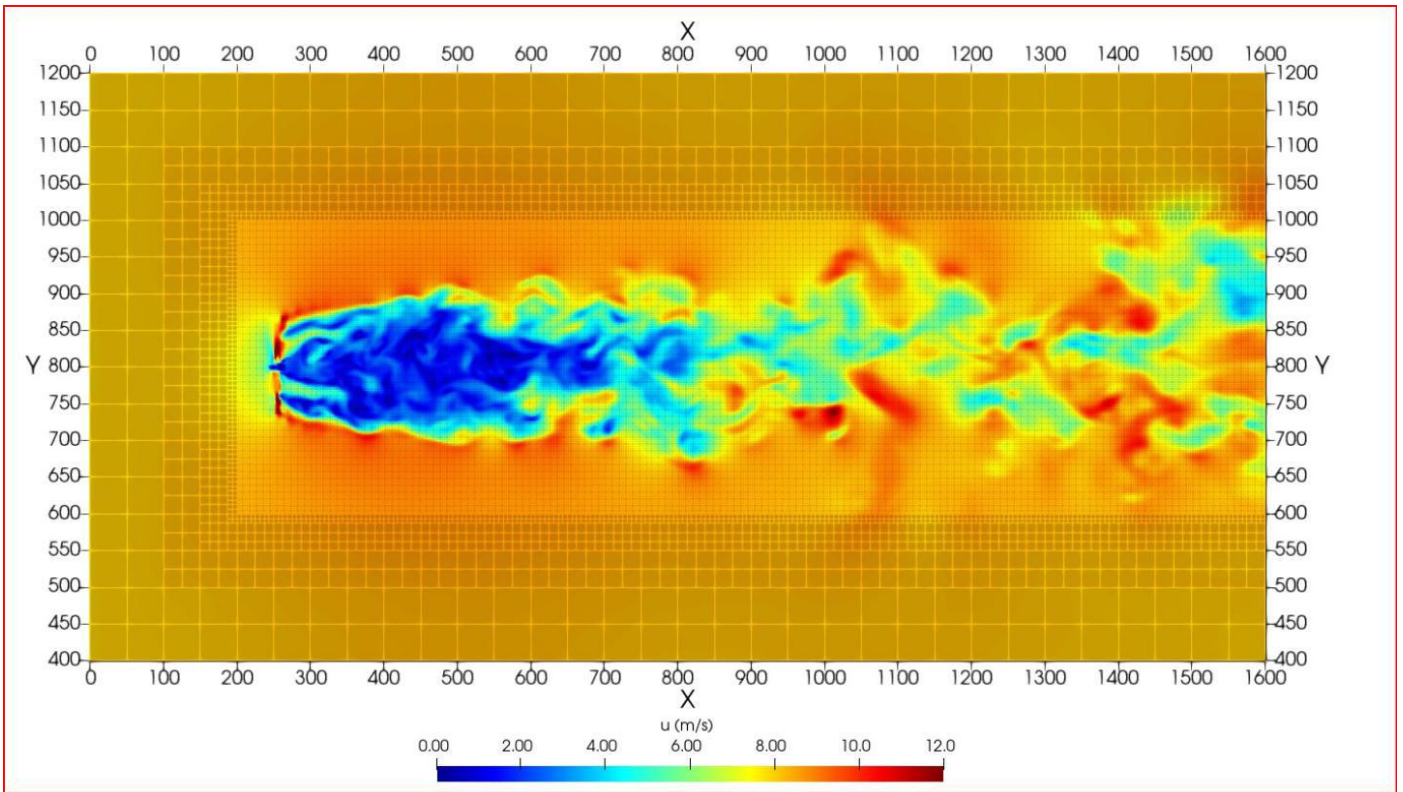
Large-eddy simulations are used to investigate how surface-layer stability (from strongly stable to strongly unstable) and free-atmosphere stratification influence wind farm flow and power output. Increased stability reduces turbulence intensity (TI), limiting wake recovery and decreasing power to downstream 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 free-atmosphere 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 | 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 $u = 8\text{m/s}$.



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.

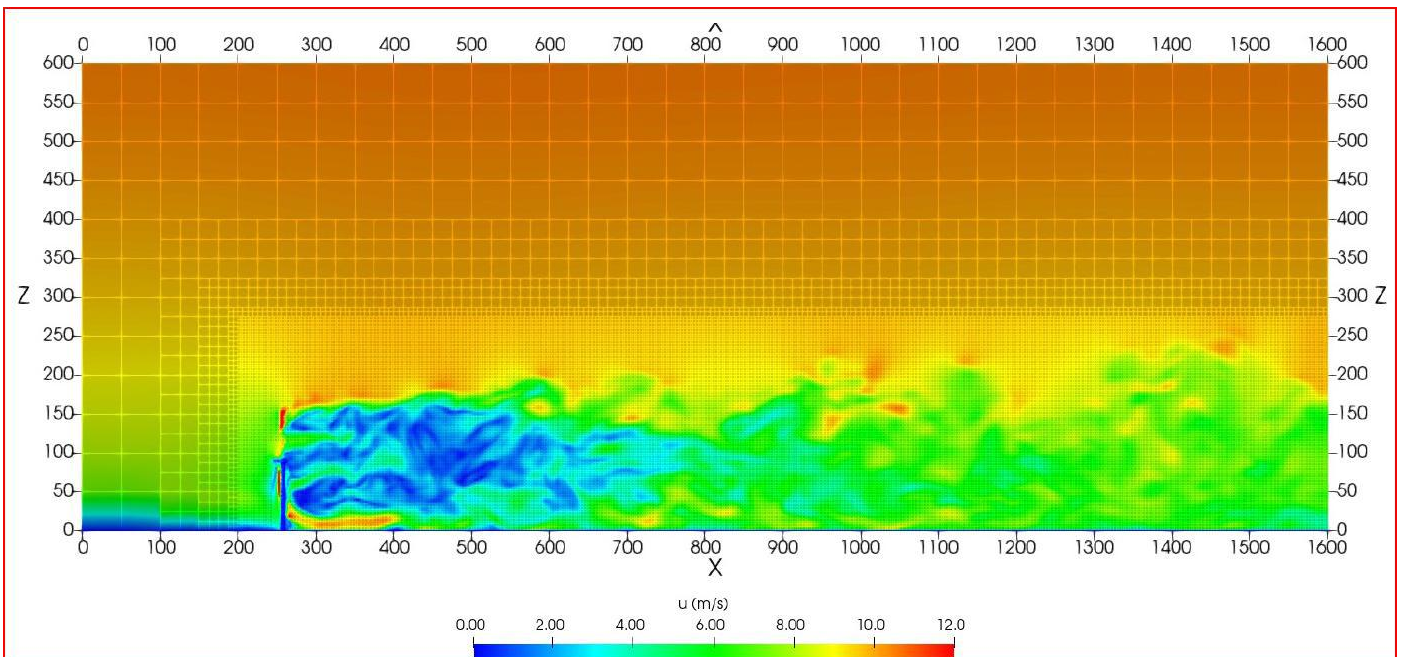


Fig. 2: The flow velocity contours development in lateral view of the NREL 5MW wind turbine.

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.

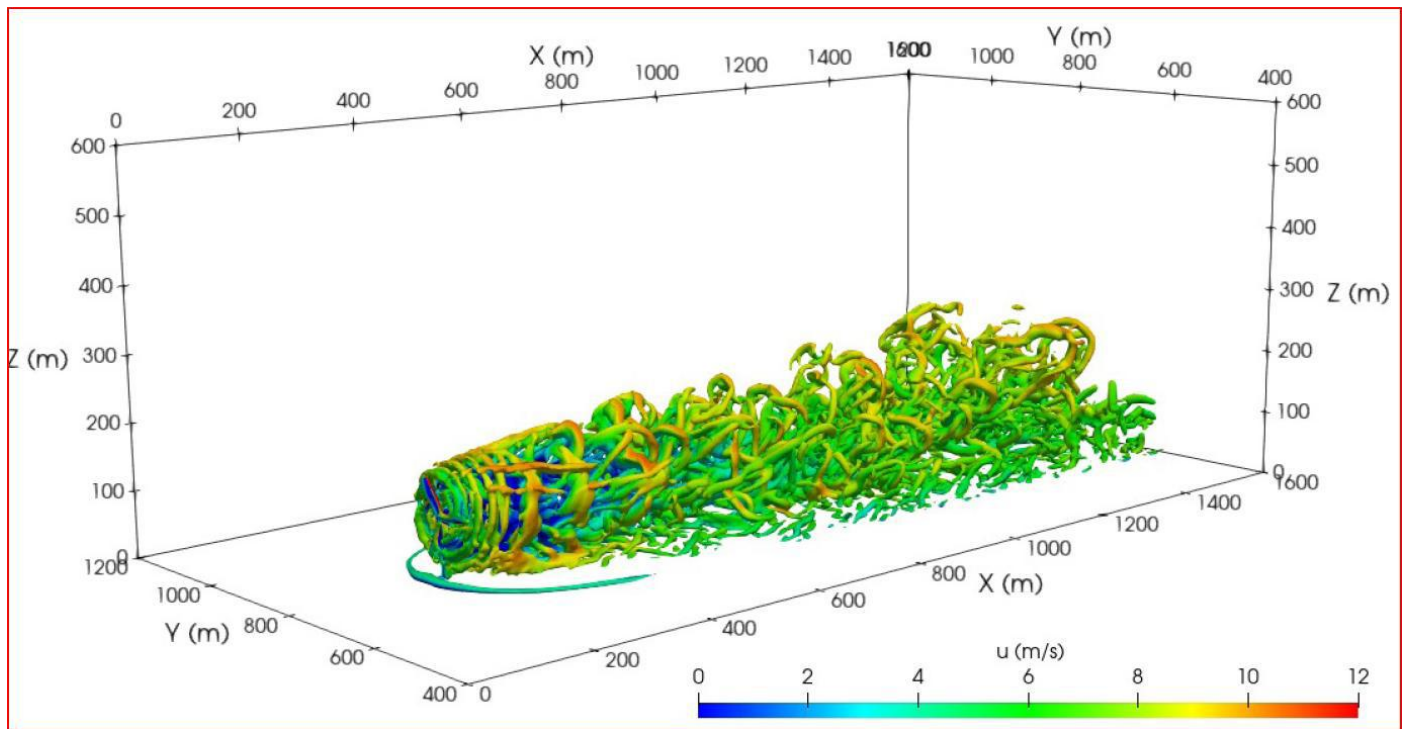
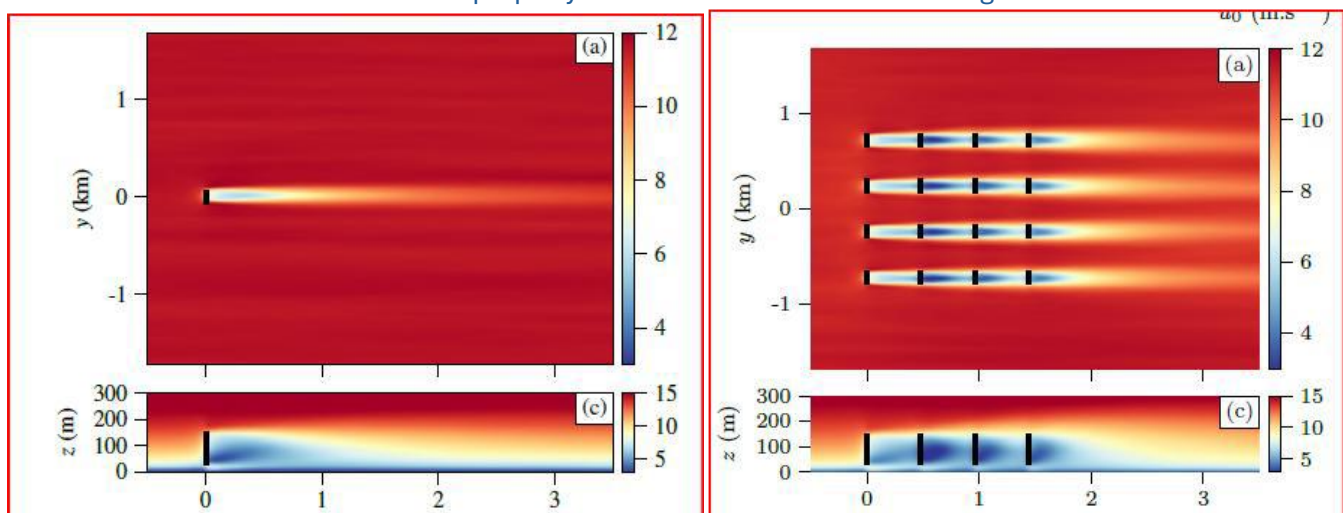
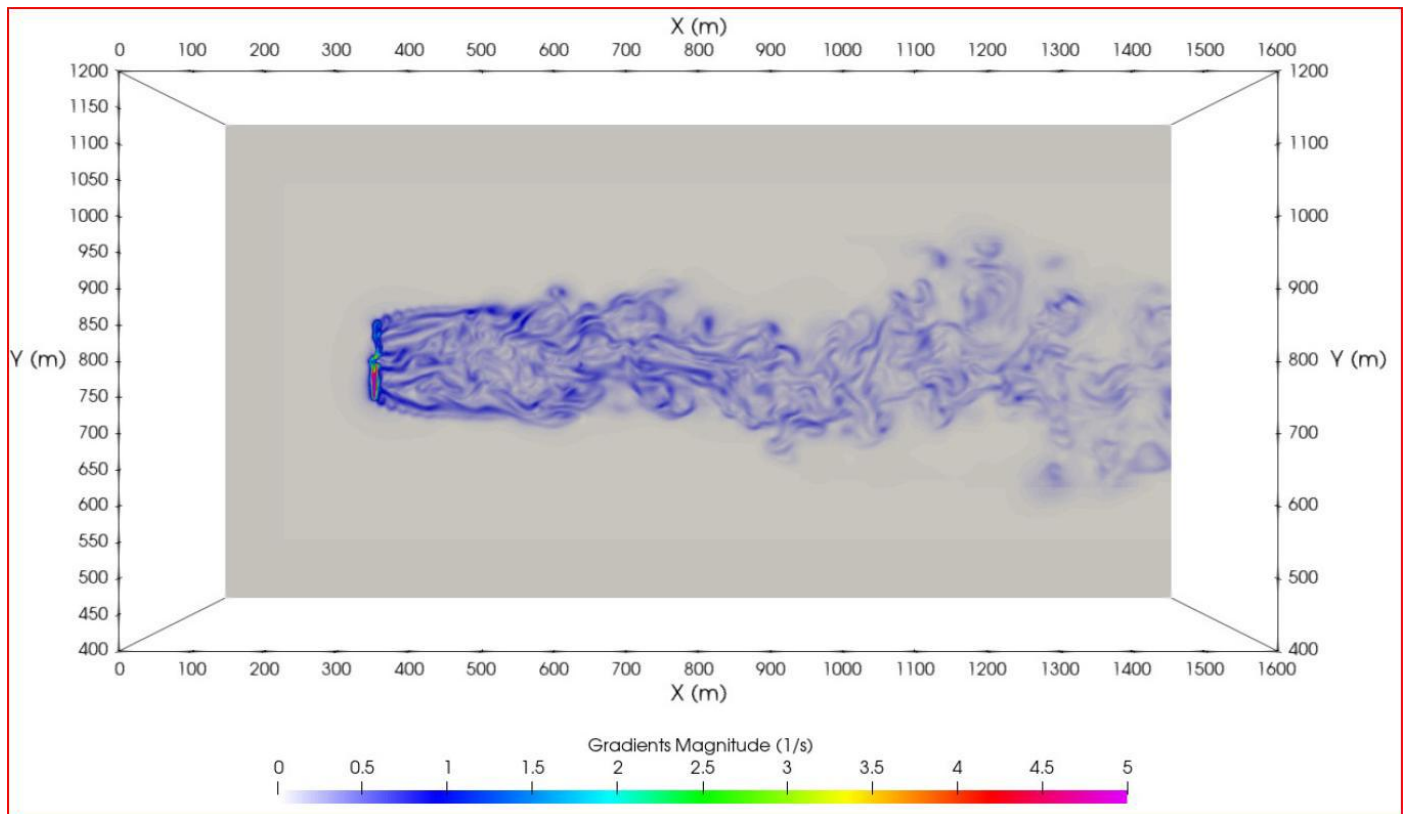


Fig. 3: Dynamic iso-surfaces of Q (Jeong & Hussain 1995), coloured by velocity around the wind turbine.

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? 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

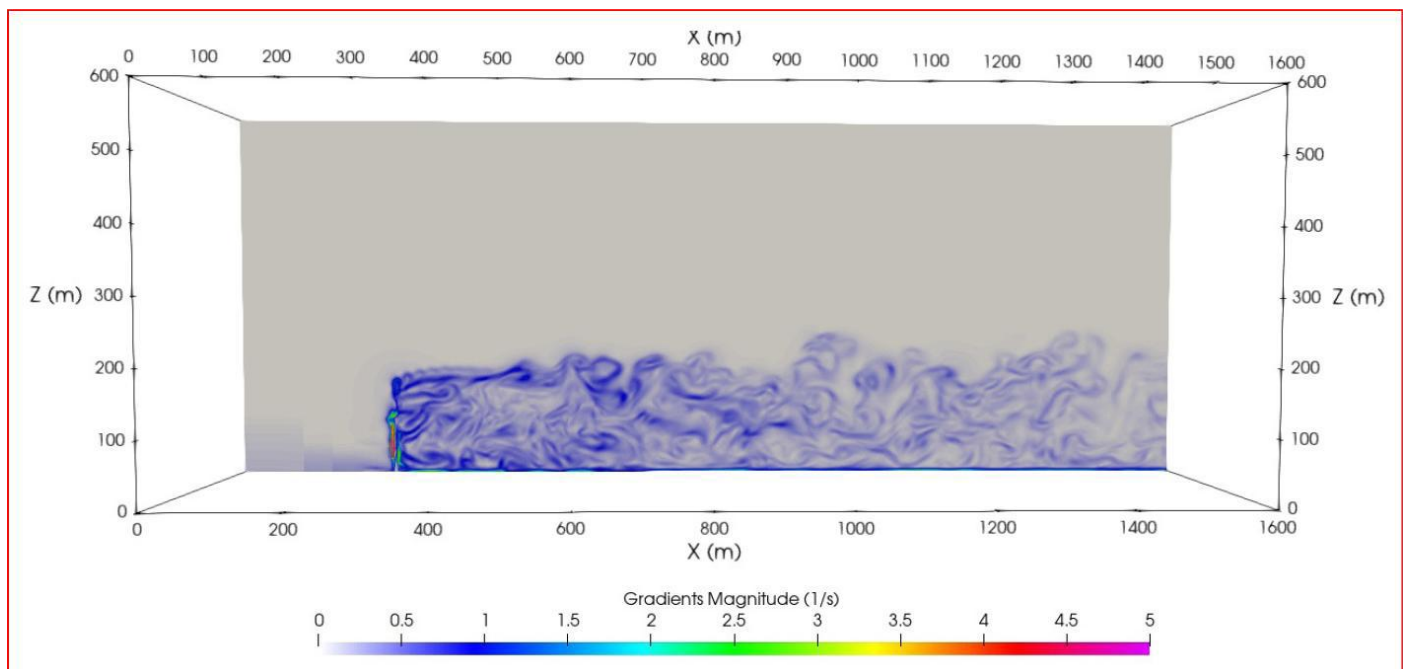


Fig. 6: Similar to Fig. 2: Vertical Contours of gradients of velocity of the overflow around the wind turbine.

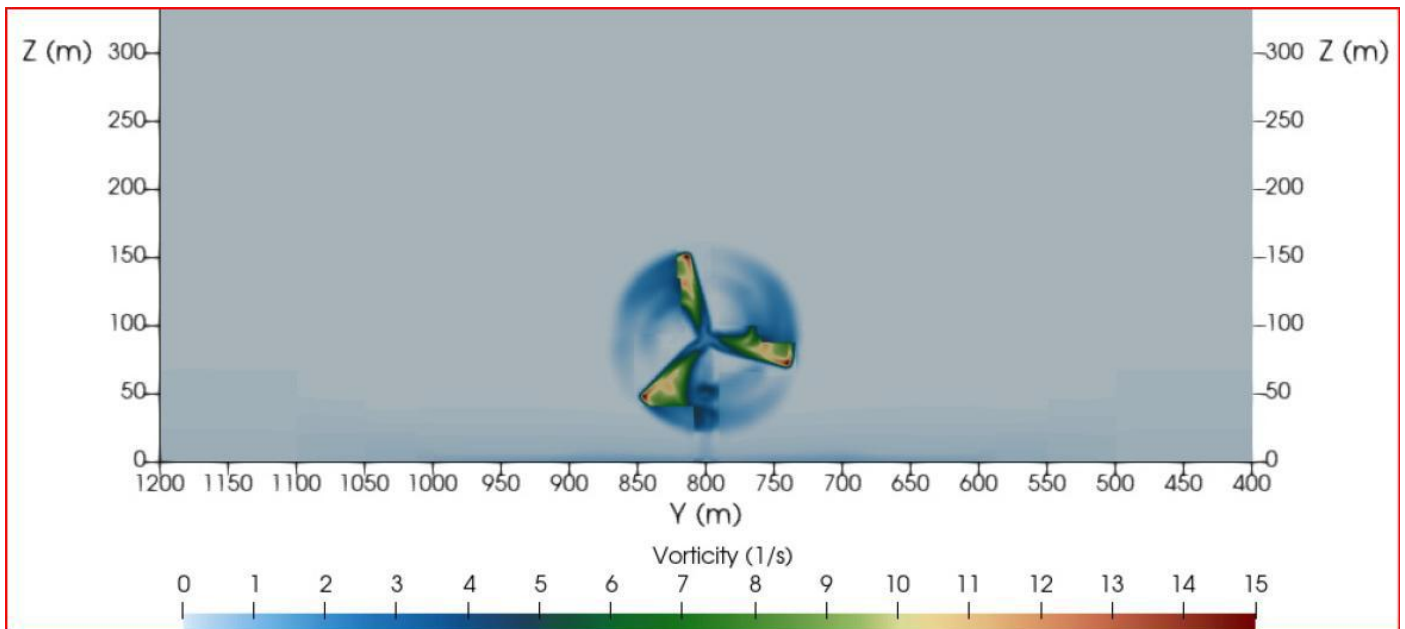


Fig. 7: Vectors of vorticity magnitude in the downstream position of the wind turbine. Insects are attracted to wind turbines & the bats follow the insects. The blade tip speed is c90metres per second. This is 324km/hr. In reality about 1.5 times the speed of a F1 motor racing car.

The 162m diameter would cover Croke Park from the outside of the Canal end to the outside of Hill 16.

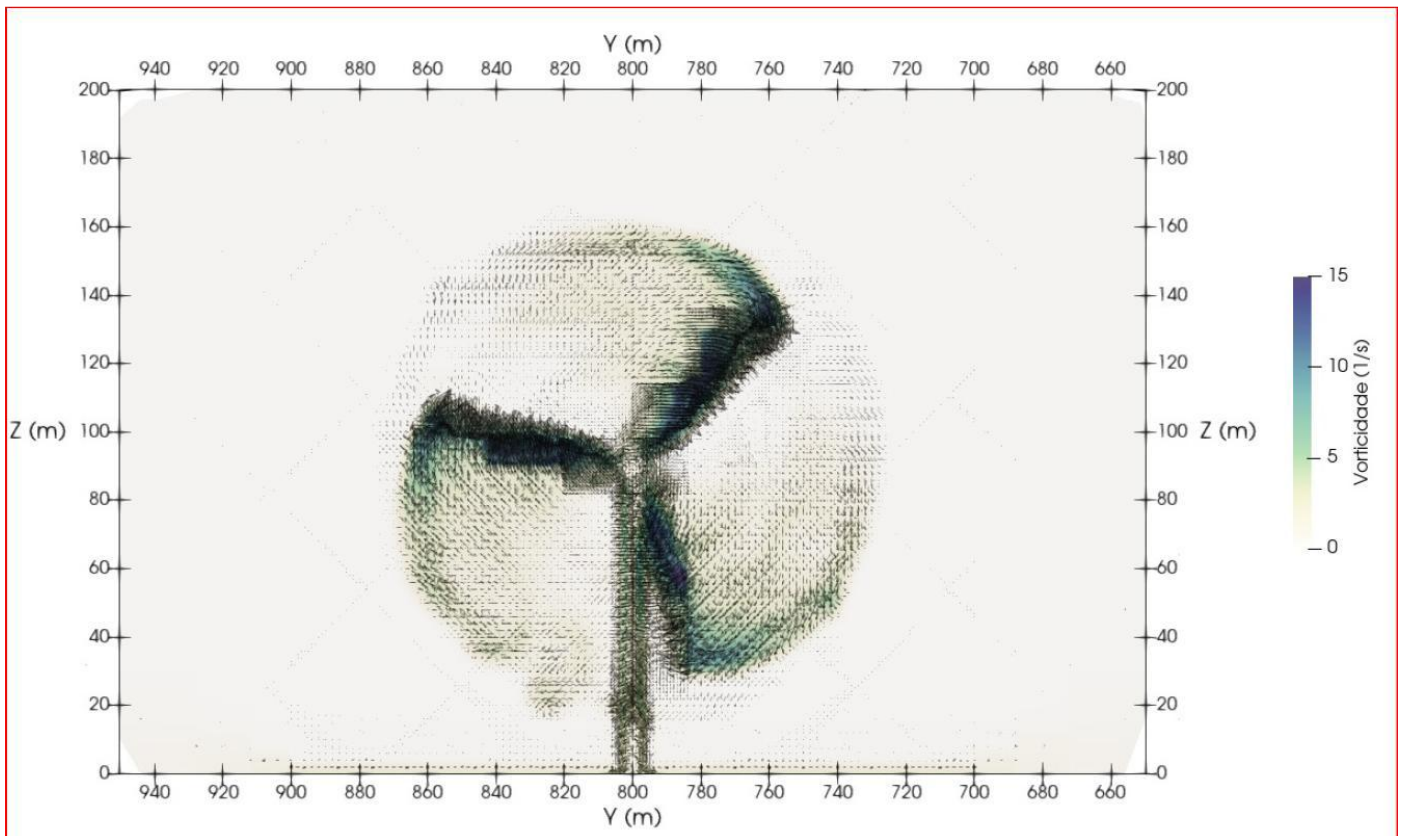


Fig. 7: Contours vorticity magnitude in the downstream position of the wind turbine

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 $f < 4 f_T$. 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>

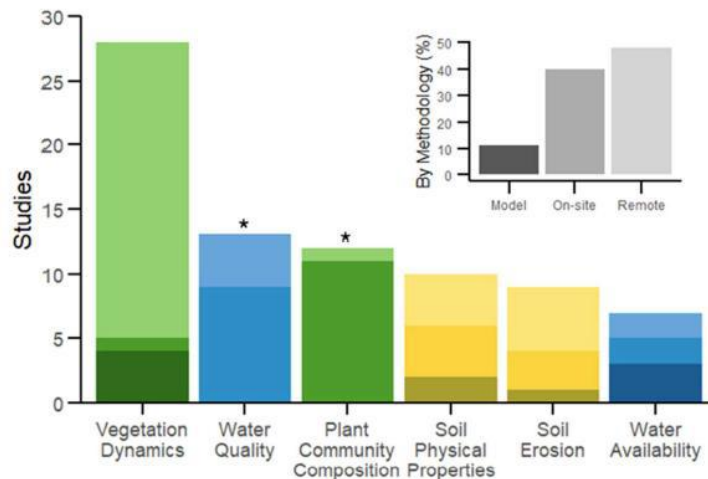


Figure 3. The number of empirical studies on the specific impacts of onshore wind energy on ecosystems. Each impact group is represented by a stack of bars, with different shades (dark, medium, and light) indicating the proportions of different methodologies used. The inset displays the overall proportions of methodologies used across all empirical studies ($N = 62$). * No model simulations were used in studies on water quality and plant community composition.

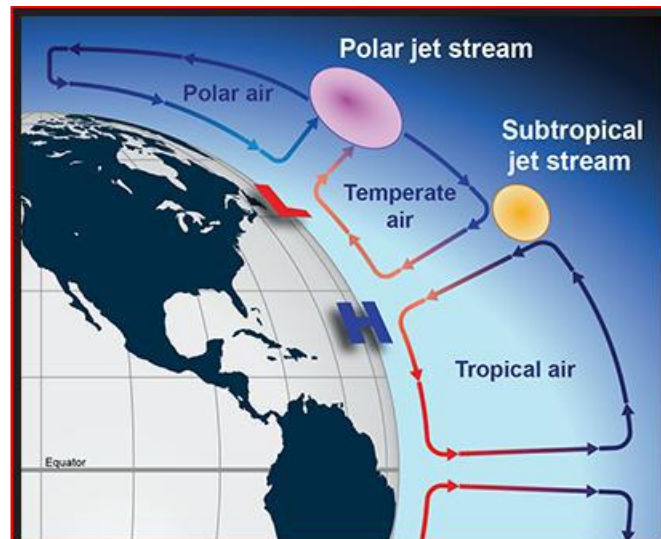
Reference 2022 : How far the wake of a wind farm can persist for? Guodan Dong, Zhaobin Li, Jianhua Qin, Xiaolei Yang. *Theoretical and Applied Mechanics Letters* 12 (2022) 100314.

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, $55D = 8.937\text{km}$ & $165D = 26.812\text{km}$. 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 m^2 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.

$$R_{wake}(x) = R_{rotor} + k_x (1)$$

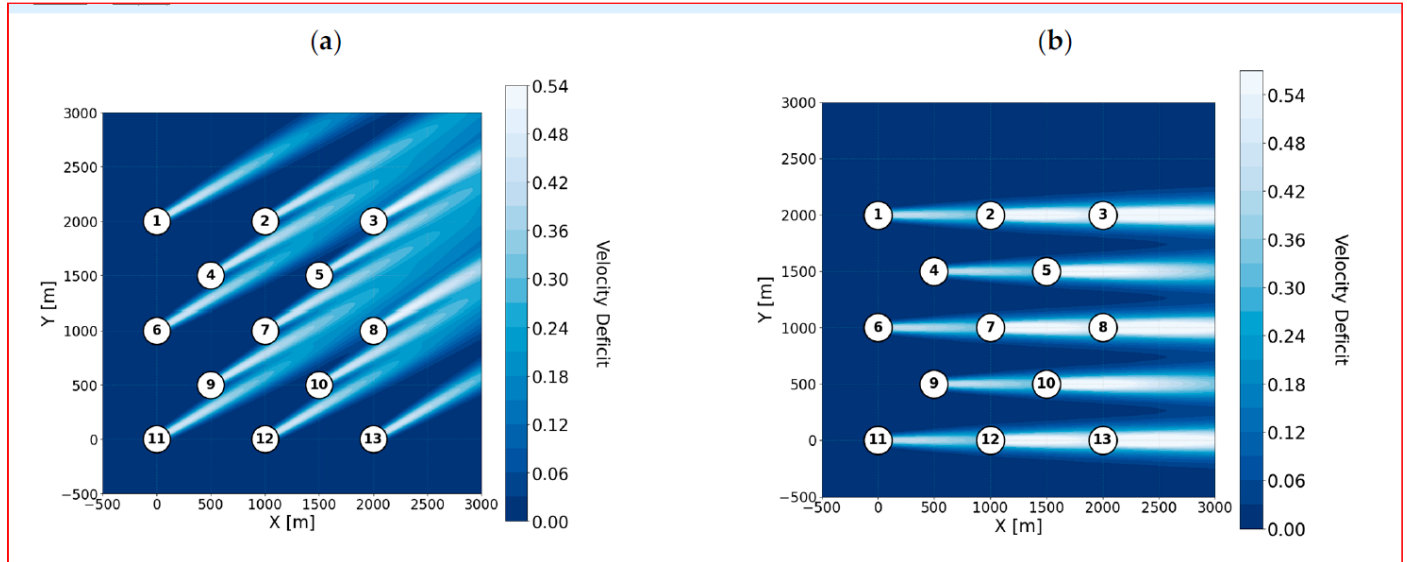


Figure 4. Wake expansion patterns for a chessboard-like turbine arrangement under different incoming wind directions: (a) 240° (south-westerly wind); (b) 180° (southerly wind).

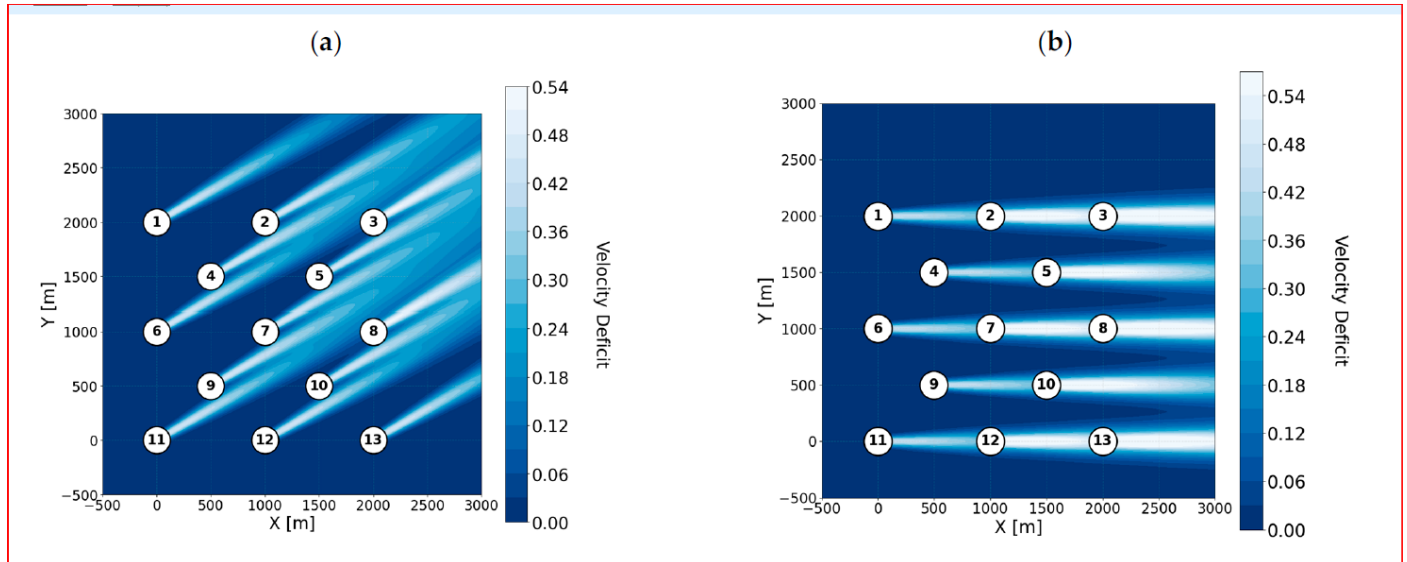


Figure 5. Wake expansion patterns for a linear turbine arrangement under different incoming wind directions: (a) 180° (southerly wind); (b) 240° (south-westerly wind).

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 $CT \approx 1$:

$$\frac{\Delta U}{U} = \left(\frac{D}{D + 2kx}\right)^2 \quad (3)$$

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	$\leq 20\%$	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 R.Alsenani, Ibrahim Mahariq, Hamed Zeinoddini-Meymand, Farhad Shahnia, Ezzeddine Touti. International Journal of Energy Research, 2026; 2026:9999516 . <https://doi.org/10.1155/er/9999516>. Wiley.

Assessment of structural design and operational performance characteristics of onshore

Onshore wind	Aspect
Peak voltage reaches 39.5 V at a wind velocity of 8.2 m/s.	Voltage output (simulated)
Surface roughness and obstacles introduce variability in wind speeds, while turbulence intensity remains lower than offshore.	Turbulence impact
Uses smaller turbines with simpler designs to enable easier installation and upkeep, generally at hub heights of ~100 m.	Turbine size
Lower and more variable, with average hub-height wind speeds of ~5–8 m/s.	Wind speed
Usually 30%–40%, with performance strongly dependent on site-specific wind conditions.	Capacity factor
Peak power attains 1.9 W under a wind velocity of 8.2 m/s.	Power output (simulated)
Turbines rated 2–4 MW produce comparatively lower energy output.	Energy output
Surface roughness and obstacles result in variable wind conditions, emphasizing the importance of optimal sitting.	Geographic challenges
Deployment potential is restricted by land-use constraints and community acceptance issues.	Scalability
Pronounced seasonal fluctuations demand comprehensive wind profiling and system optimization.	Seasonal variation
LCOE is roughly \$50 per megawatt-hour.	Levelized cost of energy (LCOE)

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

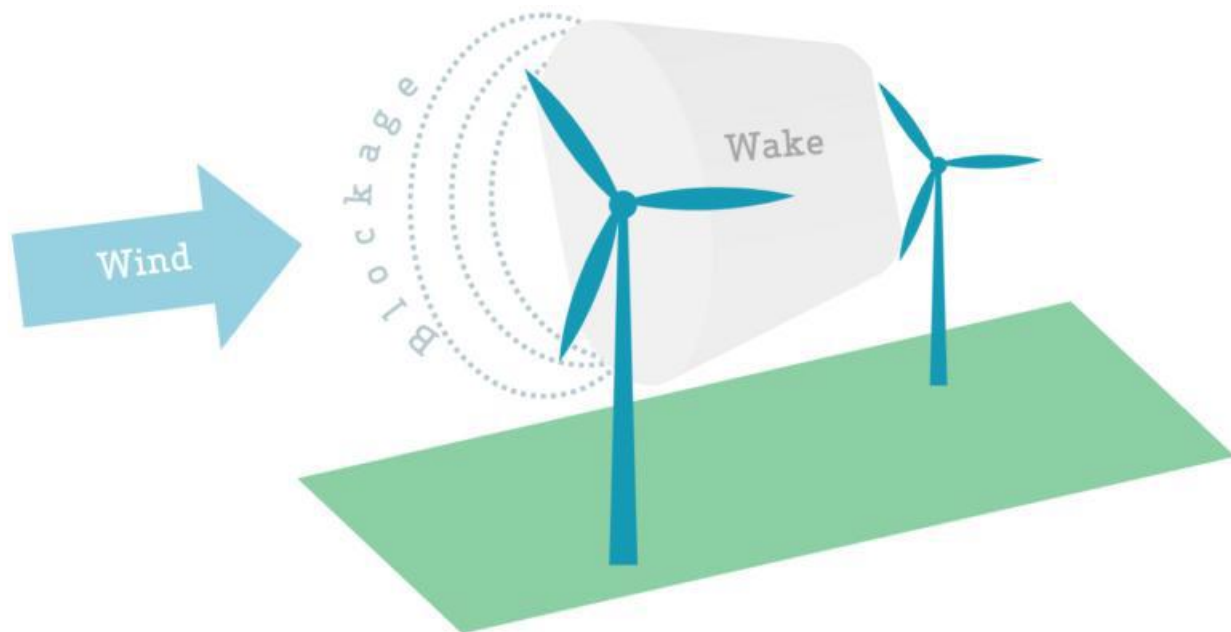
The wake effect refers to the phenomenon where wind turbines create a region of slower wind speeds and increased turbulence downstream from their rotor blades. As wind passes through a turbine, some of its kinetic energy is converted into mechanical energy for electricity generation, resulting in a reduction 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.

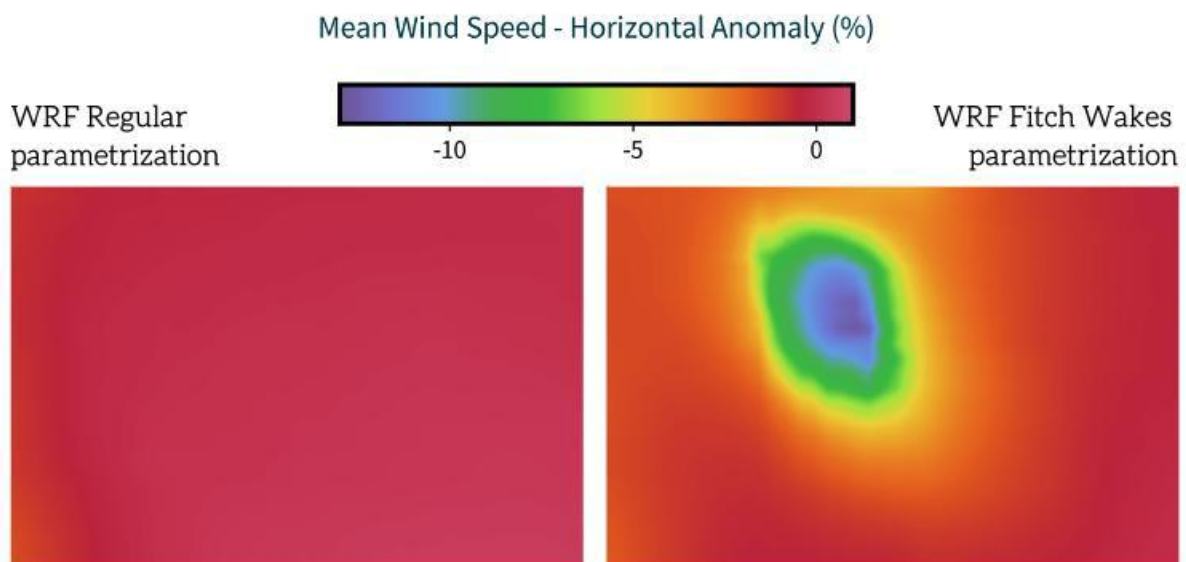


A scheme of the wake and blockage effect. The first turbine disrupts the airflow, so the second turbine will have a lower power output and more turbulence. The blockage produces a deceleration of the flow upstream of the turbine.

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

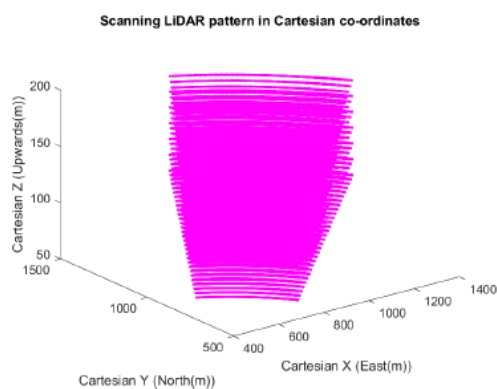


Figure A1: Scanning LiDAR pattern (Cartesian co-ordinates)

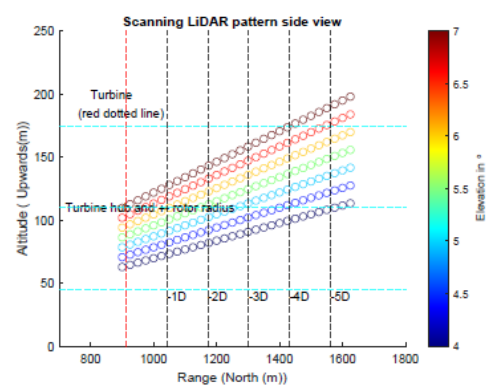


Figure A2: Scanning LiDAR pattern side view

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 background 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

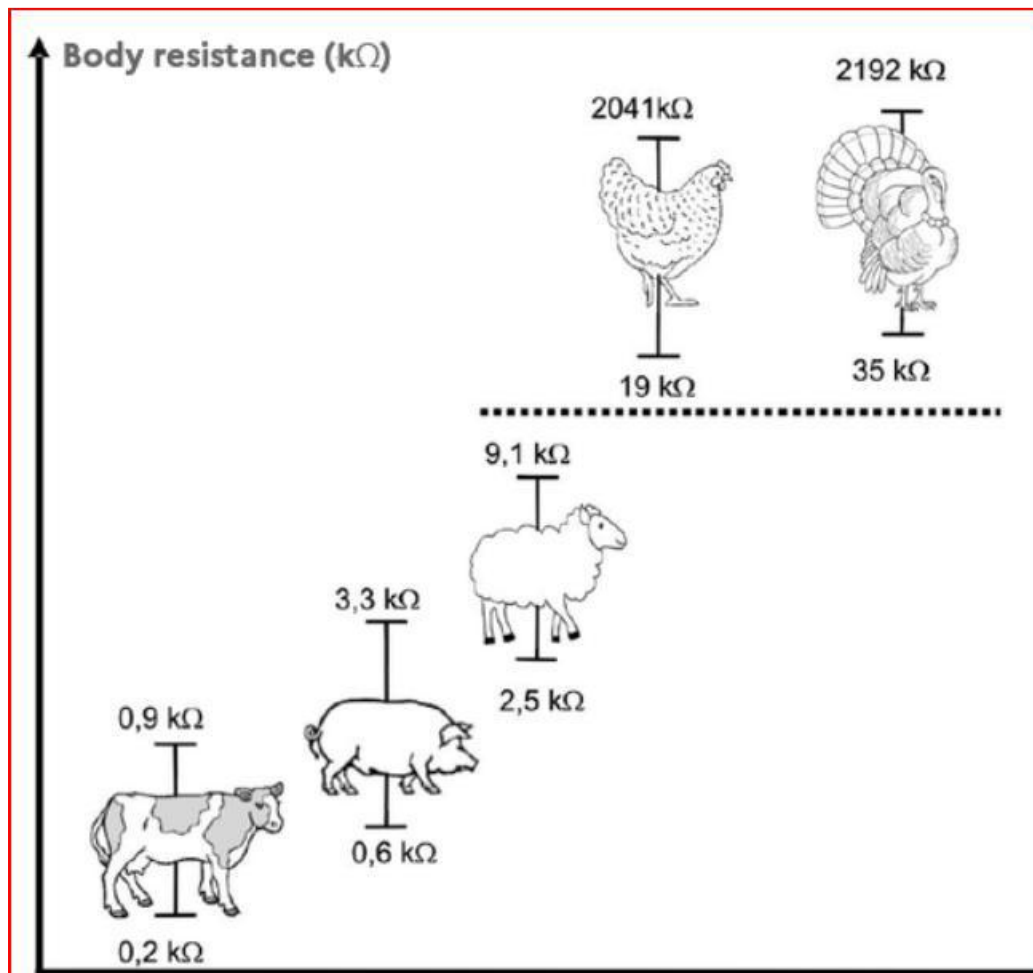
Studies conducted *in vitro* show a genotoxic effect (capacity to compromise the structure or the functioning of the genome) of electromagnetic fields. Moreover, these fields amplify the action of chemical products which have an effect on DNA. Cells submitted to electromagnetic fields are more sensitive 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) $\Rightarrow$ the current goes through the animal and back to earth through the legs.
- **Pace voltage** $\Rightarrow$ 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 hundred 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.² 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

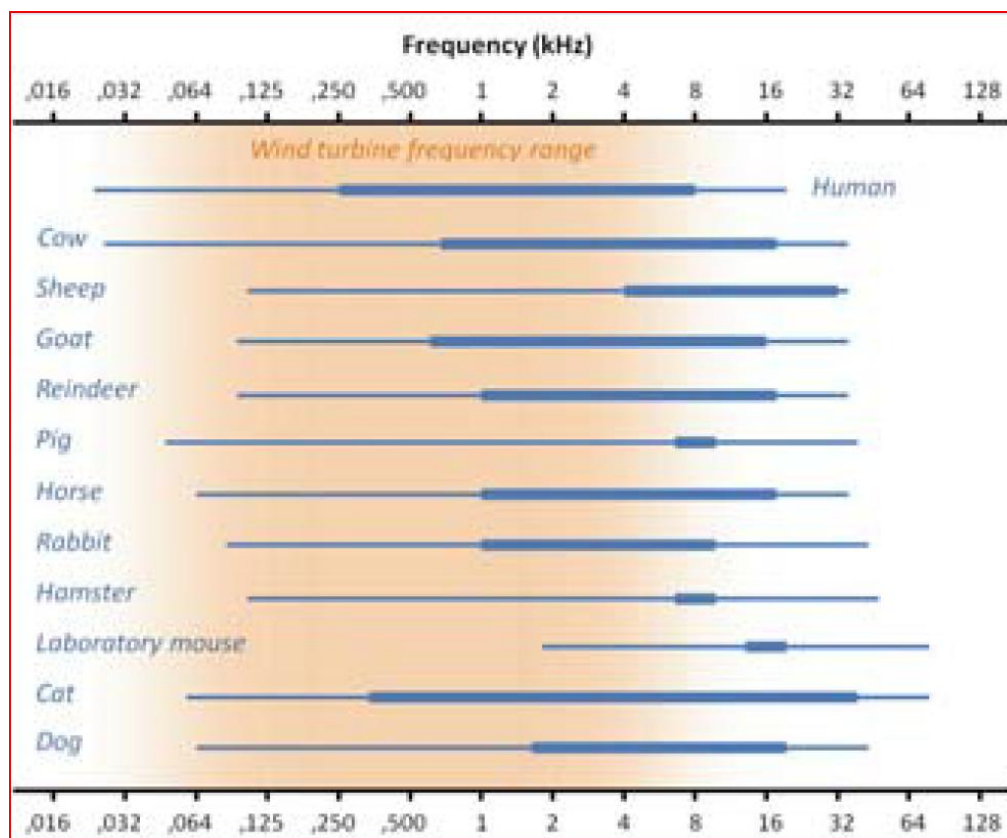
And German zoologists are raising the alarm that millions of bats are slaughtered each year because of these industrial wind projects..

Still, this article has merely grazed the scope of environmental harm these massive industrial wind 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 C18:3n-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 (C18:3n-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

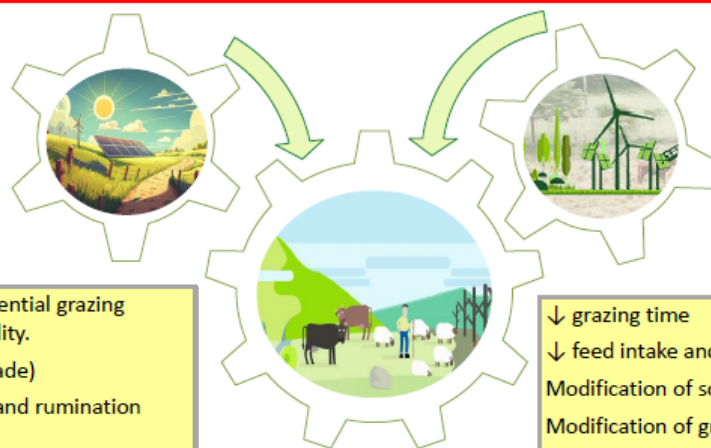
in habitat selection of areas in proximity of the WFs, in the same comparison. The results also revealed a shift in home range selection away from habitats where wind turbines became visible toward habitats where the wind turbines were obscured by topography (increase in use by 79% at 5 km). We interpret 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 stereotypes	

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.

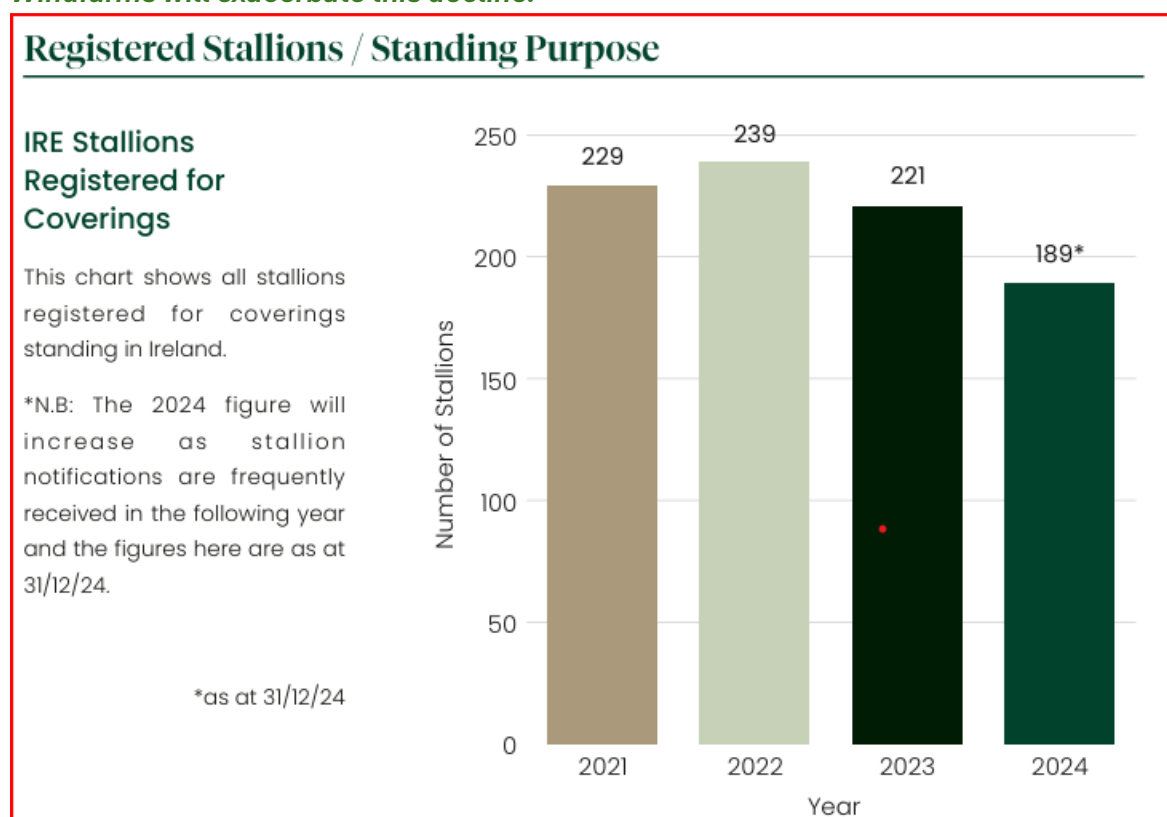
The UK's Secretary of State for Communities & Local Government acknowledged, in one of the reasons given for refusing permission for a proposed development of 9 wind turbines, that the proposed development would have a potential significant adverse impact on three nearby equine businesses (stud farms) 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."*

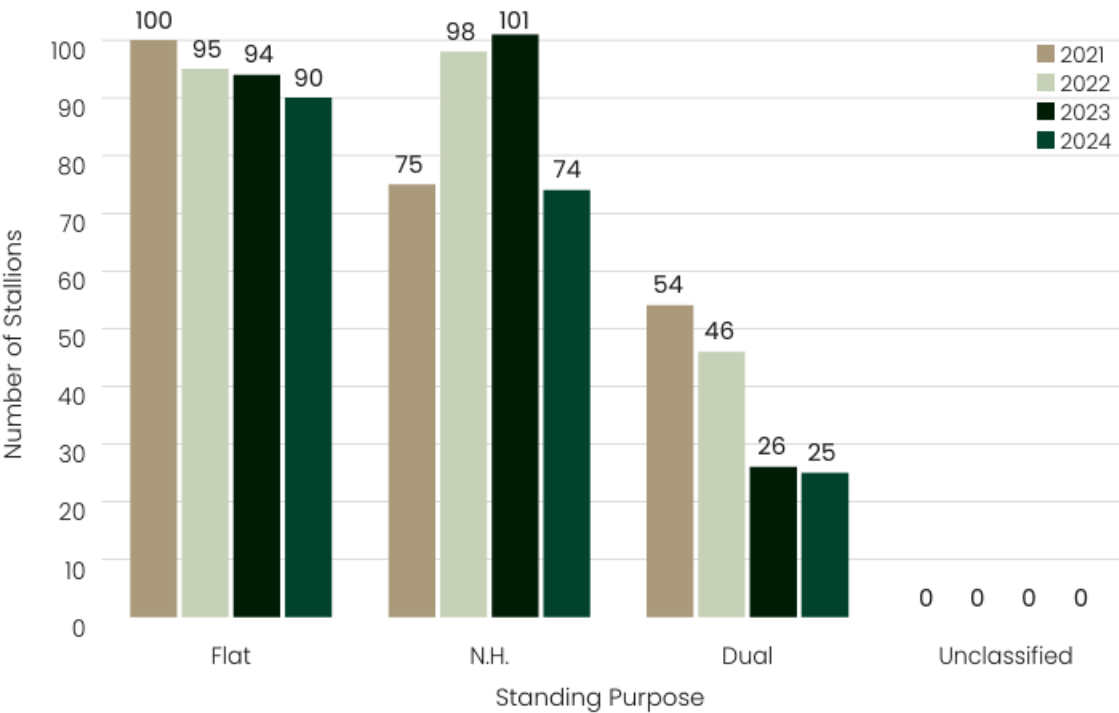
The Planning Inspector's report continued by stating that *"Whilst not every horse would be startled & as a result injures itself or its rider, some would. In my view this happening would exist over and above the normal risks these stables experience in dealing with this type of horse. These horses represent 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.



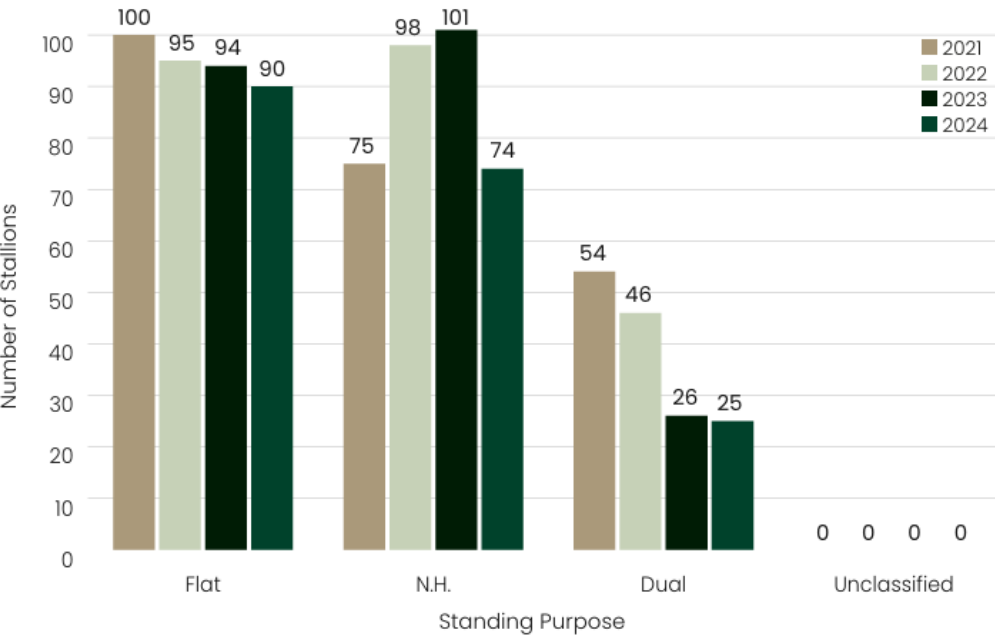
IRE Stallions Standing Purpose

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	County	Breeders	Mares	Foals
Co. Cork	810	1,611	1,021	Co. Armagh	46	68	33
Co. Tipperary	799	1,783	1,088	Co. Antrim	44	97	44
Co. Kildare	707	1,936	1,170	Co. Mayo	39	60	27
Co. Wexford	555	1,040	601	Co. Kerry	37	64	43
Co. Meath	440	1,033	575	Co. Louth	35	68	37
Co. Kilkenny	425	1,080	662	Co. Tyrone	33	53	25
Co. Waterford	254	609	340	Co. Longford	23	38	19
Co. Limerick	242	574	343	Co. Monaghan	22	28	16
Co. Galway	203	368	187	Co. Cavan	19	27	13
Co. Down	181	367	220	Co. Sligo	11	17	9
Co. Westmeath	180	713	479	Co. Fermanagh	9	15	6
Co. Wicklow	148	351	192	Co. Donegal	8	11	7
Co. Laois	145	251	138	Co. Leitrim	8	12	5
Co. Carlow	137	414	252	Co. Londonderry	8	20	8
Co. Offaly	117	289	165				
Co. Dublin	105	182	112	Sub Total	5,932	13,446	7,978
Co. Clare	82	152	82	Other	422	972	565
Co. Roscommon	60	115	59	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".

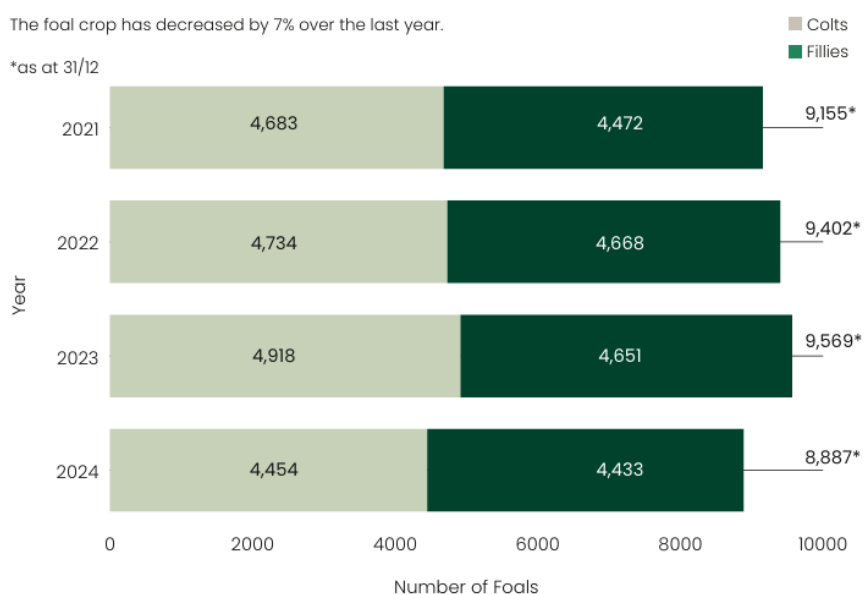
County	1-2	3-4	5-10	11-20	21-30	31+	Total
Co. Cork	669	84	46	7	3	1	810
Co. Tipperary	654	82	42	15	3	3	799
Co. Kildare	556	78	48	16	2	7	707
Co. Wexford	453	68	29	5	0	0	555
Co. Meath	352	48	32	4	2	2	440
Co. Kilkenny	339	47	26	10	1	2	425
Co. Waterford	201	31	16	2	1	3	254
Co. Limerick	193	28	14	5	0	2	242
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

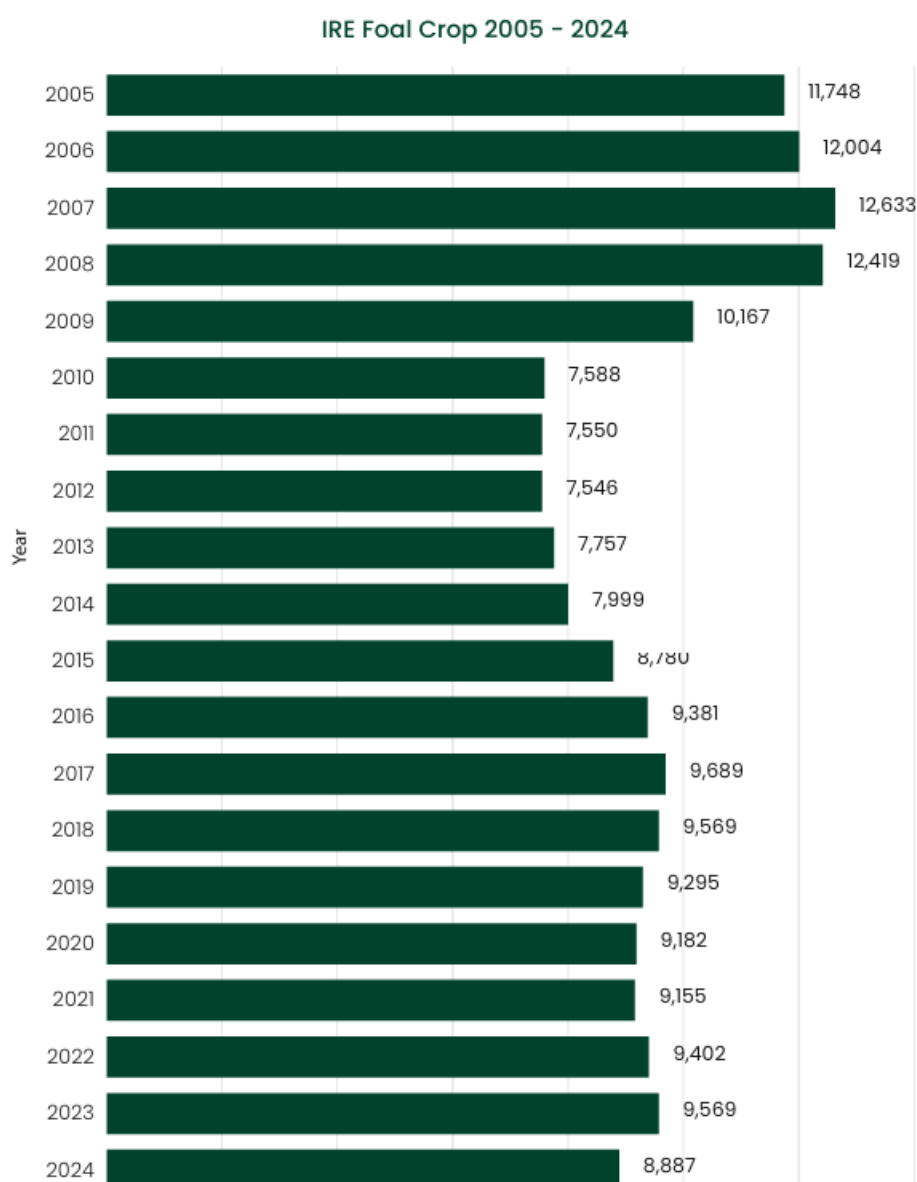
IRE Foals Born 2021-2024

The foal crop has decreased by 7% over the last year.

*as at 31/12



Historical Foal Crops



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 (Gronqvist, 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 Pleanála (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.”*

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Rates payments for the Proposed Wind Farm will contribute significant funds to GCC, which will be redirected to the provision of public services within Co. Galway. These services include provisions such as road upkeep, fire services, environmental protection, street lighting, footpath maintenance etc. along with other community and cultural support initiatives.

As stated in Section 4.9.3.3 of Chapter 4 of the EIAR, in the event that the Proposed Project is granted permission and is not developed under RESS, the Applicant is committed to paying the same amount as per the RESS commitment.

2.5.4 Human Health Impacts

Several third-party observations outlined concerns regarding potential impacts on members of the community with neurodiverse conditions and sensory sensitivities from the potential noise, infrasound and vibration as well as from road closures which would impact special needs bus services and the routes they travel. Other observations are concerned with possible impacts on sleep disturbance and the increased stress of living near wind turbines.

Response

A series of scientific papers relating to the potential impacts of wind turbines on human health are listed and links provided in Appendix 5-1 **Wind Farms & Health Literature Review – Chapman 2015**. A number of comprehensive reviews conducted in recent years to examine whether these health effects are proven has highlighted the lack of published and high-quality scientific evidence to support adverse effects of wind turbines on health. As discussed in Section 5.6 of Ch.5 of the EIAR, while there are anecdotal reports of negative health effects on people who live very close to wind turbines, peer reviewed research largely does not support these statements. There is currently no published credible scientific evidence to positively link wind turbines with adverse health effects. Extensive research has been carried out in the US, Canada, UK, Australia and by the World Health Organisation (2018). All studies conclude that that exposure to wind farms does not trigger adverse health effects.

Response from MLavelle: If that is the case, which we reject, then there can be no issue in erecting them in urban areas beside the energy demand locations i.e. Phoenix Park. Dublin Bay shoreline, & the various Parks around Dublin & National Parks as evidenced in the scientific report above from urban areas in India. Local Agenda 21 determines that production should be close to demand.

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.

Reference : 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 placebo 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 placebo 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 2 km 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 400 m to 1500 m. 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% (> 40 dB(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 -37.5 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.

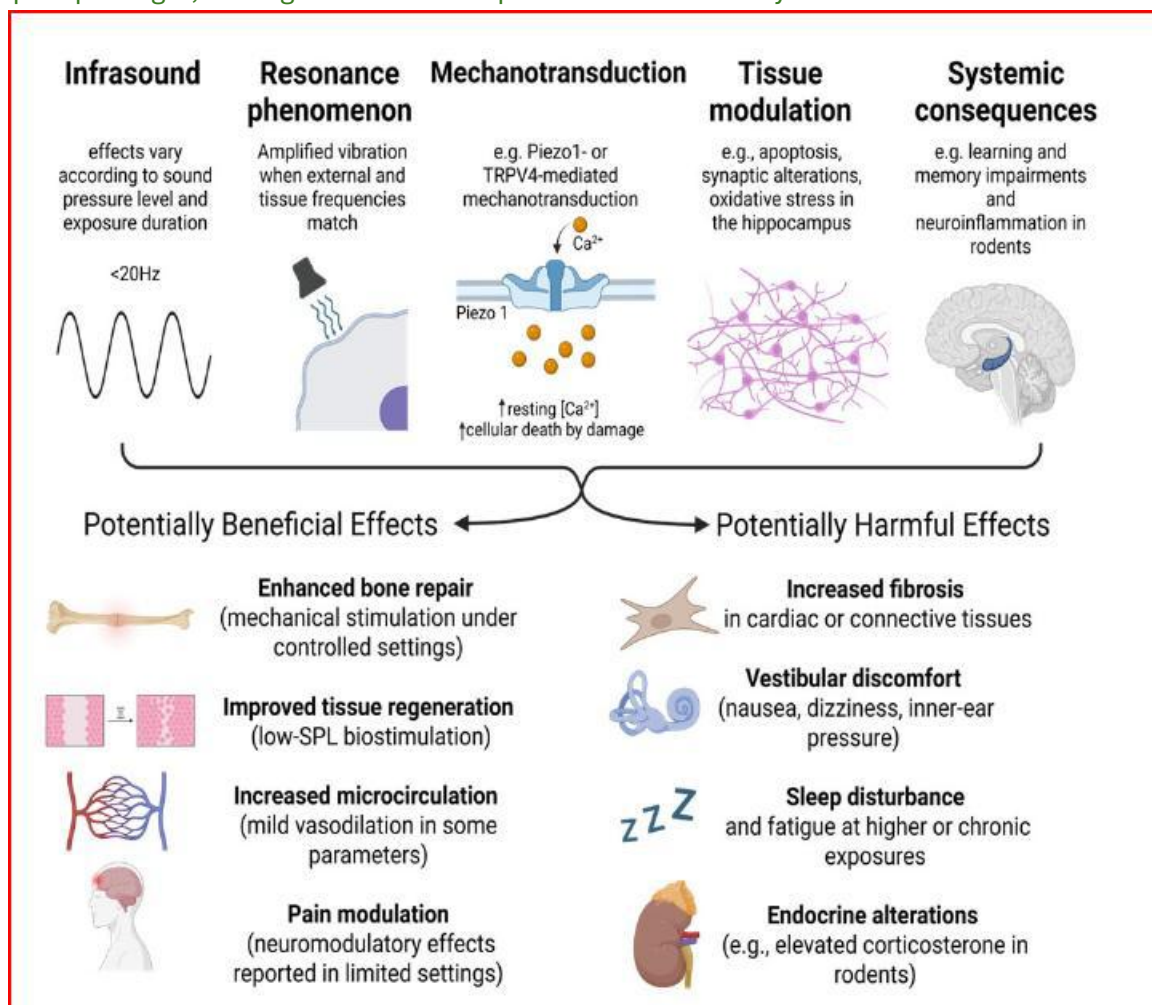
Nonetheless, there is evidence for acute vascular effects. Deng et al. reported that exposure to short-term low-frequency noise (70–100 Hz ≤ 85 dB) increased cutaneous blood flow in both humans and mice, mediated in part by nitric oxide. Although these frequencies extend slightly above the infrasonic 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 grinding), 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](https://www.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](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 2015 : On the apparent failure of silt fences to protect freshwater ecosystems from sedimentation: A call for improvements in science, technology, training and compliance monitoring S.J. Cooke, J.M. Chapman. J.C. Vermaire. Journal of Environmental Management 164 (2015) 67e73. <http://dx.doi.org/10.1016/j.jenvman.2015.08.033> 0301-4797/© 2015

In the face of development activities, regulatory bodies have enacted policies (see Mertes, 1989; Alsharif, 2010) in an attempt to reduce the input of sediment into aquatic systems given that it has been long (see Ellis, 1936) and widely accepted that such inputs are deleterious to environmental quality and aquatic biodiversity (e.g., Ryan, 1991; Wood and Armitage, 1997; Bilotta and Brazier, 2008; Chapman et al., 2014). Accompanying such policies is a suite of tools (or best practices) that are available to practitioners known as silt or sediment controls. By far the most common and visible is the silt fence (Kouwen, 1990). One doesn't have to venture far in developed countries to see them deployed adjacent to most construction activities that have the potential to mobilize sediment. **Although presumably used with good intentions, there is surprisingly little research that evaluates the effectiveness of silt fences and the factors that modulate success when properly installed and maintained.** What constitutes "proper" installation and maintenance is unclear, especially given regional- and site-level variation in precipitation, slope, soil characteristics, etc. We presented a candid critique of silt fences. Our goal was not to dismiss silt fences as a potentially useful tool. Instead, we question how they are being used and call for better science as well as better training for those that install, maintain and inspect such devices, as well as more rigorous compliance monitoring. From our perspective, the jury is still out regarding the effectiveness of silt fences with many opportunities (as we outlined here) to improve the science and practice of sediment control via silt fences. Quite simply, with insufficient literature/data to conduct a systematic review and meta-analysis on the utility of silt fences for protecting aquatic ecosystems from sedimentation, their widespread use is not consistent with an evidence-based approach to environmental management (Sutherland et al., 2004).

Reference 2019 : Structural vibration considerations for the design of onshore piled wind turbine foundations. N.R Featherston. Mott Macdonald Limited. 18th December 2019

Wind turbine structures are generally tall slender towers with a rotor and blade assembly placed at the top of the tower. These slender structures are prone to vibration due to dynamic environmental actions (such as wind

forces) as well as the structure's own dynamics (Bhattacharya & Adhikari, 2011). Analysis of the dynamic behaviour of wind turbines is fundamental to the stability, performance and operational safety of these structures. Wind turbine towers need to sustain continuous vibration-induced forces throughout their operational life (Satari and Hussain, 2008). Tower height is an important factor in the design of a wind turbine. The height of the tower is typically a compromise between the need to place the rotor as high as possible (thereby taking advantage of stronger winds), and the need to limit the height to accommodate structural foundation and constructability limitations

The operating frequency of the three-blade turbine can potentially cause dynamic amplification of the forces acting on it significantly enough to pose a threat to the overall structural integrity. Sufficient separation between the structural system natural frequency and the turbine operational frequencies is crucial to avoiding potentially catastrophic failures. The turbine operating frequency is typically lower than the structural system natural frequency, however it could approach it as higher turbine output is obtained.

Idealized assumptions of fixity at the base of the tower are generally un-conservative; a more realistic analysis accounting for the foundation flexibility yields lower estimates of the natural frequency for the system.

In these cases, soil-foundation-structure interaction modelling should be considered.

2 VIBRATION CONDITION CHECKS

There are usually two conditions that are checked for when designing a machine foundation (Chowdhury & Dasgupta, 2009):

- Resonance check
- Amplitude check

2.1 Resonance check

All machinery under operation usually induces a periodic dynamic load on the foundation and in most of the cases can be represented by a function like $P_0 \sin \omega_m t$, where P_0 = magnitude of the unbalanced force from the machine during its operation and ω_m = operating frequency of the machine usually expressed in radians/sec, Hertz or revolutions per minute (rpm).

Due to this induced dynamic load from the machinery, the pilecap foundation including some portion of the soil underlying the foundation is subjected to vibration and it is essential that the natural frequency (ω_n) of this vibration should be well away from the operating frequency of the turbine machinery i.e. the resonance condition should not prevail. Irrespective of any code the normal practise is to design the foundation in such a way that its operating frequency is at least 20% away from the natural frequency of the foundation.

2.2 Amplitude check

Under this condition, it is common to check that the amplitude of vibration of the pilecap foundation is well within the acceptable limits of engineering practise (and see Figure 3). The acceptable or the tolerable limits are usually suggested by the vendor supplying the equipment or in the absence of such data are usually obtained from the code requirements.

If the amplitude of vibration is more than this acceptable limit, it can erode the performance of the equipment in the following way:

- Rapid deterioration of the machinery due to heavy wear and tear.
- Excess amplitude of vibration, inducing fatigue in the coupling and the connecting shafts leading to repeated breakdowns.
- Increase in decibel level during operation causing discomfort to operators of the system.
- Accumulation of explosive gases which could be dangerous to human life and property.

Based on the above discussion it is mandatory that for foundations with dynamic load actions, the above two conditions are met.

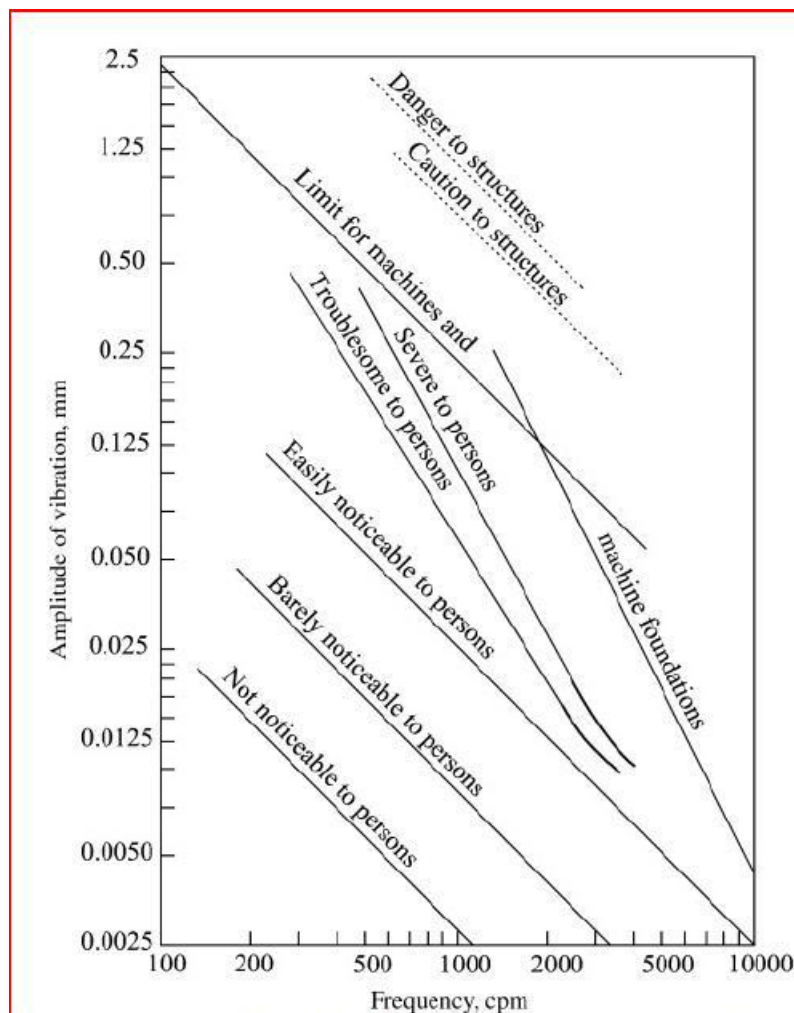


Figure 3 – Vertical amplitude vs frequency damage effects (Richart et al, 1970).

1)

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 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.

Response from MLavelle: The applicants statement that health issues are not relevant is clearly nonsense. This Report is included in Appendix.



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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.

Concerns have been raised regarding the ability for wind turbine noise to affect nearby residents with Autism Spectrum Disorder (ASD). It is acknowledged that people with ASD and other neurodivergences may experience a greater noise impact than non-neurodivergent individuals, as is discussed in literature from Howell et al. (2015). However, it should also be noted that recent studies, such as that of Li et al. (2023),

discussed that while a positive correlation was noted between fine Particulate Matter exposure and negative ASD symptoms (primarily due to roads and industry), no correlation between noise and negative ASD symptoms was noted.

It should be noted that this study considered noise from a mixed variety of sources, including roads, rail, air, industry and wind turbines, and solely considered noise impacts at dwellings and not workplaces and schools. Regardless, as highlighted in Section 12.4.1.4 of the EIAR, the Applicant proposes to appoint a community liaison officer who would be the first point of contact in the event that noise complaints were to occur and the mitigation strategy set out in Section 12.7 of the EIAR will be employed and that any complaints during the operational phase regarding wind turbine noise will be addressed promptly. Similarly, a suite of mitigation measures are provided in Section 5.10.3.2.7 to safeguard all sensitive receptors from Shadow flicker effects. Notwithstanding these mitigation measures, should shadow flicker associated with the permitted development be perceived to cause nuisance at any home, the affected homeowner is invited to engage with the Developer. The homeowner will be asked to log the date, time and duration of shadow flicker events occurring on at least five different days. The provided log will be compared with the predicted occurrence of shadow flicker at the residence, and if necessary, a field investigation will be carried out and mitigation measures will be discussed with the homeowners. If agreement can be reached with the homeowner, then it would be arranged for the required mitigation to be implemented in cooperation with the affected party as soon as practically possible and the full costs to be borne by the wind farm operator.

Regarding the potential impact to special needs bus services and their routes, it is acknowledged that the Proposed Project will cause some disruption to local road users particularly during the construction phase of the Proposed Grid Connection. A precautionary scenario where a road closure will be required for the entire route is assumed for the purpose of the assessment. Road closures for 8 sections, amounting to 7.8km, of the public road network has been assessed. The potential diversion routes that may be used during the construction of the various sections of the grid route that are on the public road network are set out in Table 15-27 and shown in Figure 15-6b in Chapter 15 of the EIAR. For sections 3, 4, 5, 6 and 8, which comprises of 7.8 km of the total route, the diversions will result in low volumes of existing traffic on local roads being diverted onto other local roads, or onto roads of a higher standard, including the N63, R332 and the R347. For Sections 1 on the R332, 2 on the N63 and 7 on the R347, this will either result in traffic volumes on these roads being diverted onto some sections of lower standard local roads (shown in orange in Figure 15-6b), or via longer diversions onto roads of a similar standard (shown in red in Figure 15-6b). Prior to the construction of the Proposed Grid Connection, the final diversion routes that will be used during the construction of the various sections of the cabling route will be discussed and agreed with GCC.

[Response from MLavelle: No structural assessment of existing roads, bridges, culvert crossings, watermains, sewers, broadband or existing ducting was provided as part of the application. Ground Penetrating Radar surveys should have been included in addition to Falling-Weight Deflectometer readings.](#)

It should be noted that the Proposed Wind Farm complies with the Draft Revised Wind Energy Guidelines 2019 (referred to as the draft Guidelines) of a 4x tip height set back from the nearest non-involved Sensitive Property in order to protect for visual amenity. It should also be noted that in relation to noise and shadow flicker, turbine technology allows for the turbines to be controlled to achieve the necessary guideline limits, including any revised guidance requirements. Concern has also been raised for depopulation in the area due to the Proposed Wind Farm.

[Response from MLavelle: Locating any house close to a potential health risk is criminal. Irrespective of involved or non-involved status, nobody should be put at risk of ill health. Who picks up the medical costs into the future?](#)

There has been no credible evidence provided that has shown a positive correlation between Wind Farms and rural depopulation.

[Response from MLavelle: Windfarm companies are objecting to planning applications from neighbouring families. Such objections lead to rural depopulation.](#)

No peer reviewed studies have proved a link between wind farm sites and depopulation.

Response from MLavelle: It is up to the applicant to produce peer reviewed studies to show that rural depopulation is not an issue.

Concern has been raised in regard to the health impacts of electromagnetic fields. It should be noted that there has been no credible evidence that electromagnetic fields can impact human health, with a study by McCallum et al. (2014), stating that magnetic field levels in the vicinity of wind turbines were lower than levels produced by common household electrical devices. None of the submissions received in relation to this topic area have set out any clear and credible evidence which in any way alters the findings of the EIAR in this regard. As such, it is concluded that the information contained within the EIAR remains valid and robust.

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

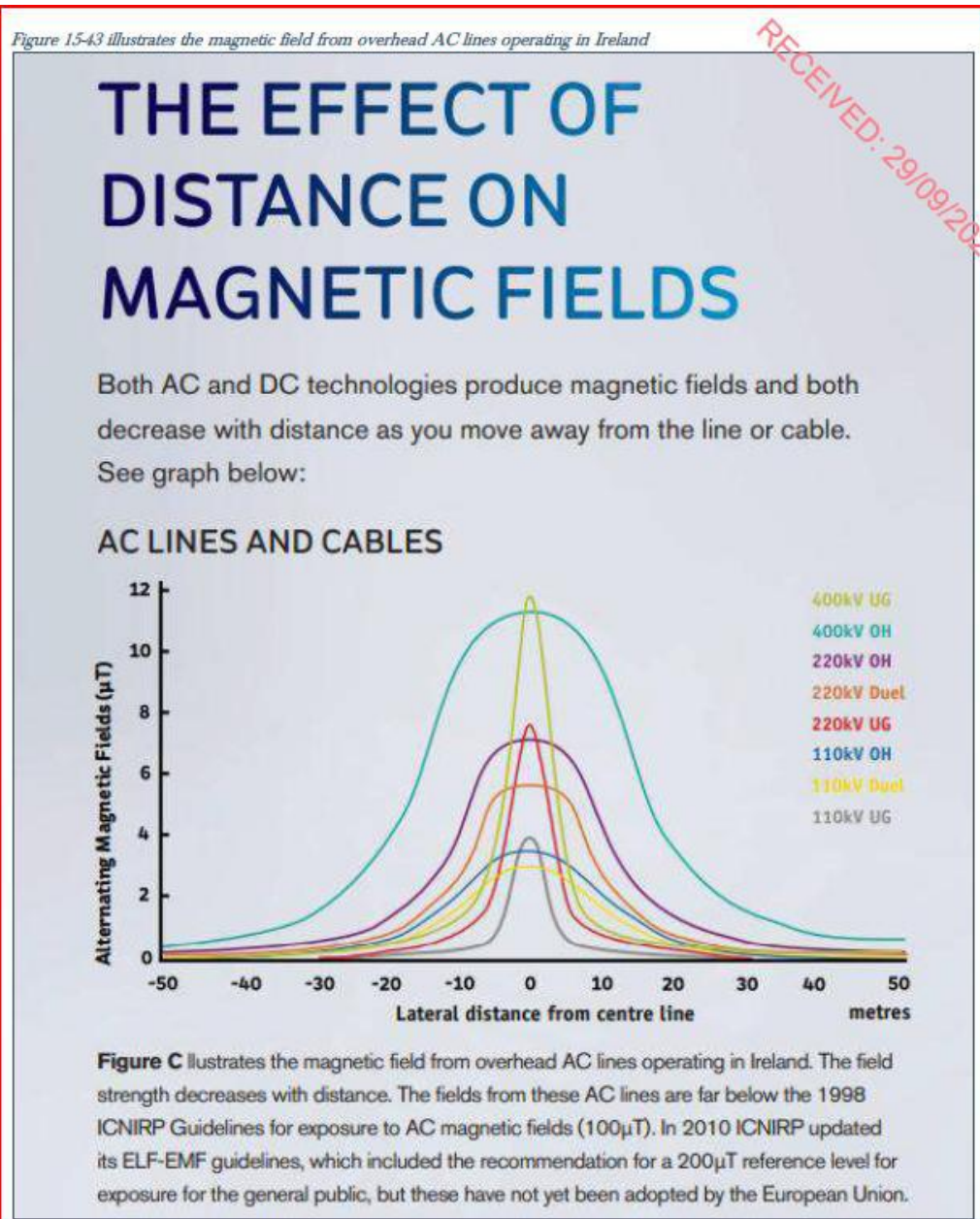
Setback distances from an asset to a residence vary across states. For example, prior to 2011 there were no setback distances for wind turbines in Victoria. The current setback distance is 1km.

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.



Response from MLavelle: The issue of Electromagnetic radiation is “scientifically uncertain” as stated above & thus the Precautionary Principle applies.

2.6 Biodiversity

A number of Third- Party submissions were made in relation to biodiversity, the European Union Habitats Directive, and general ecology related matters.

The content of these submissions was mainly focused on the potential for collision risk with bird species using the site, the bird survey methodologies employed, the risk to bat populations using the site including Lesser Horseshoe Bat, the loss of hedgerow, the protection of Annex I habitats and rare flora.

In addition, the potential for impacts to other protected wildlife were raised. Concerns regarding deficiencies in the Appropriate Assessment reports were raised in relation to the assessment of impacts on SCI species of Lough Corrib SPA. Submissions were also made regarding the cumulative assessment carried out in the EIAR and NIS.

Amongst the aspects raised with regards to ecology and biodiversity, these included:

Habitats

- Loss of Peatland Habitats
- Treelines, Hedgerows, Forestry

Fauna

- Marsh Fritillary
- Badger
- Pine Marten and Red Squirrel
- Earthworm
- Amphibians

Bats

- Legal Protection of Bats and Article 12 Compliance
- Survey Methodology and Monitoring Standards
- Impact Pathways: Collision Risk and Barotrauma
- Mitigation and Operational Controls
- Site-specific Bat Connectivity: Elmhill House & T8

Ornithology

- Survey Approach
- Assessment Approach
- Mitigation and Post-consent monitoring
- Species-specific Concerns

2.6.1 Habitats

Loss of Peatland Habitats

Several third-party submissions raised concerns regarding the impact on virgin bog, peatland and habitats which support Annex II species such as Marsh Fritillary. In particular, the proposed floating road between T7 and T9 is mentioned as a piece of infrastructure which impact the receiving environment through the excavation of peat and the hydrological regime of the area.

As outlined in Section 6.4.1.3, all margins of the mapped Article 17 Raised Bog habitat have been cut since at least the mid-1990s as evidenced from historic aerial imagery, with turbary cutting ongoing in a large part of the mapped Article 17 habitat area, as well as drainage throughout the habitat area. The entire high bog area is surrounded by either historical or active peat extraction, with small pockets of uncut areas that have not been

drained, however this area is not considered an intact raised bog habitat due to the extensive extraction and drainage that has been ongoing within this area.

The peatland habitats identified within the Proposed Project have been described in full in sections 6.4.1.3 (6.4.1.3.2 and 6.4.1.3.1). The existing drainage activities has also been detailed in Section 9.3.1 of Chapter 9 of this EIAR. Detailed relevés were taken along the proposed new floating access road, which are fully detailed within Appendix 6-1 (Section 3.3) of this EIAR.

The potential for significant effects on these habitats has been assessed within Section 6.5.2.1.2 of the EIAR. Mitigation provided includes alteration of surface water hydrochemistry (mitigation by design), mitigation to prevent significant effects via air quality impacts and dust emissions. It is concluded within the EIAR that with all mitigation measures prescribed in Section 6.5.2.1.2, there will be no residual significant impacts on peatland habitats adjacent to the development footprint. However, it has been concluded that there is potential for significant residual effects peatland habitats at a County level.

Additionally, there will also be a residual effect in relation to the alteration of drainage within approx. 50-100m distance of the proposed turbine T7 to T9 access road. Residual significant effects are anticipated at the County level.

The total area of habitat identified as raised bog (PB1) within the site boundary is approximately 32.29ha, while the identified cutover bog habitat areas are approximately 42.00ha. The proposed floating access road between T7 and T9 will result in the loss of approximately 0.18ha of raised bog (PB1), amounting to 0.54% of the total habitat area within the site. While this is still considered a significant residual effect due to the mapped Article 17 habitat within the location, the area to be lost is relatively small in comparison to the larger raised bog habitat area within the site boundaries. Figure 6-3 of Chapter 6 of the submitted EIAR is shown below and shows the Article 17 Habitats in proximity to the Site. It is noted that this figure is not included in the digital copy of Chapter 6 but is included in the hard copy of the EIAR, which is publicly available at the offices of both the Commission and GCC.

The figure is a visual representation of the information included in Chapter 6, Section 6.3.1.3, of the submitted EIAR and does not present any new or additional information.

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 microtopography 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

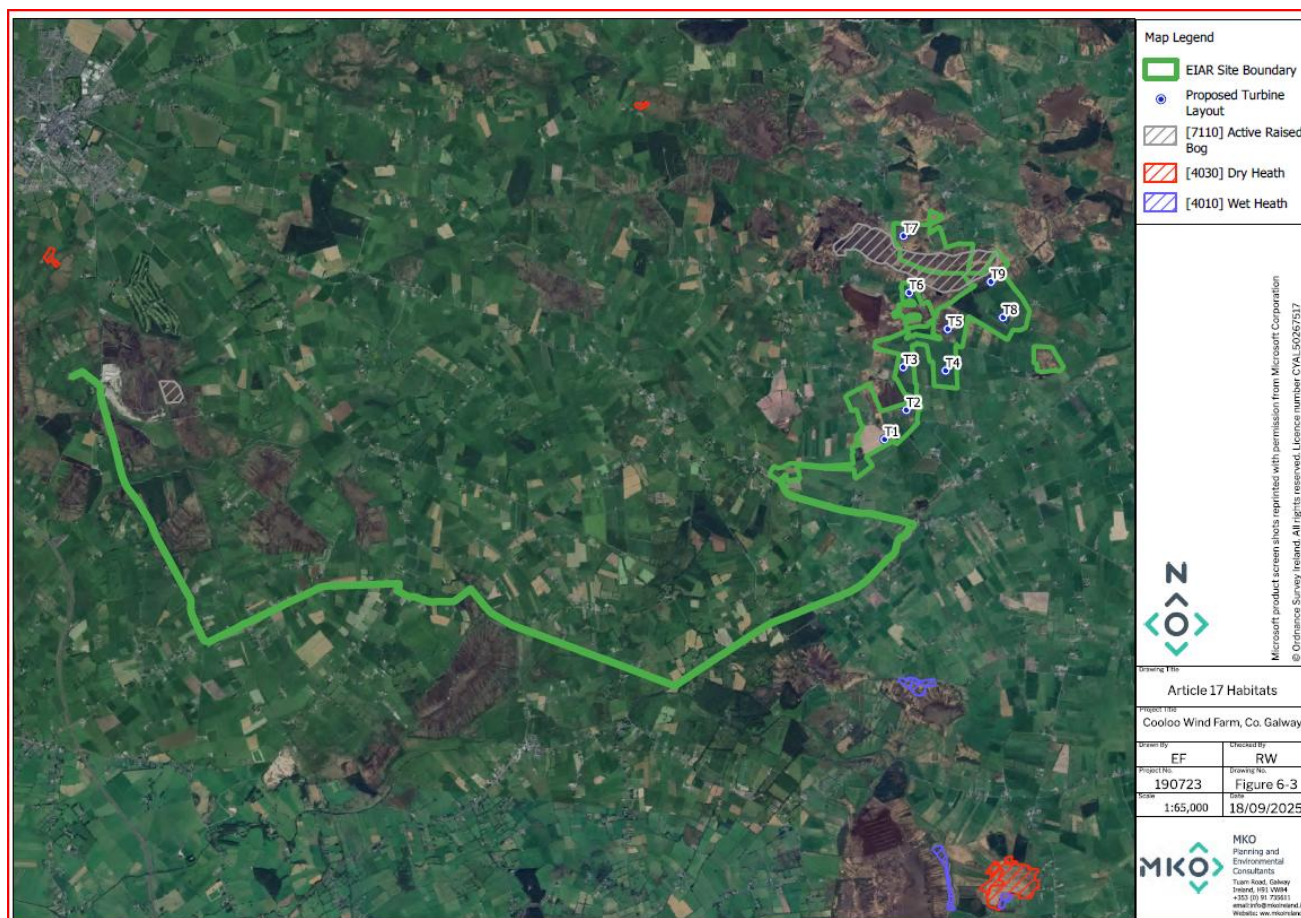
The majority of studies (41 studies) focused exclusively on impacts, while fewer considered the subsequent need for mitigation (24 studies) or restoration (23 studies). This was especially apparent in empirical research, where more than half of the studies (35 out of 62 studies) focused exclusively on 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.



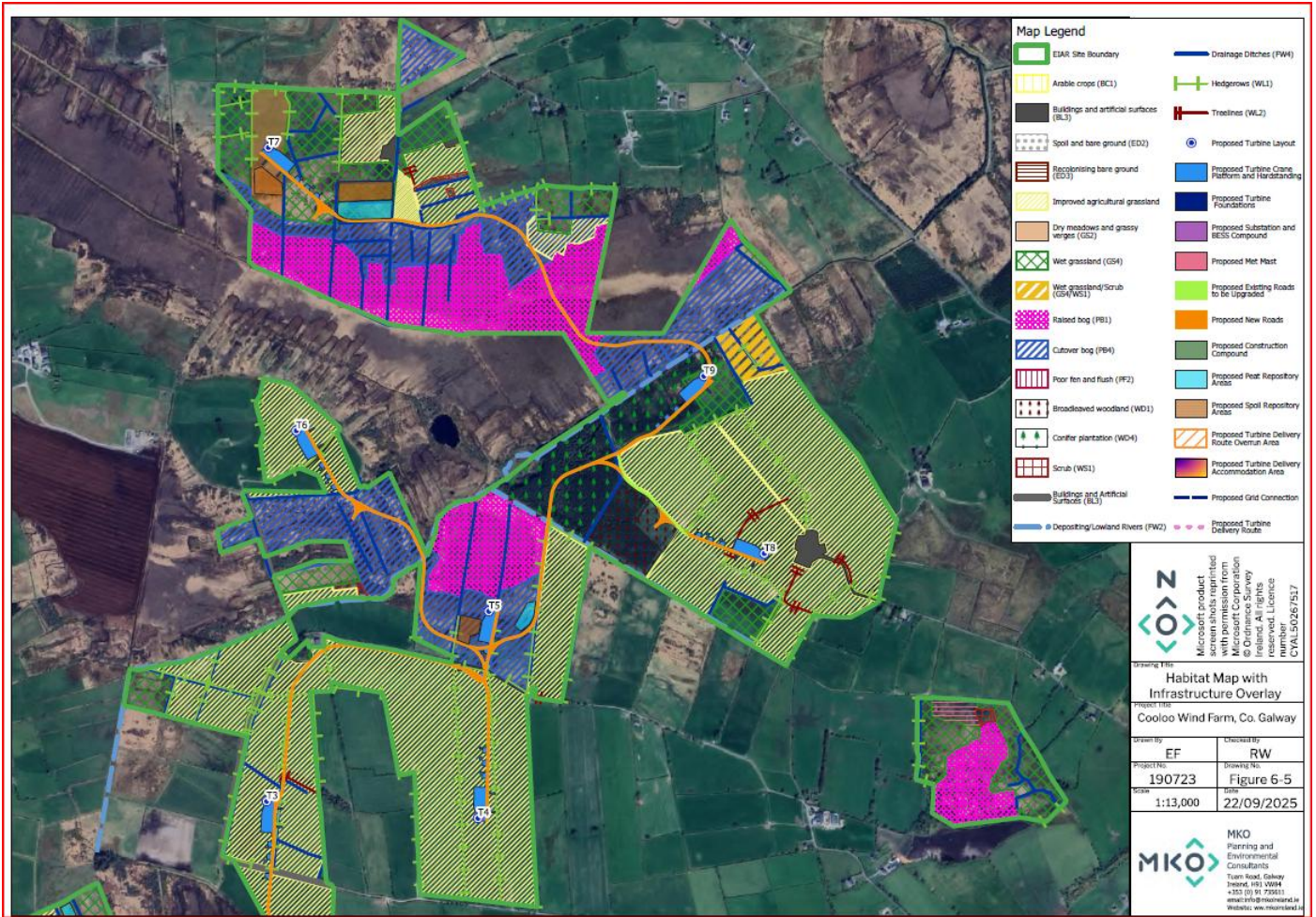
Treelines, Hedgerows, Forestry

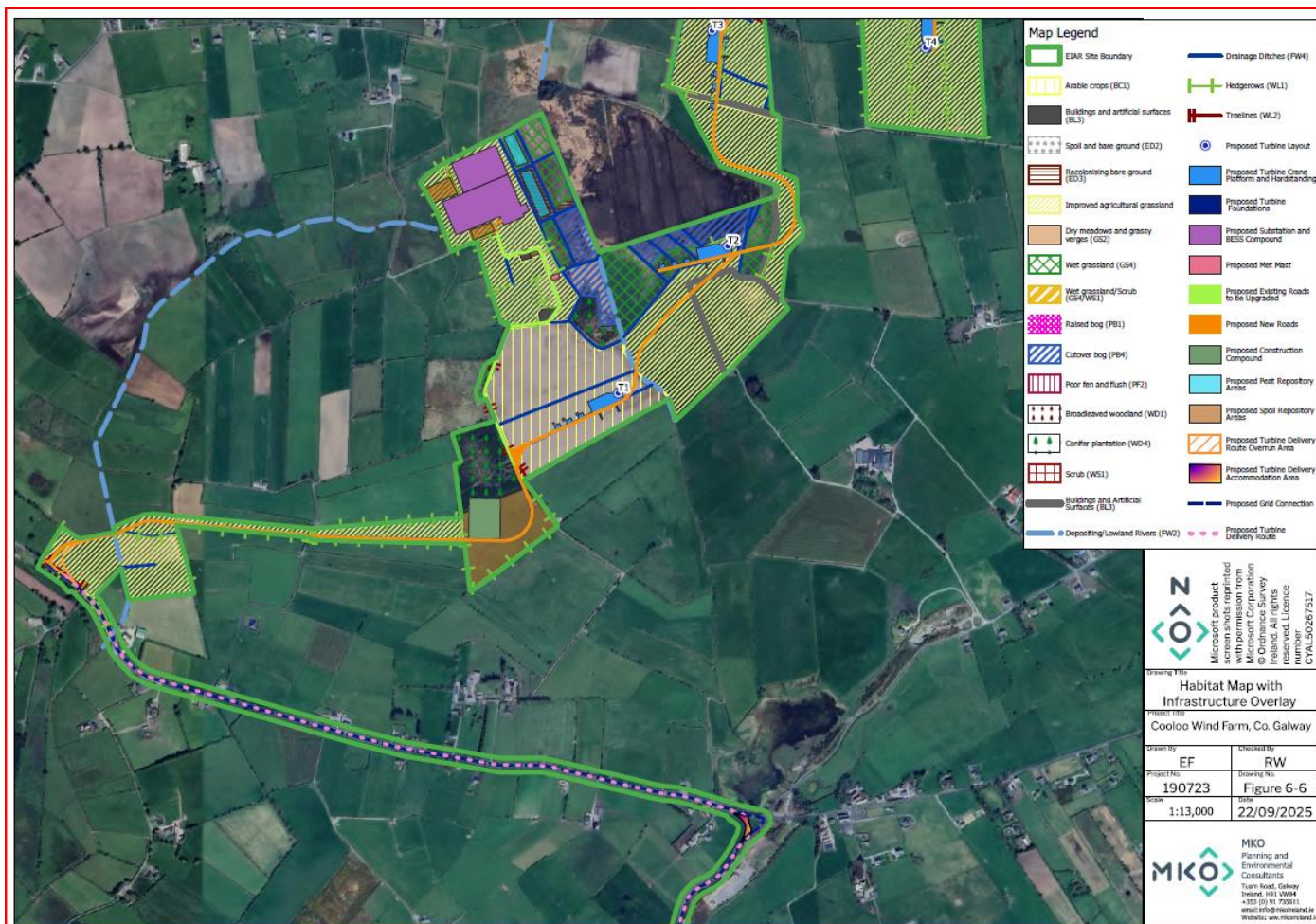
A number of third-party submissions referenced the potential for impact upon trees, hedgerows, forestry and grassland habitats, and the flora and fauna associated with those habitats. The submissions state studies carried out for the EIAR assessment cannot accurately assess the impact of such a large-scale development on the receiving environment.

The potential for impacts on woodland habitats and linear features (treelines/hedgerows) has been considered within Chapter 6 of the EIAR. Section 6.4.1.2 describes the existing woodland habitats. Section 6.4.1.5.2 and Section 6.4.1.5.3 details the existing hedgerow and treeline habitats within the site.

Figure 6-4, Figure 6-5 and Figure 6-6 of Chapter 6 of the submitted EIAR are shown below and shows the habitats and contextualises their diversity on the Site. It is noted that these figures are not included in the digital copy of Chapter 6 but is included in in the hard copy of the EIAR, which is publicly available at the offices of both the Commission and GCC. The figure is a visual representation of the information included in Chapter 6, Section 6.4.1, of the submitted EIAR and does not present any new or additional information.



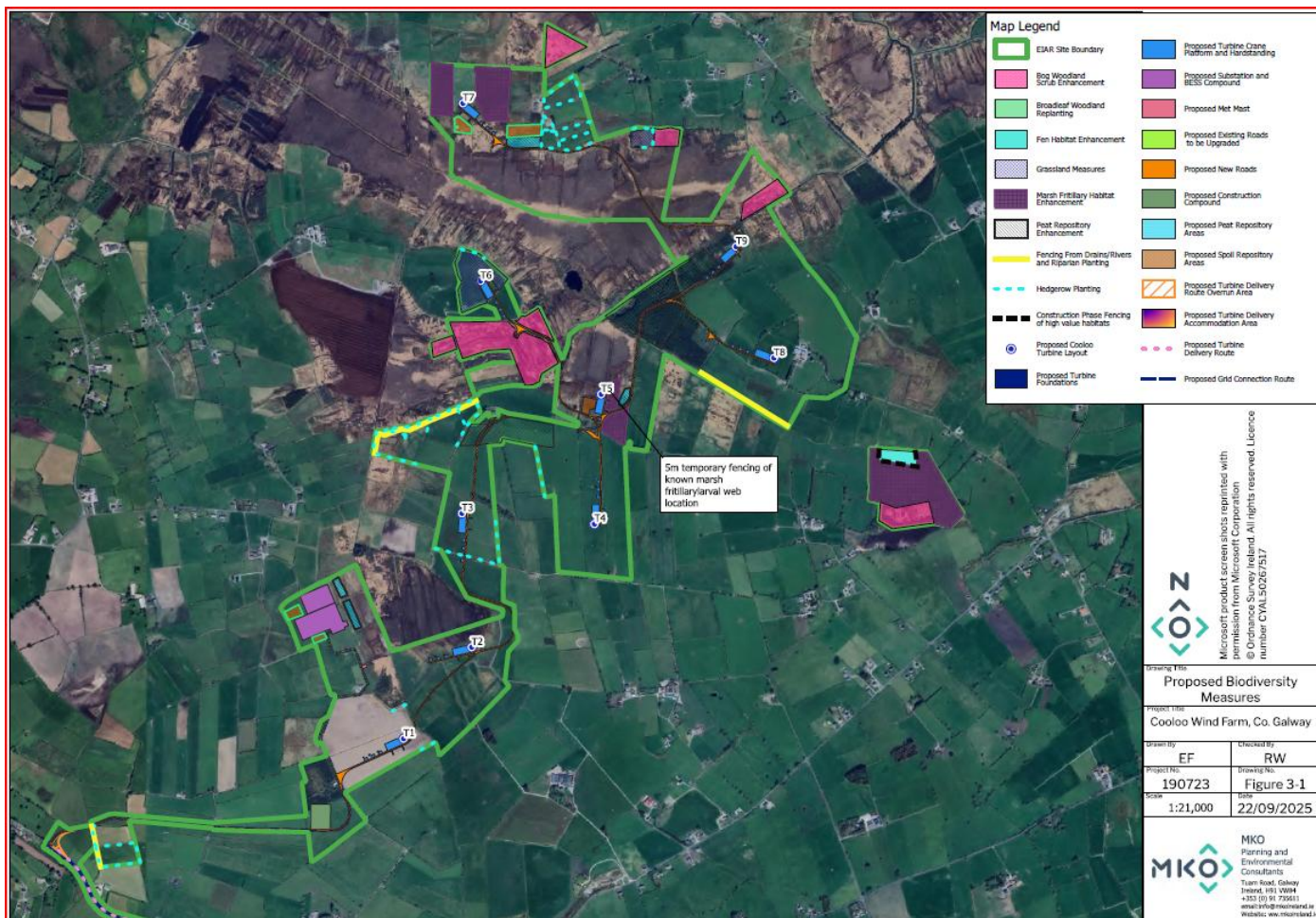




The majority of the woodland habitats consists of monoculture, conifer plantation which accounts for 15.94ha of the Proposed Project. Native broadleaf woodland only accounts for approximately 3.80ha of the Proposed Project, and there will be a loss of approximately 0.17ha of this habitat (4% of the total area). In relation to linear habitats, there is an existing 14.9km of hedgerows and 1.30km of treelines within the site. The assessment of potential significant effects on these habitats is fully described in Sections 6.5.2.1.3 and 6.5.2.1.4 of the EIAR. Mitigation has been provided in the way of broadleaf woodland habitat creation as well as new hedgerow and riparian planting along rivers and drains. A total of 4.7km of hedgerows will be replanted throughout the site to offset and enhance the loss of 3.74km of linear features. In total, approximately 11.5ha of broadleaved woodland will be planted throughout the site.

The BMEP in Appendix 6-4 provides detailed species composition and locations for the proposed hedgerow and broadleaf woodland replanting, specifically in Sections 3.3.1 and 3.3.2. Ongoing maintenance and monitoring measures have been provided within the BMEP to ensure that these habitats are established and the success is monitored. A site-specific monitoring and evaluation programme is necessary to ensure that the success of the proposed measures remains long-term. It will also assist in situations where the habitat establishment may not have been successful by providing evidence of shortcomings, allowing a revised management plan to be formulated. Figure 3-1 of the BMEP of the submitted EIAR is shown below and shows highlighting the proposed locations across the Site that will see proposed biodiversity measures take place. It is noted that this figure is not included in the digital copy of the BMEP but is included in in the hard copy of the EIAR, which is publicly available at the offices of both the Commission and GCC. The figure is a visual representation of the information included in the BMEP, Section 3.3, of the submitted EIAR and does not present any new or additional information.

A temporary residual effect has been identified in relation to woodland and hedgerow replanting, given that there will be an interim period between the removal/loss of hedgerows and the replanting of hedgerow and woodland habitats. However, this will be a temporary residual effect and will not be long-term once the BMEP is implemented.



2.6.2 Fauna

Marsh Fritillary

A number of third-party observations make reference to the potential impact on Marsh Fritillary butterfly, which is an Annex II species. The observations state the findings of the EIAR outline that larval webs were found near the location of the proposed T5 and that the disturbance, dust and drainage associated with the construction phase of the Proposed Project would threaten the species survival.

Larval webs were also recorded within a field to the northwest of the Proposed Wind Farm site which was proposed as a potential woodland replanting area early in the design of the Proposed Project.

Following the discovery of webs within this area, the layout design was altered to avoid this field. This field is no longer located within the Proposed Wind Farm boundaries. Additionally, the substation was initially proposed to be located within one of the fields discovered as containing larval webs before mitigation by design was applied to the finalised Proposed Wind Farm layout to avoid impacts on this species. There is no infrastructure proposed within this habitat area. A singular larval web was recorded within the proposed access road near T5. The road layout was re-designed to avoid the singular larval web.

The potential for significant effect on Marsh Fritillary breeding habitat is assessed in Section 6.5.2.2.5 of the EIAR, with mitigation provided to prevent loss of breeding habitat and dust mitigation during the construction phases of the Proposed Project. The potential for any hydrological impacts has also been considered in Section 9.5.2.16 of Chapter 9 of the EIAR and it was determined that 'due to the already cutover nature and existing extensive drainage at these locations, no significant additional effects on remaining areas of intact bog nearby.' Similarly, the potential for any impacts on breeding marsh fritillary during the operational phase of the Proposed Project has been considered in Section 6.5.3.2, stating:

'it is not anticipated that the operation of the Proposed Project will have any effect on marsh fritillary or habitat for the species during the operation of the Proposed Project. Implementation of the BMEP measures during the operational phase of the development will ensure that habitats are managed for marsh fritillary during the

operational life of the Proposed Project having a positive impact on this species as well as other local invertebrate/pollinator species.’

The BMEP (Appendix 6-4 of the EIAR) also outlines measures for the protection of Marsh Fritillary during the construction phase of the Proposed Project, as well as measures to enhance existing, and create additional habitat for marsh fritillary.

As outlined in Section 3.1 of the BMEP, known marsh fritillary suitable habitat containing larval webs (including the larval web identified within proximity of T5) identified during 2024 surveys. The fencing will contain signage strictly prohibiting entry to these areas. This will denote the area where strictly no machinery, storage of materials or entry of construction site personnel will be permitted. The protective fencing will be inspected and signed off by the supervising Ecological Clerk of Works (ECoW) prior to commencement of the Proposed Project. Section 3.1.2. outlines a suite of measures designed to protect and maintain the existing identified marsh fritillary breeding habitat within the Proposed Project boundaries. None of these identified areas have any proposed infrastructure located within the known breeding habitat areas. Section 3.4.2 of the BMEP also proposed to create an additional 12.76ha of suitable marsh fritillary habitat within the Proposed Project site boundaries. A management regime to maintain this newly created habitat has also been provided in Section 3.4.2.1 of the BMEP.

Badger

A number of third-party observations state the habitats which support badger populations would be impacted by the Proposed Project.

As detailed in Section 6.2.3.3.1 of the EIAR, badger surveys were undertaken during all of the multidisciplinary walkover surveys undertaken between 2021-2025.

As presented in Section 6.4.3.1 of the EIAR, no signs of badger foraging activity were recorded within the Proposed Wind Farm site, and no badger setts were recorded within the Proposed Wind Farm.

Only two incidental records were found during the ornithological survey effort outside of the Proposed Wind Farm site. Section 6.4.3.1 also details the presence of supporting badger habitat within conifer plantation and linear features found on site. Therefore, taking a precautionary approach given the likelihood of the Proposed Project being used by this species, it was assessed that there may be direct and indirect impacts upon these species, and mitigation has been provided in Section 6.5.2.2.1 to prevent any significant effects on badgers. Figure 6-7 of Chapter 6 of the submitted EIAR is shown below and shows the areas within which evidence of fauna was observed across the Site. It is noted that this figure is not included in the digital copy of Chapter 6 but is included in the hard copy of the EIAR, which is publicly available at the offices of both the Commission and GCC. The figure is a visual representation of the information included in Chapter 6, Section 6.4.3, of the submitted EIAR and does not present any new or additional information.

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 Pohlmeier 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.

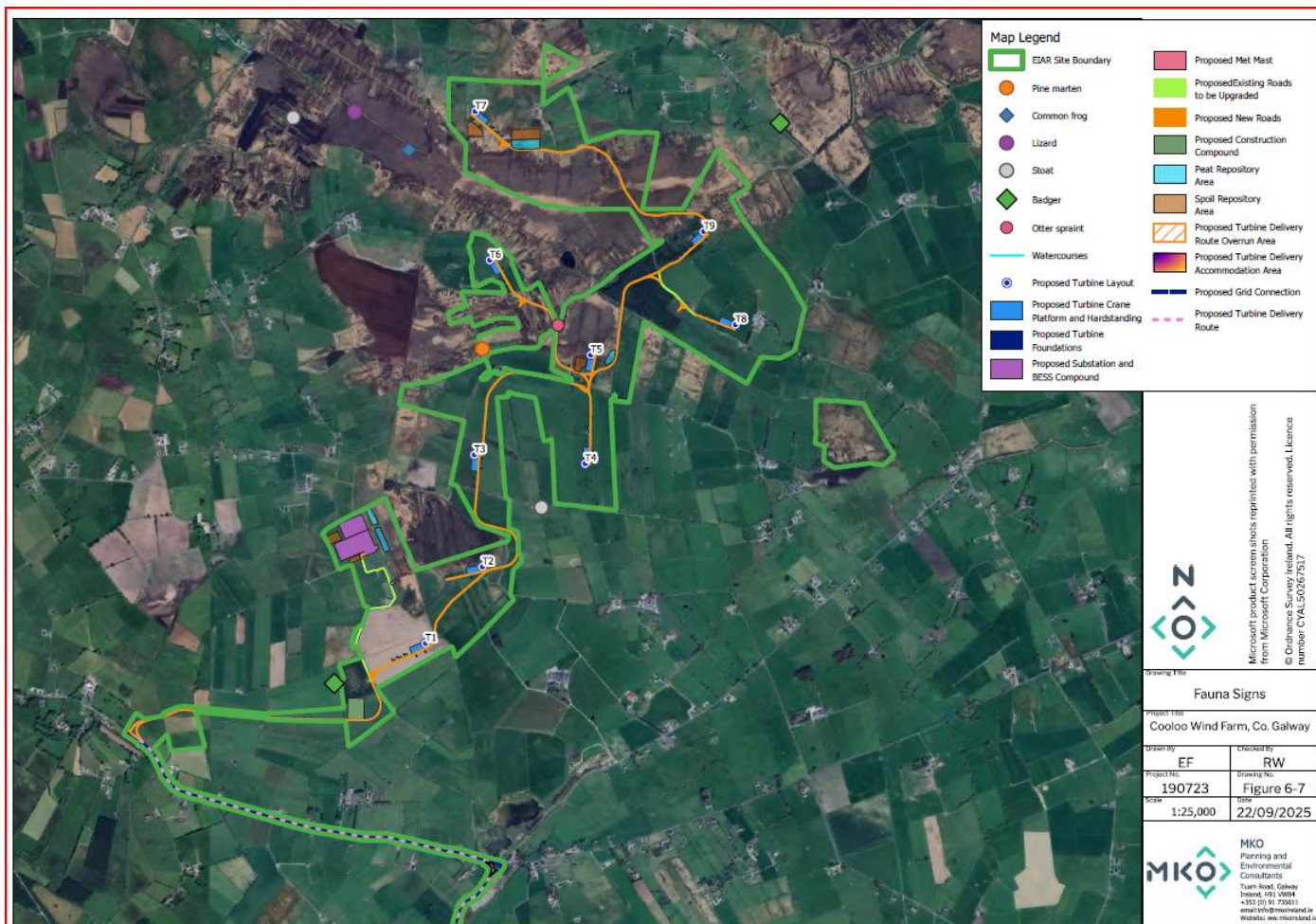
Herbivorous mammals

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; Cleverger 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; Bongí 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 Pohlmeier 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).



Pine Marten and Red Squirrel

Several third-party submissions make reference to the potential impact of the Proposed Project on pine marten and red squirrel.

As outlined in Section 6.5.2.2.3 of Chapter 6 of the EIAR, no pine marten dens or red squirrel dreys were found within the EIAR site boundary. No direct impacts to these species via habitat loss or mortality are anticipated. However, taking a precautionary approach, mitigation has been provided in Section 6.5.2.2.3 to prevent any significant effects on these species as a result of the Proposed Project.

Earthworm

A number of observations from third-parties reference the potential for impact upon on soil biodiversity and ecosystem function, and earthworm populations from wind turbine induced vibrational noise. The observations state that these noise impacts are particularly concerning on agricultural soils. The observations claim that these impacts are not addressed by the submitted EIAR.

The Proposed Project infrastructure will be located largely within a lower-value, highly improved agricultural landscape (improved agricultural grassland - GA1) and to a lesser extent on cutover bog (PB4) and raised bog (PB1) habitats. Due to the high-water table and therefore lack of oxygen within bog habitats, this prevents earthworms from living within these habitats. Additionally, low-diversity and monocultural grassland habitats similar to the GA1 habitats found within infrastructure locations are not highly suitable for earthworms given that they lack food diversity and may have a nutrient depletion.

As provided in Appendix 6-4, a biodiversity management and enhancement plan (BMEP) has been provided. Within the BMEP it is proposed to create 4.45ha of long-flowering meadows as well as create and enhance seminatural marsh fritillary suitable habitat with the objective of creating species-rich low management, nutrient habitats which will provide favourable habitat for earthworm populations.

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 (Mittra 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 earthworm 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).

Amphibians

A number of third-party submissions are concerned regarding the potential impacts on amphibian migration and habitat disruption.

Incidental records of amphibians recorded within the Proposed Wind Farm during the walkover surveys included a record of the adult common frog within a cutover bog/raised bog habitat in the northeast of the site, south of the proposed road between T7 and T9. Frog spawn was also recorded on one occasion in 2022 along a roadside drain, and the common frog was heard on a number of occasions throughout the survey effort. Therefore, it is assumed that the common frog utilises the site regularly. No further evidence of amphibians, including newts, were recorded within the Proposed Project.

The potential for significant effects on amphibians has been considered in Section 6.4.3.5 and Section 6.6.4 (Table 6-18) of Chapter 6 of the EIAR. The chapter concludes:

The Proposed Project will not result in a significant loss of suitable habitat for reptiles and amphibians. It is considered that suitable habitat is extremely widespread in the study area and beyond.

Therefore, given that the suitable habitat for the only recorded amphibian within the Proposed Project (common frog) is widespread within the local area and moreover will be retained following the completion of the Proposed Project, mitigation was not deemed as required to prevent any significant effects on this species.

2.6.3 Bats

2.6.3.1 Legal Protection of Bats and Article 12 Compliance

Submissions raised concerns that the presence of Annex IV bat species triggers strict protection obligations under the Habitats Directive and asserted that the EIAR does not demonstrate that proposed mitigation measures reduce impacts to a level compliant with Article 12, including suggestions that permission cannot be granted in the absence of zero risk.

Response

All bat species in Ireland are afforded strict protection under Article 12 of the EU Habitats Directive.

The EIAR acknowledges the presence of Annex IV bat species within the receiving environment and, informed by the detailed assessment presented in the Bat Survey Report (Appendix 6-2), undertakes a proportionate, site-specific assessment of potential interactions with bats in line with best-practice guidance with respect to the following pathways:

- (i) collision mortality, barotrauma and other injuries;
- (ii) loss or damage to commuting and foraging habitat;
- (iii) loss or damage to roosts; and
- (iv) displacement of individuals or populations.

Article 12 of the Habitats Directive prohibits 'deliberate' impacts on Annex IV species, including capture, killing, disturbance, deterioration and destruction of breeding and resting places. As outlined in Chapter 6 of the EIAR and the Bat Survey Report (Appendix 6-2), the Proposed Wind Farm has been specifically designed to avoid such deliberate impacts. All practicable means and mitigations have been prescribed to avoid, beyond reasonable scientific doubt, the potential for such deliberate impacts.

As such, the Proposed Project is in compliance with Article 12 of the Habitats Directive.

2.6.3.2 Survey Methodology and Monitoring Standards

Submissions questioned the adequacy of the bat survey methodology and monitoring strategy, citing the absence of nacelle-level monitoring, the reliance on ground-level surveys and transects, and referencing Behr et al. (2023) in support of calls for additional monitoring and standardisation.

Response

As described in the dedicated Bat Report (Appendix 6-2), the bat survey methodology and impact assessment were undertaken in accordance with recognised and current best-practice guidance, including NatureScot (2021) Bats and Onshore Wind Turbines – Survey, Assessment and Mitigation and Collins (2023) Bat Surveys for Professional Ecologists: Good Practice Guidelines. The baseline survey programme was designed to characterise bat assemblage, activity patterns and habitat use across the Site, and to inform a comprehensive and proportionate assessment of potential collision risk and habitat-related impacts in line with best practice guidance.

Post-construction bat monitoring is proposed in line with best practice guidance to establish the operational baseline and to evaluate the effectiveness of the site-specific mitigation strategy. Where monitoring reveals a potential change in collision risk at specific turbines, further targeted monitoring (including nacelle-level acoustic monitoring, where appropriate) and site-specific operational mitigation will be implemented and refined in accordance with best-practice guidance.

In line with best practice guidance, NatureScot (2021) identifies pre-construction nacelle-mounted monitoring as appropriate where existing infrastructure is present (e.g. operational turbines), where meteorological masts are available, or where other supporting evidence indicates a high likelihood of bat activity within the rotor-swept zone. None of these scenarios apply at the Proposed Wind Farm site.

Accordingly, surveys at turbine height were not required to support the EIAR, and the ground-level static detector and transect survey programme is considered sufficient and proportionate to characterise baseline bat activity across the Site in accordance with best-practice guidance. Overall, a comprehensive assessment was achieved and the potential for collision risk to local bat species was fully assessed in accordance with best practice guidance.

2.6.3.3 Impact Pathways: Collision Risk and Barotrauma

Submissions raised concerns regarding the potential for bat mortality through collision with turbine blades and pressure-related injury (barotrauma) and questioned the compatibility of wind turbines with bat flight behaviour.

Response

As described in the dedicated Bat Report submitted as Appendix 6-2 to the EIAR, the bat survey methodology and assessment followed the most recent recognised industry best practice i.e. Bats and Onshore Wind Turbines: Survey, Assessment and Mitigation (NatureScot, 2021). Therefore, the risk to bats was fully assessed in accordance with best practice guidance.

An adaptive mitigation and monitoring plan, including bat buffers, blade feathering and 3 years post construction monitoring, has been devised for the Proposed Wind Farm in line with NatureScot guidance to safeguard bats. This adaptive monitoring plan will assess potential changes in bat activity post-construction and can be adjusted as deemed necessary to ensure bats are safeguarded accordingly. MKO considers the proposed mitigation and monitoring plan outlined in Sections 6.1 and 6.2 of Appendix 6-2 of the EIAR to be appropriate and in line with best practice guidance to ensure no significant impacts on local bat populations occurs during the operational phase. Provided the Proposed Wind Farm is operated in line with the proposed mitigation and monitoring plan, no residual significant effects on bats is anticipated as a result of collisions or barotrauma.

2.6.3.4 Mitigation and Operational Controls (Including Curtailment)

Submissions asserted that the EIAR does not commit to validated curtailment systems and argued that operational mitigation measures are insufficient to address potential bat mortality. Further submissions sought additional measures including multi-season and multi-year surveys, monitoring of bat activity at blade height, carcass searches with bias correction, and the application of adaptive mitigation based on operational monitoring results. In addition, the Department of Housing, Local Government and Heritage recommended refinements to the proposed lighting specifications to further minimise potential disturbance to bats.

Response

The EIAR applies the mitigation hierarchy through embedded design avoidance, impact reduction measures, habitat reinstatement and enhancement, and post-construction monitoring. Potential disturbance to bat commuting routes has been minimised through the retention of key linear features where practicable, with temporary losses addressed through reinstatement and enhancement measures set out within the Bat Report (Appendix 6-2) and the Biodiversity Management and Enhancement Plan (BMEP; Appendix 6-4), to maintain and strengthen habitat connectivity over the long term.

As outlined in the Bat Report (Appendix 6-2), post-construction monitoring will comprise a multi-season, and multi-year programme, with at least three years of monitoring proposed in accordance with relevant guidance. Monitoring will include static detector surveys, walked activity transects and systematic carcass searches at turbines to record any bat fatalities resulting from collision. Carcass searches will be undertaken in accordance with current best-practice guidance and will include searcher efficiency trials and assessment of scavenger removal rates, allowing appropriate bias correction to be applied when estimating collision mortality. This approach provides a robust, standardised approach for assessing potential impacts and informing adaptive operational mitigation.

The EIAR commits to the use of bat-sensitive lighting in accordance with ILP Guidance Note 08/23: Bats and Artificial Lighting at Night. Where lighting is required during construction and operation, directional lighting will be used to prevent overspill onto woodland and forestry edges and other linear features used by commuting and foraging bats. Luminaires will be designed to minimise upward and lateral light spill, with appropriate shielding and directional accessories, and lighting will be directed away from mature trees and treelines. The Applicant also commits to the Dark Sky Ireland lighting principles, including that lighting will be justified, used only where necessary, directed where required, and of the minimum intensity appropriate for safety and operational needs. In this context, the Department of Housing, Local Government and Heritage's recommendation to specify warm white lighting with a correlated colour temperature (CCT) of $\leq 2700\text{K}$, rather than the more general "warm white" specification ($<3000\text{K}$) referenced in Dark Sky Ireland guidance, is welcomed and will be incorporated into the detailed lighting design where practicable and subject to safety and operational requirements.

Limited aviation lighting will be required on turbines in accordance with aviation safety requirements.

Post-construction monitoring will assess any potential for lighting-related effects on bats. Significant effects as a result of lighting are not anticipated; however, should monitoring identify any lighting related disturbance to bats, site-specific mitigation measures will be reviewed and refined to avoid such effects.

MKO considers the proposed mitigation and monitoring plan outlined in Sections 6.1 and 6.2 of Appendix 6-2 of the EIAR to be appropriate and in line with best practice guidance to ensure no significant impacts on local bat populations occurs during the operational phase. Provided the Proposed Wind Farm is operated in line with the proposed mitigation and monitoring plan, no residual significant effects on bats is anticipated.

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

<i>European Skylark</i>	33	3
<i>Brown Falcon</i>	26	7
<i>Large Forest Bat</i>	16	6
<i>Lesser Long-eared Bat</i>	15	<3
<i>Little Forest Bat</i>	13	6
<i>Unidentified Bat</i>	11	6
<i>Southern Freetail Bat</i>	10	4
<i>Southern Bent-wing Bat</i>	8	<3
<i>European Goldfinch</i>	7	5
<i>Common Starling</i>	7	5
<i>Welcome Swallow</i>	6	4
<i>Chocolate Wattled Bat</i>	6	4
<i>Red-rumped Parrot</i>	5	<3
<i>Grey-headed Flying-fox</i>	4	<3
<i>House Sparrow</i>	4	<3
<i>Magpie-lark</i>	4	<3
<i>Southern Forest Bat</i>	4	<3

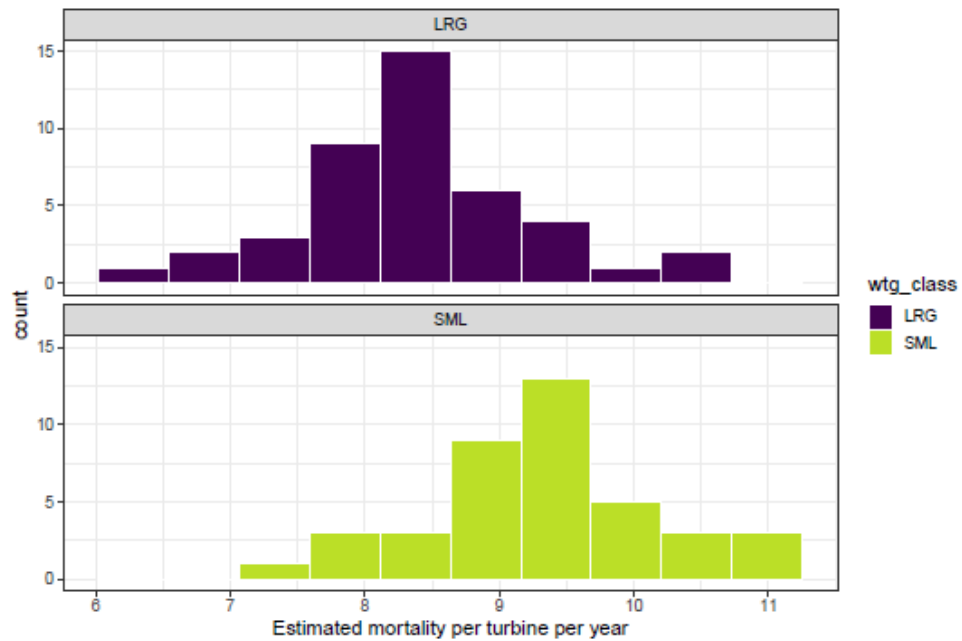


Figure 11: Credible Distribution of Bat Mortalities per turbine year

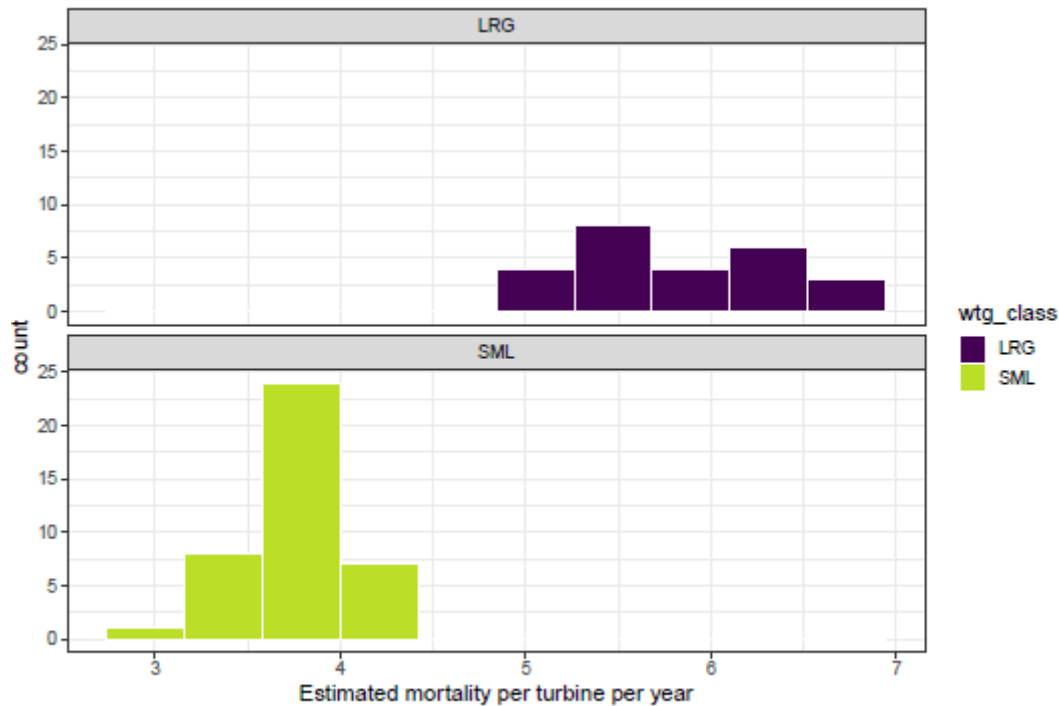


Figure 12: Credible Distribution of Bird Mortalities per turbine year

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 echolocation 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 Meteorological 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.*
- 3) Loss of, or damage to, roosts*
- 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 $11 \pm 34 \text{ km}^2$, 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 $11 \pm 34 \text{ km}^2$ ”.

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>

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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; Roелеke 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 studies 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). Benítez-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, BenítezLopez ´ 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
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Birds			
<i>Cranes</i>	3	0	3
<i>Gallinaceous birds</i>	11	7	18
<i>Owls</i>	2	0	2
<i>Passerines</i>	16	16	32
Raptors	24	6	30
Waders	8	11	19
Waterfowl	6	1	7
<i>Several</i>	3	2	5
Sum	73	43	116
Bats	21	8	29
<i>Terrestrial mammals</i>			
<i>Canids</i>	1	1	2
<i>Cervids</i>	8	1	9
<i>Small mammals</i>	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-Catas'us ' et al., 2018). Nighttime lights and the rotation of turbines were suggested to disturb birds and have adverse effects on communication (Gomez-Catas'us ' 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 (Farfan ' 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 ecolocators) *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 (*Canis 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 Eftestøl 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
<i>Nyctalus</i> spp.	<i>Eptesicus</i> spp.	<i>Myotis</i> spp.
<i>Pipistrellus</i> spp.	<i>Barbastella</i> spp.	<i>Plecotus</i> spp.
<i>Vespertilio murinus</i>	<i>Myotis dasycneme</i> ²	<i>Rhinolophus</i> spp.
<i>Hypsugo savii</i>		
<i>Miniopterus schreibersii</i> ¹		
<i>Tadarida teniotis</i>		

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 effect	significant	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	
Curtailement 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

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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 ^δ), 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) ^δ , 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) ^δ	
Increased mortality due to flight behavior		
Migratory species particularly at risk	Arnett et al. (2008) ^δ , Baerwald et al. (2009)*, Cryan and Brown (2007)*, Cryan and Barclay (2009) ^δ , Grodsky et al. (2012)*, Johnson et al. (2003)*, (2004)*, and Kunz et al. (2007) ^δ	Ahlén (2003) ^δ , Brinkmann et al. (2006) ^δ , Behr et al. (2007)*, Hull and Cawthen (2013)*, Rydell et al. (2010a) ^δ , and Voigt et al. (2012)*
Use of echolocation during flight, reaction time insufficient	Grodsky et al. (2011)*, Kunz et al. (2007) ^δ , Long et al. (2009) ^δ , and Rydell et al. (2010a) ^δ	
Increased risk for sub-adults (e.g., lower flight ability)	Fiedler et al. (2007) ^δ (sub-adults and juveniles)	Arnett et al. (2008) ^δ , Grodsky et al. (2012)*, Hull and Cawthen (2013)*, Johnson et al. (2004)*, Kerns et al. (2005) ^δ , and Rydell et al. (2010a) ^δ
Bats approach turbines while mating, feeding, or swarming	Arnett et al. (2008) ^δ , (2011b) ^δ , Behr et al. (2007)*, Cryan and Brown (2007)*, Cryan (2008) ^δ , 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) ^δ	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) ^δ , (2010b) ^δ	
Increased mortality due to attraction		
Investigating turbines as possible tree-roosts increases collisions risk	Ahlén (2003) ^δ , Cryan and Brown (2007)*, Cryan (2008) ^δ , Cryan and Barclay (2009) ^δ , Cryan et al. (2014)*, Hull and Cawthen (2013)*, and Kunz et al. (2007) ^δ	
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) ^δ , and Rydell et al. (2010b) ^δ	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) ^δ , 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) ^δ , 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)	Hötter (2006) ^δ (displacement of resting birds)	Barclay et al. (2007)*, Everaert (2014)*, Hötter (2006) ^δ (breeding birds); Pearce-Higgins et al. (2012)*, and Stewart et al. (2007) ^δ
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)*, Hötter 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)*	Hötter et al. (2005) ^δ and Rydell et al. (2012) ^δ
Enhanced effects due to species characteristics		
Resting birds are more sensitive to wind turbines than breeding birds (avoidance)	Hötter et al. (2005) ^δ , Reichenbach and Steinborn (2006) ^δ , and Steinborn et al. (2011) ^δ	
Collision risk is species-specific	Drewitt and Langston (2006) ^δ , 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 <i>Galliformes</i>)/outside the rotor swept zone	Brennan et al. (2009) ^ψ , 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) ^ψ
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) ^δ , Hötter 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)*, Muñoz 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 <i>Falco tinnunculus</i>)	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 Fågelvind (2011) ^δ	
	Increased micro-avoidance at operating wind turbines	Hill et al. (2014) ^δ	
Habituation	Over the years	Plonczkier and Simms (2012)*	

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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) ^δ , 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) ^δ	
Collision with floating or submerged structures	Gill (2005) ^δ and Simmonds and Brown (2010) ^δ	Russell et al. (2014)*
Disorientation due to change of magnetic fields	Gill (2005) ^δ , 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) ^δ , and Simms and Ross (2000) ^δ	
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) ⁶ , Nedwell et al. (2007) ⁶ , Nehls and Betke (2011) ⁶ , and Thompson et al. (2010)*	
Mother-calf-separation/disturbance	Dähne et al. (2014b) ^W , and Kastelein (2013a) ^W	
Increased vessel activity causing stress/disturbance and risk of strikes	Carstensen et al. (2006)*, Gordon (2012) ^W , Nedwell and Howell (2004) ^W , SMRU (2009) ^W , Simmonds and Dolman (2008) ^W , and Simmonds and Brown (2010) ⁶	
Tendency to return after piling	Brandt et al. (2009) ⁶ , Haelters and Vanermen (2013) ^W , Nehls and Betke (2011) ⁶ , Scheidat et al. (2011)*, Tougaard et al. (2006b) ⁶ : Horns Rev, and Wahl et al. (2013) ^W	Tougaard et al. (2006a) ⁶ : 2 years
Disperse of sediment causing re-suspension of potentially polluted sediment and turbidity	Carstensen et al. (2006)*, Gill (2005) ⁶ , and Simmonds and Dolman (2008) ^W	
During operation		
Masking causing disruption of usual behavior	Koschinski et al. (2003)*: harbor seals; Lucke (2008) ⁶ : at very short distance	Gordon (2012) ^W , Haelters and Vanermen (2013) ^W , Koshinski et al. (2003)*: harbor porpoises, Lucke (2008) ⁶ , Nehls and Betke (2011) ⁶ , and Tougaard et al. (2009b)*
Avoidance of wind farm area/change of behavior due to noise emission and vibration	Simmonds and Dolman (2008) ^W and Tougaard et al. (2009b)*: porpoises at very short distance/seals likely	Dähne et al. (2014a) ⁶ , McConnell et al. (2012) ⁶ , Nedwell et al. (2007) ⁶ , and Scheidat et al. (2011)*
During decommissioning		
Habitat loss due to removal of structure	Gill (2005) ⁶ , and Gordon (2012) ^W	
Injury or behavioral response due to noise emission (e.g., explosion, cutting)	Gordon et al. (2007) ⁶ , Lucke et al. (2009)*, Prior and McMath (2008) ^W , SMRU (2009) ⁶ , and Simmonds and Dolman (2008) ^W	
Increased vessel activity causing stress/disturbance and risk of strikes	Nedwell and Howell (2004) ^W , and Simmonds and Brown (2010) ⁶	
Disperse of sediment causing re-suspension of potentially polluted sediment and turbidity	Carstensen et al. (2006)*, Gill (2005) ⁶ , and Simmonds and Dolman (2008) ^W	

Note The possible impacts to Bats from Windfarms are extensive & under the Precautionary Principle have to be refused.

Reference 2024 : Global Review on Environmental Impacts of Onshore Wind Energy and Their Implications for Forest Ecosystems. Leon Sander , Christopher Jung , Dirk Schindler. Posted Date: 27 May 2024 doi: 10.20944/preprints202405.1727.v1

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](https://doi.org/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](https://doi.org/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. Bošnjaković, M.; Hrkać, F.; Stoić, 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.

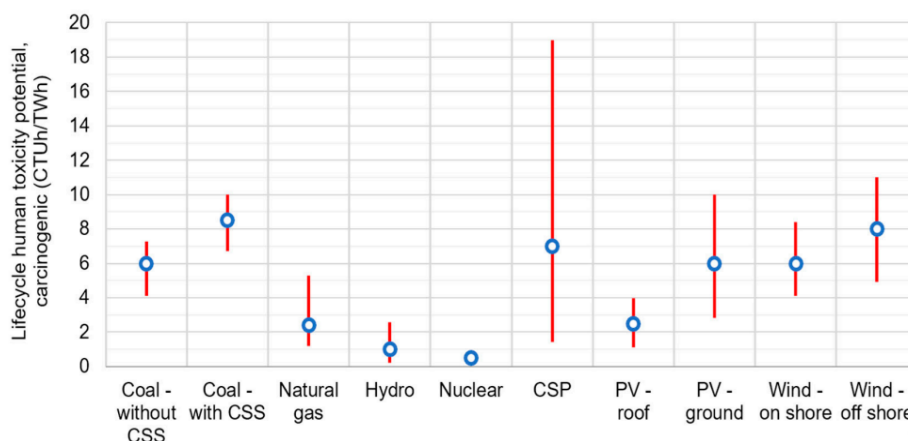


Figure 4. Lifecycle human toxicity potential, carcinogenic. The red line represents the range and the circle represents the median.

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. Gallinaceous 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 ± 7 dB. 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.

2.6.3.5 Site-specific Bat Connectivity: Elmhill House & T8

Submissions raised concerns regarding the removal of hedgerows and potential effects on bat commuting routes, the proximity of a confirmed bat roost at Elmhill House to Turbine 8, and the potential for bats emerging from this roost to commute through the vicinity of Turbine 8 to access foraging habitat. Submissions also raised claims regarding potential effects of turbine-generated “ultrasound” on bat navigation.

Response

Hedgerows and treelines are recognised as important commuting and foraging features for bats. The Proposed Wind Farm has been designed to retain and avoid key linear features where practicable.

Where limited removal of hedgerows or treelines is required to facilitate access or infrastructure, this is addressed through replacement planting and habitat enhancement measures set out within the Biodiversity Management and Enhancement Plan (BMEP; Appendix 6-4). These measures are designed to maintain and strengthen habitat connectivity over the medium to long term, resulting in no net loss of linear habitat connectivity across the Site.

A confirmed small soprano pipistrelle roost of less than 20 individuals is present at Elmhill House, approximately 180 m east of Turbine 8 and will be avoided and retained as part of the Proposed Wind Farm. Walked transect surveys indicate that soprano pipistrelles emerging from this roost primarily commute eastwards along treeline networks into the wider landscape, away from Turbine 8. Bat activity recorded to the west of Turbine 8 is dominated by common pipistrelles and is considered to reflect use by bats commuting along separate linear features within the wider landscape, rather than bats originating from the Elmhill House roost.

The EIAR acknowledges that Turbine 8 is located in an area where relatively higher levels of common pipistrelle activity were recorded during specific survey periods. However, per-detector results indicate that elevated median activity was recorded at multiple turbine locations across the Site (including Turbines 1, 2, 3, 4 and 7) during different seasons, and that Turbine 8 does not represent a unique activity hotspot in the context of overall site-wide bat activity patterns. This reflects the dynamic and seasonally variable distribution of bat activity across the Site, rather than the presence of a single consistently high-activity turbine location. This sensitivity has been considered within the site-specific assessment (Appendix 6-2, Bat Report) for Turbine 8, including the application of bat buffers to minimise interaction with key linear features in this area.

With respect to claims regarding turbine “ultrasound” affecting bat navigation, there is no robust evidence that operational wind turbines emit ultrasonic sound at levels that interfere with bat echolocation or navigation. The EIAR therefore focuses on established impact pathways (collision, barotrauma and habitat connectivity) and manages these through design, mitigation and adaptive operational controls.

Post-construction bat monitoring will be undertaken, with particular attention to activity patterns and any evidence of collision risk at Turbine 8. Should monitoring indicate changes in collision risk at this turbine, site-specific operational mitigation, including curtailment, will be implemented and refined in accordance with best-practice guidance

2.6.3.5.2 **Bats Conclusion**

The EIAR and Bat Survey Report provide a robust, evidence-based assessment of potential impacts on bats associated with the Proposed Wind Farm. With the implementation of the embedded design measures, mitigation and enhancement measures, and the post-construction monitoring and adaptive operational mitigation framework, no significant long-term residual effects on bat populations are anticipated.

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.

Gallinaceous 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.

2.6.4 Ornithology

2.6.4.1 Survey Approach

2.6.4.1.1 Survey Guidelines

Concerns were raised as to the use of SNH (2017) for guidance on survey methodology.

Response

The methodology outlined in this submission is not specifically designed to survey a wind farm and a project of this scale and complexity. SNH (2017) survey guidelines were specifically designed with wind farms in mind and allows for the collection of a robust dataset which can be relied upon for an impact assessment. These methodologies are industry best practices for surveying at proposed wind farm sites.

Furthermore, the methodologies do not include flight activity surveys for collision risk analysis, or surveys of the hinterland to assess the impacts on species in the wider area, both of which are outlined in SNH (2017) and have been completed as part of the comprehensive suite of surveys undertaken at the Proposed Wind Farm Site. In the absence of specific national bird survey guidelines for Ireland, the ornithological surveys were designed and undertaken in full accordance with the guidance document 'Recommended bird survey methods to inform impact assessment of onshore wind farms' (SNH, 2017).

This survey guidance is widely accepted in the Irish onshore wind farm industry to provide best practice recommendations for undertaking bird surveys at a proposed wind farm site at the time of survey. These guidelines have recently been updated in NatureScot (2025), after the survey period ended. However, the survey methods employed remain consistent and compliant with the updated guidance in NatureScot (2025). A submission suggested that the EIAR policy and guidance section selectively referenced academic studies and omitted research with findings unfavourable to wind farm development. The EIAR Chapter 7 Section 7.1.2 (Legislation, Guidance and Policy Context) refers to the relevant legislation to the assessment process and guidance on conducting an assessment. These documents do not evaluate research on the favorability of wind farm developments.

2.6.4.1.2 Vantage Point Survey Detectability

A submission questioned the accuracy of the Vantage Point Surveys methodology provided in SNH (2017) in relation to detection rates declining with distance from the vantage point data.

Response

Survey methodology followed SNH (2017) survey guidelines, which were specifically designed with wind farms in mind and allow for the collection of flight activity information suitable for use in a collision risk model. It is acknowledged that bird detectability will decrease with distance. However, the viewsheds at the Proposed Wind Farm site provide extensive coverage of farmland and peatland within 1km of the surveyor's location, where detectability is considered to be highest. As such, the data collected provides accurate information on the species assemblage and level of flight activity within these habitat types during surveys. Because farmland and peatland are the main habitat types within the Proposed Wind Farm site, the dataset provides a representative sample of the species assemblage and flight activity throughout the Proposed Wind Farm site.

2.6.4.1.3 Nocturnal Surveys

A submission raised concern that the guidelines followed during field surveys for the Proposed Wind Farm to not take account of night-time bird activity, and in particular the lack of thermal imaging and passive audio recording surveys to give a measure of night-time activity at the Proposed Wind Farm site.

Response

It is acknowledged that some birds, particularly waterbirds, commute between feeding and roosting locations during periods of low light, typically before sunrise or after sunset. However, the survey scope that was undertaken at the Proposed Wind Farm site included the low light periods before sunrise or after sunset during the migratory/wintering season surveys: as described in the EIAR Chapter 7 Section 7.2.3.2.1, Vantage Point Surveys were conducted during periods of low light one hour after sunset or one hour before sunrise. Furthermore, as outlined in Appendix 7-6 Collision Risk Assessment, the nocturnal activity of birds recorded at the Proposed Wind Farm site has been accounted for within the collision risk model: within the model, crepuscular species are presumed to be active for 25% of the night.

2.6.4.1.4 Survey Effort

A submission queried the field survey effort conducted at the Proposed Wind Farm site.

Response

As stated in the EIAR Chapter 7 Section 7.2.3.2, dedicated multi-year and multi-season ornithological field surveys were conducted from **October 2019 to March 2022 and again from August 2023 to March**

2025, consisting of three breeding seasons (April – September) and five winter seasons (October – March). As described in Section 7.2.3.2.1, these included Vantage Point Surveys to monitor flight activity that is used to inform a Collision Risk Model, which is described in full in Appendix 7-6 Collision Risk Assessment. Mitigation specific to birds is described in Chapter 7 Section 7.6. **Note that carcass search surveys can only be conducted where there are already existing turbines.**

Response from MLavelle: Where are the surveys from existing windfarms in Ireland?

2.6.4.1.5 **Survey Coverage**

Submissions queried field survey coverage at the Proposed Wind Farm site, particularly in relation to dedicated barn owl and hen harrier surveys. These surveys conducted were targeted towards areas of suitable habitat where these species may be present. These habitat types were not present in all areas of the Proposed Wind Farm site, therefore did not occur in all areas.

Response

A submission also queried whether the Vantage Point Survey coverage was adequate. As outlined in the EIAR Chapter 7 Section 7.2.3.2.1, a viewshed analysis was conducted to ensure the Vantage Point Surveys had adequate coverage of the Proposed Wind Farm site and turbines to inform the collision risk assessment.

2.6.4.2 **Assessment Approach**

2.6.4.2.1 **Significance of Impacts**

Submissions queried the impact assessment process used in the EIAR and how the significance of impacts was determined.

Response

The significance of impacts on birds is described in the EIAR Chapter 7 Section 7.5. This includes the impact of collision risk, disturbance/displacement and habitat loss. Cumulative impacts on birds are described in Section 7.7 of the EIAR.

As stated in Section 7.1.2 of the EIAR, the EIAR has been prepared in accordance with the requirements of EU Environmental Impact Assessment Directive 2014/52/EU. As described in Section 7.2.4.5 of the EIAR, the impact assessment is quantified following two widely accepted assessment criteria for bird species in Ireland: **Percival (2003)** and the Environmental Protection Agency (EPA, 2022), which provide the best available guidance applicable to birds in Ireland to quantify the magnitude of impacts. The two assessment criteria have been used to independently characterise impacts to inform a robust assessment of potential effects. The significance of the impacts is characterised based on this guidance for each key ornithological receptor within the relevant geographical framework (described in Section 7.2.4.1 of the EIAR). Key Ornithological Receptors are assessed in Section 7.5.2 of the EIAR, which includes an assessment of barn owl, hen harrier, merlin, whooper swan, golden plover and lapwing as well as other protected species.

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.

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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, four 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 Ireland's 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.

2.6.4.2.2 **Collision Risk Impacts**

Submissions raised concerns over the use of the Band (2007) model to predict collision risk estimates for birds. A submission queried the origin of the assumptions made in the Band (2007) model. Band (2007) outlines a number of assumptions in the modelling process. These assumptions arise from the modelling methodology itself and are not cited from other literature.

Response

As stated in the EIAR Chapter 7 Section 7.2.4.4, the Band (2007) model is the standard modelling methodology for terrestrial wind farms recommended by NatureScot. More recently, this modelling methodology has been updated in Band (2024). However, Band (2024) states that 'collision risk estimates resulting from application of this report should not differ substantively from those deriving from correct application of the earlier [NatureScot] guidance'.

A submission queried why collision risk was not estimated for birds not recorded flying at potential collision risk height during Vantage Point Surveys. Following Band (2007; 2024) guidance, collision risk modelling is informed by the results of Vantage Point Surveys, which cover a specific known area and are conducted for a standardised length of time. Collision risk can only be predicted for a species if it was recorded at potential collision risk height during Vantage Point Surveys (if a bird was not recorded at potential collision risk height, then the collision risk will calculate at zero).

Submission queried the avoidance factors used in the collision risk assessment, in particular those of whooper swan. The avoidance factors used during the collision risk modelling process are those from NatureScot guidance (SNH, 2016). NatureScot guidance provides the best available avoidance rate estimates from these species for Ireland.

2.6.4.2.3 **Cumulative Impacts**

A number of third-party submissions query the cumulative impacts of the Proposed Project.

Response

The cumulative impacts of the development are assessed in the EIAR Chapter 7 Section 7.7.

2.6.4.3 **Mitigation and Post-consent Monitoring**

Submissions queried the design and oversight of post-consent monitoring of the Proposed Wind Farm site.

Response

As part of the EIAR application, a bird mitigation plan and monitoring programme were prepared (EIAR Appendix 7-7 Bird Mitigation Plan and Appendix 7-8 Bird Monitoring Programme). These were designed based on the avian community present and their use of the Proposed Wind Farm site, as recorded during baseline surveys. Mitigation regarding potential bird collisions with turbines will occur during the operational phase of the Proposed Wind Farm as that is when potential collisions could occur.

Post-consent monitoring will be overseen by an appropriately qualified ecologist or ornithologist. As described in the EIAR Appendix 7-8 Bird Monitoring Programme Section 2.4, monitoring reports will be submitted to the planning authority and the National Parks and Wildlife Service at the end of each monitoring year to demonstrate compliance with the mitigation plan and monitoring programme.

2.6.4.4 **Species-specific Concerns**

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

2.6.4.4.1 **Whooper Swan**

A number of submissions queried the impact of the Proposed Wind Farm on whooper swan activity and habitat, including a submission that raised concern over the effects of the Proposed Wind Farm on a turlough used by whooper swans located near the Castle.

Submissions queried the impact assessment process for whooper swan, particularly in relation to wetlands (such as Horseleap Lough) in the surrounding area, and the location of the raw data and maps used for assessment.

Response

As stated in the EIAR Chapter 7 Section 7.2.3.2.4, Waterbird Distribution and Abundance Surveys were conducted at significant wetlands and waterbodies within 5km of the Proposed Wind Farm site during the 2019/2020, 2020/2021, 2021/2022, 2023/2024 and 2024/2025 winter and passage seasons. The area surveyed exceeded the 500m for foraging waterbirds and 1km for roosting waterbirds required by SNH (2017) and follows the recommendations of SNH (2016). The results of this survey were considered in the impact assessment; the assessment for whooper swan specifically is in Section 7.5.2.5 of the EIAR.

As described in the EIAR Chapter 7 Section 7.2.4.5, the impact assessment is quantified following two accepted assessment criteria for bird species in Ireland: Percival (2003) and the Environmental Protection Agency (EPA, 2022). The two assessment criteria have been used to independently characterise impacts to inform a robust assessment of potential effects on whooper swan.

Response from MLavelle: Note Tables 1 & 2 below from Percival (2003). Note the size of the turbines ; - Large >1.5Mw, Medium 500Kw to 1.5Mw, Small <500Kw. Note most of the list relates to small turbines comparatively speaking to current turbine sizes.

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 (Hötter 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 (Hötter 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.

Table 1. Bird-windfarm collision studies: summary of findings.

Species group	Sites studied	Windfarm size	Turbine type	Exposure to collision risk	Incidence of collision	Population effect
Divers	Burgar Hill ^{1,2}	S	S/M	M	Nil	No
Cormorants	Buffalo Ridge ³	VL	M	L	Nil	No
	Blyth ^{4,5}	S	S	L	VS	No
Swans	Yukon ⁶	S	S	S	Nil	No
	Urk ⁷	M	S	M/L	VS	No
Geese	Buffalo Ridge ³	VL	M	L	Nil	No
	Klondike ⁸	M	M	M	S	No
	Kreekrak ¹²	S	S	M	S	No
	Gotland ¹⁰	L	M	L	Nil	No
	Urk ⁷	M	S	M	Nil	No
Ducks	Blyth ^{4,5}	S	S	L	S	No
	Buffalo Ridge ³	VL	M	L	VS	No
	San Gorgonio ¹¹	VL	S	-	VS	No
	Kreekrak ¹²	S	S	L	M	No
Eagles, vultures, hawks	Altamont ^{11,13}	VL	S	L	S	Likely
	Tehachapi ¹¹	VL	S	-	VS	Possible
	San Gorgonio ¹¹	VL	S	-	VS	No
	Tarifa ^{14,16}	VL	S	L	VS	Possible
	Navarre ¹⁵	VL	M	L	S	Possible
Harriers	Buffalo Ridge ³	VL	M	M	Nil	No
	Altamont ^{11,13}	VL	S	L	VS	No
	Foot Creek Rim ⁸	L	M	-	VS	No
Falcons	Altamont ^{11,13}	VL	S	L	S	Possible
	Burgar Hill ¹	S	S	S	VS	No
	Novar ¹⁷	M	M	M	VS	No
	Tehachapi ¹¹	VL	S	-	VS	No
	Tarifa ^{14,16}	VL	S	L	VS	Possible
Upland gamebirds	Buffalo Ridge ³	VL	M	S	VS	No
	Novar ¹⁷	M	M	S	VS	No
	Tehachapi ¹¹	VL	S	-	VS	No
Owls	Altamont ^{11,13}	VL	S	L	VS	Possible
	San Gorgonio ¹¹	VL	S	-	VS	No
	Tehachapi ¹¹	VL	S	-	VS	Possible
Waders	Kreekrak ¹²	S	S	L	S	No
	Gotland ²¹	L	M	L	VS	No
	Blyth ^{4,5}	S	S	M/L	VS	No
	Oosterbierum ¹⁸	M	S	M/L	VS	No
	Ovenden Moor ¹⁹	M	S	L	VS	No
	Buffalo Ridge ³	VL	M	L	VS	No
Gulls	Blyth ^{4,5}	S	S	L	M	No
	Kreekrak ¹²	S	S	L	M	No
	Zeebrugge ²⁰	M	S/M	L	L	Possible
	Buffalo Ridge ³	VL	M	L	Nil	No
Terns	Zeebrugge ²⁰	M	S/M	L	M	Possible
	Blyth ^{4,5}	S	S	M	Nil	No
Passerines	Blyth ^{4,5}	S	S	M/L	Nil	No
	Buffalo Ridge ³	VL	M	L	M	No
	Oosterbierum ¹⁸	M	S	L	L	No

KEY

Sources: 1. Meek *et al.* 1993; 2. Haworth 2002; 3. Johnson *et al.* 2000; 4. Still *et al.* 1995; 5. Painter *et al.* 1999; 6. Mossop 1998; 7. Winkelman 1989; 8. Young *et al.* 2003; 9. Johnson *et al.* 2003; 10. Percival 1998b; 11. Erickson *et al.* 2001; 12. Musters *et al.* 1995, 1996; 13. Thelander *et al.* 2003; 14. SEO/BirdLife 1995; 15. Lekuona 2001; 16. Janss 2000; 17. Bioscan 2001; 18. Winkelman 1992a; 19. EAS 1997; 20. Everaert *et al.* 2002; 21. Percival 2000.

Windfarm size: VL = very large (>200 turbines); L = large (50-200 turbines); M = medium (10-50 turbines); S = small (<10 turbines).

Turbine type: L = large (>1.5 MW); M = medium (500 KW-1.5 MW); S = small (<500 KW).

Exposure to collision risk (based on number of flights at rotor height/in proximity to turbines per year: L = large (>10,000); M = medium (1,000-10,000); S = small (<1,000).

Incidence of collision: L = large (>10/turbine/yr); M = medium (1-10/turbine/yr); S = small (0.1-1/turbine/yr); VS = very small (<0.1/turbine/yr).

Population effect: determined on the basis of the total numbers killed in relation to the population dynamics.

Table 2. Bird-windfarm disturbance studies: summary of findings.

Species group	Sites studied	Habitat	Windfarm size	Turbine type	Disturbance distance
Cormorant	Blyth ¹	Coastal	S	S	None *
Swans	Urk ³	Farmland and coastal	M	S	None (Bewick's), 300 m (Whooper)
Geese	Germany ^{4,5}	Farmland	M	S/M	Up to 600 m
	Urk ³	Farmland and coastal	M	S	None
	Denmark ⁶	Farmland	L	M	1-200 m
	Gotland ⁷	Coastal marsh	L	M	0-25 m
	Toronto ⁸	Parkland	S	M	None
Ducks	Tunø Knob ⁹	Offshore	M	M	None
	Utgrunden ¹⁰	Offshore	S	L	None
	Urk ³	Coastal	M	S	Up to 300 m
Raptors	Bryn Tytli ¹⁶	Upland moor	M	S	None
	Altamont ¹⁷	Grassland	VL	S	None
Waders: breeding	Ovenden Moor ¹¹	Upland moor	M	S	None
	Various UK sites ¹²	Upland	S/M	S/M	None
	Gotland ²²	Coastal and farmland	L	M	None
	Oosterbierum ¹⁵	Lowland farmland	S	S	Up to 300 m
Waders: non-breeding	Germany ¹³	Lowland farmland	S/M	S/M	Up to 200 m
	Blyth ¹	Coastal	S	S	None
	Tjaereborg ²	Farmland	S	M	800 m
	Zeebrugge ¹⁴	Coastal	M	S/M	Up to 250 m
Gulls	Oosterbierum ¹⁵	Farmland	M	S	500 m
	Tjaereborg ²	Farmland	S	M	800 m
	Blyth ¹	Coastal	S	S	None
Terns	Zeebrugge ¹⁴	Coastal	M	S/M	None
	Blyth ¹	Coastal	S	S	None
Passerines	Various UK sites ¹²	Upland	S/M	S/M	None
	Buffalo Ridge ¹⁸	Grassland	VL	M	1-200 m
	Bryn Tytli ¹⁹	Upland moor	M	S	None
	Burgar Hill ²⁰	Upland moor	S	S	None
	Novar ^{21,23}	Upland moor	M	M	None

KEY

Sources: 1. Still *et al.* 1995; 2. Pedersen and Poulsen 1991; 3. Winkelman 1989; 4. Kowalik & Borbach-Jaene 2001; 5. Kruckenberg & Jaene 1999; 6. Larsen & Madsen 2000; 7. Percival 1998a; 8. James 2003; 9. Guillemette *et al.* 1998, 1999; 10. Pettersson & Stalin 2003; 11. Bullen Consultants 2002; 12. Thomas 1999; 13. Ketzenberg *et al.* 2002; 14. Everaert *et al.* 2002; 15. Winkelman 1992b; 16. Green 1995; 17. Thelander *et al.* 2003; 18. Leddy *et al.* 1999; 19. Phillips 1994; 20. Meek *et al.* 1993; 21. Bioscan 2001; 22. Percival & Percival 1998; 23. Percival 2002.

Windfarm size: VL = very large (>200 turbines); L = large (50-200 turbines); M = medium (10-50 turbines); S = small (<10 turbines).

Turbine type: L = large (>1.5 MW); M = medium (500 KW-1.5 MW); S = small (<500 KW).

Disturbance distance: 'None' indicates no significant disturbance effect; * disturbance noted during construction but not operation.

The data used in this assessment, including flight-path maps, are presented in the EIAR Appendix 7-4 Survey Data and, where appropriate, Appendix 7-5 Confidential Survey Data. As above, loughs and turloughs in the area were surveyed during the Waterbird Distribution and Abundance Surveys within 5km of the Proposed Wind Farm site during the 2019/2020, 2020/2021, 2021/2022, 2023/2024 and 2024/2025 winter and passage seasons (see Section 7.2.3.2.4 of the EIAR).

As detailed in the Section 7.6.1 of the EIAR, the turbine layout has been designed to avoid siting turbines in proximity to Horseleap Lough, which is utilised by whooper swan. The nearest turbine is over 800m from the wetland. This avoids habitat loss, ameliorates disturbance during construction and displacement during operation, and reduces the potential for collisions as birds fly to and from the wetland. In addition, Section 7.6.2 of the EIAR outlines a Construction and Environmental Management Plan with specific measures for all bird species using the Proposed Wind Farm site, including whooper swan.

2.6.4.4.2 *Golden Plover*

Submissions queried the mitigation methods proposed for golden plover.

Response

It is acknowledged that there has not been opportunity to test the effectiveness of tethered bird control kites in reducing collisions at wind farms. This method has been tested more extensively in deterring birds for crop protection and at reducing bird numbers/flyovers in airfields and landfill sites. However, the purpose of the kites is to deter golden plover from foraging or roosting on grassland within the turbine area, therefore such research applies in this context.

Response from MLavelle: This wasn't stated in the application & only excused in this FI after this author identified his experience with kites at landfills, where they were ineffective. Now the applicant states that the use of kites has not been tested. It is not acceptable to include a mitigation item without backup experience & scientific reports.

A Bird Monitoring Programme (EIAR Appendix 7-8) has been prepared to monitor the effectiveness of this mitigation plan by an appropriately qualified ecologist. The information collected during this monitoring will inform how this mitigation measure can be used in future.

Response from MLavelle: Absolute nonsense. The suggestion here is that an idea might be useful, but they have no experience or science to suggest it as a mitigation measure.

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 (Hötter 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 (Hötter 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 Hötter et al. (Hötter 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 (Hötter 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.

2.6.4.4.3 **Hen Harrier**

Submissions queried hen harrier collision risk and the lack of mitigation measures specifically proposed for this species.

As outlined in the EIAR Chapter 7 Section 7.5.2.2, a low effect significance was determined for direct habitat loss and disturbance/displacement, while a very low effect significance was determined for collision risk. No mitigation measures are specifically proposed for hen harrier, however, as detailed in the Section 7.6.1 of the EIAR, the turbine layout has been designed to avoid siting turbines in proximity to the regularly used hen harrier roost at Cloonboo More. The nearest turbine is over 700m from the section of bog habitat in which hen harrier are roosting. This avoids habitat loss at the bog, ameliorates disturbance during construction and displacement during operation, and reduces the potential for collisions as hen harrier enter and leave the roost. In addition, Section 7.6.2 of the EIAR outlines a Construction and Environmental Management Plan with specific measures for all bird species using the Proposed Wind Farm site, including hen harrier.

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.

2.6.4.4.4 **Barn Owl**

A submission queried the location of the data collected for barn owl and queried the impact of the Proposed Wind Farm on barn owl activity and habitat.

Response

All of the field survey data used in this assessment are presented in the EIAR Appendix 7-4 Survey Data and, where appropriate, Appendix 7-5 Confidential Survey Data. Records containing barn owl information such as potential roost sites are considered ecologically sensitive and placed in Appendix 7- 5 Confidential Survey Data. The significance of impacts to birds, including barn owl, is described in the EIAR Chapter 7 Section 7.5. This includes the impact of collision risk, disturbance/displacement and habitat loss.

2.6.4.4.5 **Curlew**

A submission queried the effects associated with curlew and how the development could impact the Curlew Conservation Programme for breeding curlew populations in Ireland.

Response

As stated in the EIAR Chapter 7 Section 7.3.7, there was no evidence of breeding curlew at the Proposed Wind Farm site during surveys.

2.6.4.4.6 **Ground-nesting Waders**

A submission queried the effects associated with ground-nesting waders including curlew, lapwing and snipe.

Response

As stated in the EIAR Chapter 7 Section 7.3.7, there was no evidence of breeding curlew at the Proposed Wind Farm site during surveys. Lapwing were breeding at Horseleap Lough and there was a probable breeding snipe territory in the Proposed Wind Farm site and a second to the north of the Proposed Wind Farm site. The potential effects of the development on both of these species has been assessed in full in Section 7.5.2 of the EIAR.

2.6.4.4.7 **Migratory Birds**

Submissions raised concerns about migratory birds using the site.

Response

A full description of the baseline avian community and their use of the site is presented in the EIAR Chapter 7 Section 7.3.7. Key ornithological receptors are identified in Section 7.4.2 and the potential impacts of the Proposed Wind Farm on these species are assessed in Section 7.5.2, including displacement and barrier effects and collision risk. The potential for the site to be used by migrating birds was considered at each of these stages. No significant displacement/barrier effect or collision risk was anticipated for birds on migration.

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.

2.6.4.4.8 **Wetland Birds**

A submission dated queried the inclusion of the BirdWatch Ireland sensitivity mapping tool in the assessment.

Response

The bird sensitivity mapping tool was included in the assessment desk study in the EIAR Chapter 7 Section 7.3.3.

[Response from MLavelle: Bird counts were not conducted during the Greenland White fronted Geese migratory period.](#)

2.6.4.4.9 **Farmland Birds**

A submission highlighted the Farmland Bird Hotpot Mapping Report produced by BirdWatch Ireland, which was not included in the desk study for this EIAR. A submission also queried the impact on corncrake conservation efforts.

Response

This report analysed 28 species of farmland bird from a number of different data sources and developed a bird hotspot map in for Ireland. Of the 28 species analysed, 26 were considered ‘target’ species during field surveys for the Proposed Wind Farm (all species listed under Annex I, on the Birds of Conservation Concern in Ireland Red List, and/or a species of raptor, waterbird, groundbird) and detailed information was collected for these species if they were encountered during surveys. In addition, the presence of all other species (including the remaining 2 species of farmland bird in the report, skylark and tree sparrow) was recorded if they were encountered during Vantage Point Surveys, Breeding Walkover Surveys and Winter Walkover Surveys. As such, the baseline conditions for farmland birds was described using the field data collected over multiple breeding seasons of survey.

The impact assessment then considered species of conservation interest for which significant effects of habitat loss, disturbance/displacement and collision risk may occur.

Corncrake declines in Ireland are mainly associated with the mechanisation of mowing and the switch from hay to silage making. A corncrake reintroduction programme is not underway at the Proposed Wind Farm site.

2.7 Land, Soils, Geology

This section of the response has been prepared by Gavin & Doherty Geosolutions (GDG) who prepared the Peat and Spoil Management Plan (Appendix 4-2), Peat Stability Risk Assessment (Appendix 8-1) and Karst Risk Assessment (Appendix 8-2) of the EIAR.

A number of third-party submissions raise concern in relation to peat stability and the karst risk assessment of the Proposed Wind Farm site. Responses to these third-party observations has been prepared and is included in Appendix 1 ‘GDG Response’ of this response document.

The following observations are addressed by GDG in detail in Appendix 1:

Peat Stability

Karst Risk Assessment

2.8 Hydrology and Hydrogeology

This section of the response document has been prepared by Hydro-Environmental Services (HES) who prepared Chapter 8 Land Soils and Geology and Chapter 9 Hydrology and Hydrogeology of the EIAR.

A number of third-party submissions raise concern in relation relating to the water, land, soils and geological environment. Responses to these third-party observations has been prepared and is included in Appendix 2 ‘HES Response’ of this response document. Effects on local group water scheme supplies;

- Surface water and groundwater quality affects;
- Potential effects on local private wells;
- Potential impacts on Lough Corrib SAC; and,
- Potential Increased flood risk

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.

2.9 Noise

This section of the response document has been prepared by TNEI Ireland Ltd. who prepared Chapter 12 Noise and Vibration of the EIAR.

A number of third-party submissions raise concern in relation to noise effects due to the construction and operation of the Proposed Project. Responses to noise related observations has been prepared and is included in Appendix 3 'TNEI Response' of this response document.

The following third-party observations are addressed in full in Appendix 3:

- Noise assessment standards, guidelines and legislation
- Health impacts from noise pollution
- Low Frequency Noise (LFN) and infrasound
- Amplitude Modulation (AM)
- Potential impacts on animals (livestock)
- BESS noise
- Construction noise
- Vibration

2.10 Climate

A number of third-party submissions raised concerns centred on the climatic impacts of the Proposed Project in relation to:

- Drainage and excavation of peatlands
- Deforestation
- Carbon calculations

Response

Drainage and excavation of peatlands

The construction of the Proposed Project will involve the drainage and excavation of peatlands. As outlined in Table 8-16 in Section 8.5.2.1 in Chapter 8 of the EIAR, there is 42 hectares (ha) of 'Cutover Bog' within the lands of the Proposed Project – of which, 2.12ha or 5% will be lost. The drainage and excavation of peat soils will give rise to emissions due to the loss of 'carbon fixing potential from plants on peat land' as stated in Section 11.4.2 in Chapter 11 of the EIAR. Section 11.4.2 describes the methodology used for calculating the losses of carbon associated with the Proposed Project. The assessment has used the Macauley Institute carbon calculator for the purposes of this assessment, and the results have been included in Appendix 11-2 of the EIAR, 'Carbon Calculations'.

The carbon balance of proposed wind farm developments in peatland habitats has attracted significant attention in recent years. When developments such as wind farms are proposed for peatland areas, there will

be direct impacts and loss of peat in the area of the development footprint. There may also be indirect impacts where it is necessary to install drainage in certain areas to facilitate construction.

The works can either directly or indirectly allow the peat to dry out, locally, which permits the full decomposition of the stored organic material with the associated release of the stored carbon as CO₂. It is essential therefore that any wind farm development in a peatland area saves more CO₂ than is released. The Proposed Project is situated in predominantly cutover bog, coniferous forestry and agricultural land. For this reason, the carbon balance between the use of renewable energy and the loss of carbon stored in the peat are assessed in Section 11.4.3.1 of the EIAR.

As outlined in Section 11.4.3.1 in Chapter 11 of the EIAR, The figure of 17,555 tonnes of CO₂ arising from ground activities associated with the Proposed Project is calculated based on the entire Proposed Project development footprint being in “Acid Bog”, as this is one of only two choices the model allows (the other being Fen). The habitat that will be impacted by the development footprint comprises a mix of peatland, coniferous forestry, native woodland, and pastoral agriculture land rather than acid bog, as assumed by the model. The value of 17,555 tonnes of CO₂ arising from ground activities in ‘Acid Bog’ is under a precautionary scenario, and therefore the actual CO₂ losses are expected to be lower than this value.

Deforestation

The construction of the Proposed Project will result in the deforestation of conifer plantations, broadleaved woodland, scrub habitat and hedgerows. As outlined in Table 6-19 in Chapter 6 of the EIAR, the extent of habitat loss to the Proposed Project is listed as well as the percentage of the total area of that habitat on Site. With regard to the loss of trees, scrub and hedgerows, the following figures are given within Table 6-19:

- Scrub (WS1) - 0.06ha Lost to the Proposed Project
- Conifer Plantation (WD4) - 11.25ha Lost to the Proposed Project
- Broadleaved Woodland (WD1) - 0.17ha Lost to the Proposed Project
- Hedgerow (WL1) and associated stone walls (BL1) - 3.21km Lost to the Proposed Project
- Treeline (WL2) - 0.53km Lost to the Proposed Project

A Biodiversity Enhancement Management Plan (BEMP), included in Appendix 6-4 of the EIAR, states the mitigation measures that will be implemented in the event of the Proposed Project being granted and constructed. The same measures are also described in relation to Broadleaved Woodland (WD1) and Hedgerows, Treelines and Stone walls. Outlined in Section 3 of the BEMP, the proposed biodiversity measures will include protection of existing high value habitats and the creation and maintenance of newly created habitats on-site. Stated in Section 3.2.1 of the BEMP, approximately 1.2km of riparian fencing and planting of native tree species, such as willow and alder, will occur to protect waterbodies and strengthen riverbank stability. In Section 3.2.4 of the BEMP, it is proposed that a number of uncut raised bog (PB1) and regenerating cutover bog (PB4) habitats, which have started to recolonise with scrub, will be allowed to regenerate into what is expected will become bog woodland habitat. In Section 3.3.1 of BEMP, it is stated that approximately 3.74km of linear features will be lost due to the Proposed Project. It is proposed that 4.7km of hedgerows will be planted within the Proposed Wind Farm – resulting in a net gain of 960m in linear habitats. The addition of 960m of new linear features equates to a 26% increase of such habitats across the Site. The proposed sections of hedgerow planting have been designed in order to strategically link up existing areas that have known bat activity thus increasing the connectivity of the Site.

Stated in Section 3.3.2 of the BEMP, it is proposed that an area of 11.25ha of conifer woodland will be lost across the Site. It is also proposed that 11.5ha of native broadleaved woodland will be planted across the Site with a maintenance schedule implemented to ensure the establishment of the planting scheme is a success. The proposed measures in relation to afforestation and planting, once established, will increase the carbon storage capacity of the Proposed Project.

Carbon Calculations

Chapter 11: Climate of the EIAR identifies, describes, and assesses the potential direct and indirect effects on climate arising from the construction, operation and decommissioning of the Proposed Project and has been completed in accordance with the EIA guidance and legislation set out in Chapter 1: Introduction. The objective of this assessment is to assess the potential effects that the Proposed Project may have on Climate and sets out proposed mitigation measures to avoid, reduce or offset any potential significant effects that are identified.

As mentioned above, the carbon balance of wind farm developments in peatland habitats has attracted significant attention in recent years. When developments such as wind farms are proposed for peatland areas, there will be direct impacts and loss of peat in the area of the development footprint. There may also be indirect impacts where it is necessary to install drainage in certain areas to facilitate construction, or from the reinstatement of extracted peat. The works can either directly or indirectly allow the peat to dry out, locally, which permits the full decomposition of the stored organic material with the associated release of the stored carbon as CO₂. It is essential therefore that any wind farm development in a peatland area saves more CO₂ than is released. To assess the carbon losses and carbon savings, Section 11.4.3 of Chapter 11 states the Scottish Government's online carbon calculator was used for the purposes of this assessment. The potential for losses and savings takes into account peat removal and reinstatement, drainage, habitat improvement, felling and site restoration. In relation to embodied carbon and associated transport movements of all other ancillary elements of the Proposed Project, the TII Carbon Tool has been utilised to assess the impacts of the Proposed Project in terms of potential carbon losses in regard to construction phase transport emissions and embodied carbon. The worksheet models and online tools calculate that the Proposed Project will give rise to 145,705 tonnes of CO₂ equivalent losses over its 35-year life. Of this total figure, the Proposed Wind Farm site turbines directly account for 54,656 tonnes, or 38%. Losses due to backup account for 40,949 tonnes, or 28%. Losses from reduced carbon fixing potential accounts for 1.1% or 1,656 tonnes. Losses from soil organic matter, i.e., CO₂ loss from disturbed soil and subsoils, will equate to 17,555 tonnes, or 12%. Losses due to tree felling account for 4,981 tonnes or 3.4%. Losses due to embodied carbon accounts for 25,603 tonnes or 17.6% and losses due to construction phase transport emissions accounts for 0.2% or 304 tonnes. Section 11.4.3.2 of Chapter 11 in the EIAR, outlines the projected reduction in carbon dioxide emissions as a result of the Proposed Wind Farm generating electricity and offsetting the fossil fuels sources that would've been required to generate electricity in the absence of the Proposed Wind Farm. Based on the calculation with project specific information included such as the rated capacity of the entire development, 39,462 tonnes of carbon dioxide will be displaced per annum from largely carbon-based traditional energy mix by the Proposed Wind Farm site. Over the proposed 35- year lifetime of the development, therefore 1,381,176 tonnes of carbon dioxide will be displaced from traditional carbon-based electricity generation. Based on the Scottish Government carbon calculator as presented above in Section 11.4.3.1 in Chapter 11 of the EIAR, approximately 145,705 tonnes of CO₂ will be lost to the atmosphere due to changes in the soil and ground conditions and due to the construction and operation of the Proposed Project. This represents 11% of the total amount of carbon dioxide emissions that will be offset by the Proposed Project. The 72,211 tonnes of CO₂ that will be lost to the atmosphere due to changes in soil and ground conditions and due to the construction and operation of the Proposed Project will be offset by the Proposed Wind Farm site in approximately 44 months (3.6 years) of operation. As stated in Section 11.5.3.1 of Chapter 11 in the EIAR, there will be a Long-term moderate positive effect on Climate as a result of reduced greenhouse gas emissions. [Response from MLavelle: The carbon calculator model is referred to, but its calculations were not included with the application.](#)

2.11 Landscape and Visual

A number of third-party observations raise concerns about the landscape and visual impact of the proposed turbines would have on the receiving environment. The submissions reference the size and scale of the proposed turbines in a rural landscape will alter the character of the wider area.

Furthermore, the size and scale of the proposed turbines would result in an industrialisation of what is a rural landscape and overwhelm the character of the area. Several observations raise the cumulative impact of the Proposed Project due to a number of other proposed wind energy developments in the North and East Galway area submitted to the planning system or currently in design. One submission makes the point that aviation lighting atop of the proposed turbines would add "skyglow and visual intrusion beyond daylight hours."

The observations from third-parties claim that the proposed turbines are too large of a size and scale for

a rural landscape of East Galway. This LVIA EIAR has followed the current industry best practice guidance, as listed in Section 1.3 of Appendix 13-1 of the EIAR LVIA. While following guidance from the WEDGs (2006) and Draft WEDGs (2019), the EIAR has also followed EPA (2022) guidance in the assessment of effects of the proposed turbines.

As outlined in 13.7.3.2.6 in Chapter 13 of the EIAR, during multiple surveys conducted in 2021, 2022, 2023 and 2024, visibility appraisals determined that most visibility of the proposed turbines will occur within 1-3km of the proposed turbines. This area is a modified working and settled landscape with residential housing organised along the local road network, as well as small settlement clusters around local crossroads and junctions. Some residential receptors located in close proximity to the Proposed Wind Farm site will likely have views of the proposed turbines and are likely to have the greatest visual effects arising as a result of the Proposed Wind Farm. The Proposed Project exceeds the recommended 500m set-back distance in the 2006 Guidelines and also the 4-times-tip-height set-back distance ($4 \times 180\text{m} = 720\text{m}$) explicitly set out for residential amenity prescribed by the draft 2019 Guidelines

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 [1–11]. In addition to technological and economic factors [1–4,10,12], 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 [13–22]. Among them, an important element is the impact of wind farms on the landscape [1–4,13,15–40]. 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.

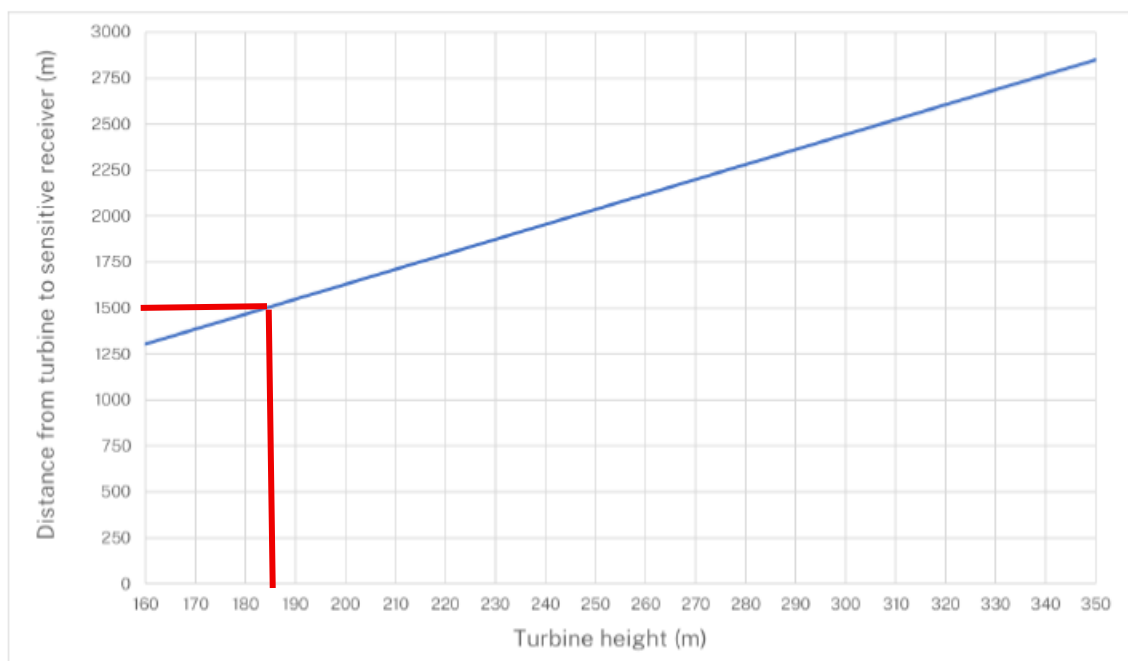


Figure 2. Setback from sensitive receivers

Response from MLavelle: For a sensitive receptor & 185m turbine height, the setback distance should be 1.5km.

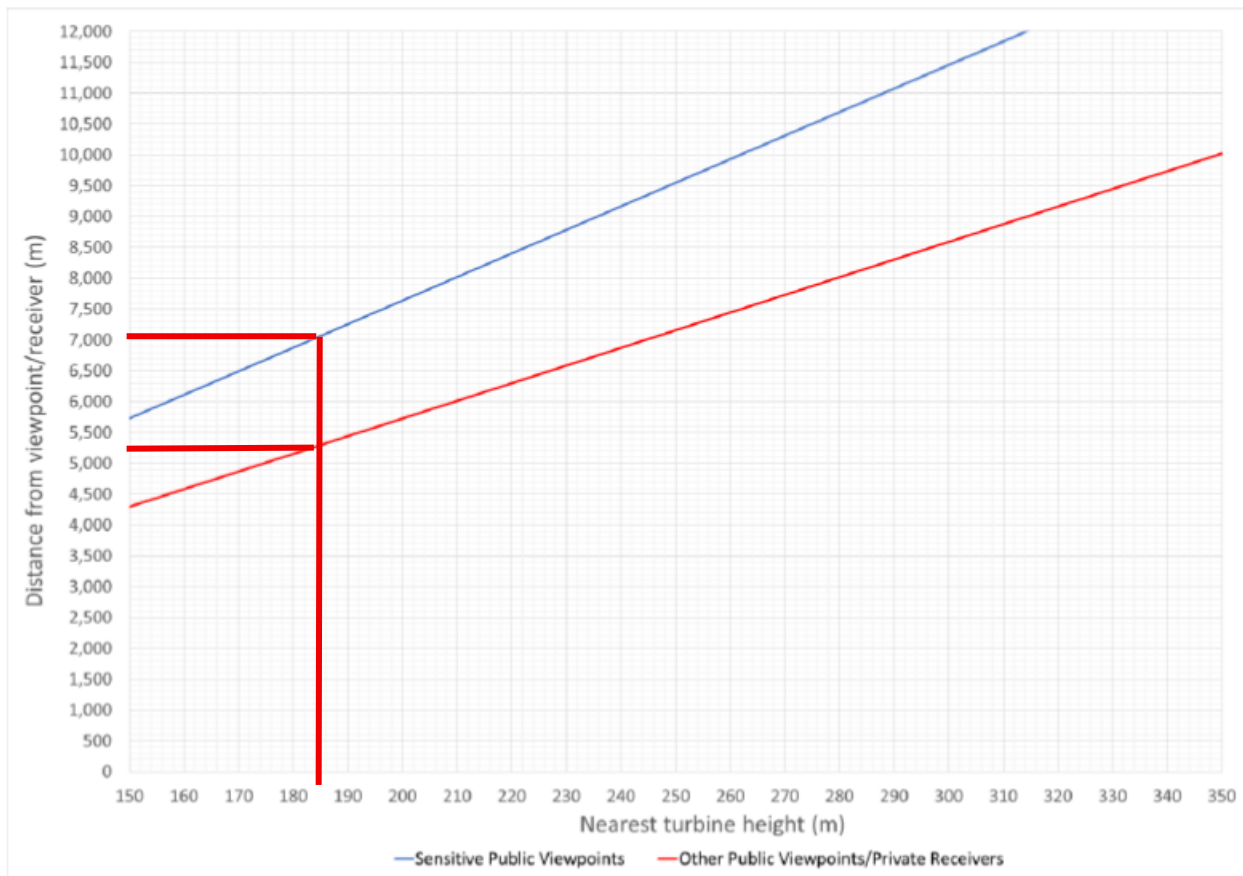


Figure 7. Extent of the scoping study area

Response from MLavelle: For a sensitive public viewpoint & 185m turbine height, the setback distance should be 7.1km. For other viewpoints, the setback should be 5.25km.

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.

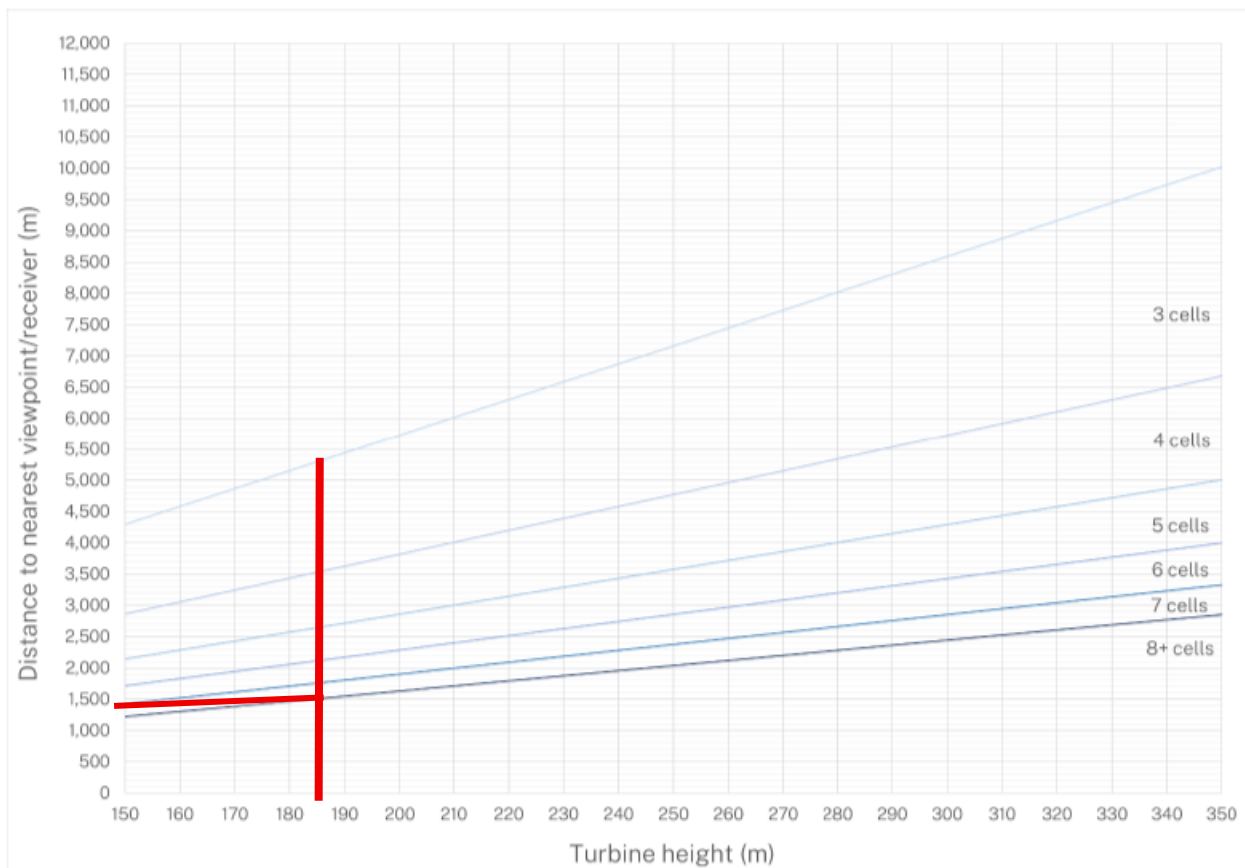


Figure 10. Potential vertical magnitude

Response from MLavelle: *For a windfarm with more than 8 turbines, the setback should be 1.5km.*

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:

- The large scale of the investments (large size, concentration, and extent) in relation to the scale and carrying capacity of the landscape;
- Negative impacts on avifauna, fossil records, Natura 2000 areas, and sensitive ecosystems;
- Potential degradation of slow and sustainable tourism, including ecotourism, agritourism, and cultural tourism;
- Adverse effects on the sustainable management of natural and cultural resources, such as agriculture and livestock farming;
- Detrimental consequences for both natural and cultural heritage;
- The significant profits garnered by wind energy companies through exploitation of the 'commons', potentially deepening socio-economic inequalities;
- Disruption of prospects for localized sustainable development;
- Inadequate provision of information and the lack of meaningful public consultation and engagement from the outset;
- Depreciation of land values in affected areas;
- Generation of surplus electricity primarily intended for export rather than local use;
- The relatively small number of job opportunities created in the wind energy sector;
- General lack of public involvement and democratic deliberation;
- 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; Tesfahunegn *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 (Terkentli, 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 (Świdnyńska *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	Misalignment between wind energy expansion
		visual integration and spatial dissonance.	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	Privatization of public lands often leased at low cost to private investors
		environmental goals (climate change), often at the expense of local communities.	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	Widespread installations in areas of cultural or national importance,
		landscapes, erasing the connection between people and their historical environment.	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
Experiential dimension of the landscape	Site-Specific Barriers	Context-dependent and unique challenges that vary by location, tied to specific landscapes or environmental conditions.	
	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, rock climbing, mountain biking) may be hindered by the presence of large-scale wind farms.	Decline in ecotourism and agrotourism activities due to the presence of turbines 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.

Given Ireland's renewable energy targets which have been set by the State for onshore renewable wind energy development, wind turbines will form a new component in the working landscape for the foreseeable future. The focus for visual impact assessment of wind energy developments is therefore distance, arrangement, location and potential disruption to key scenic sensitivities rather than a commonly misconceived focus on whether turbines are visible or not from a particular vantage point.

The outcome of the visual impact assessment, with regards to the EPA (2022) definition of significance, is calibrated in the overall context of LVIA of wind energy developments in Ireland and what is acceptable in the context of emerging baseline trends and the acceptability of wind turbines within views as a result of national policy.

Over time, wind turbines have, and will become, a more familiar and accepted component of the Irish landscape, particularly in working rural contexts.

[Response from MLavelle: Where is the "accepted component" documented & by whom? My contacts are diametrically opposed to this position with protests & potential conflicts planned.](#)

Accordingly, their presence may not carry the same level of perceived visual intrusion as less common or incongruous forms of development.

[Response from MLavelle: What are the less common or incongruous forms of development?](#)

In this context, the calibration of visual impact significance reflects both the policy-driven imperative for renewable energy development and the evolving visual baseline in parts of the Irish landscape.

[Response from MLavelle: There is no policy-driven imperative or evolving visual baseline.](#)

While the visibility of turbines remains an important consideration, it does not in itself equate to significant visual impact.

[Response from MLavelle: Who determined that it doesn't equate to significant visual impact?](#)

As outlined in Section 13.7.3.1.1 of Chapter 13 of the EIAR, the landscape of the Proposed Wind Farm will undergo changes by the introduction of the proposed turbines as vertical, man-made structures within the material area of the site. This will result in a ‘Substantial’ magnitude of change to the landscape in localised areas within the Site, however, as per the landscape classifications outlined in the Galway County Development Plan 2022-2028, the proposed turbines are located within an area classified as ‘Low’ sensitivity. The proposed turbines are located within a landscape of the same general type and character – that of modified working landscape comprising agricultural fields, commercial forestry and cutover bogs – which are landscape types effectively capable of absorbing wind energy development. Considering the overall “Low” landscape sensitivity rating (lowest rating in Co. Galway) of both the Proposed Wind Farm site and the entire LVIA Study Area, it is relevant that all proposed turbines are sited within similar landscape types which have been assessed and concluded as being effectively capable of absorbing the development.

[Response from MLavelle: The Elected Members of most County Councils are now rejecting this position & it is more than likely that they will exclude them from future County Development Plans.](#)

The Biodiversity Management and Enhancement Plan (BMEP) included as Appendix 6-4 of the EIAR will have the dual effect of providing ecological enhancement to the landscape area of the Proposed Wind Farm site as well as potential screening of some lower lying infrastructure of the Proposed Wind Farm, thereby ultimately mitigating effects on landscape character during the operational phase.

As outlined in Section 15.2.4.4.2 of Chapter 15 of the EIAR, contained within the scoping replies from the Department of Defence (DOD) and the Irish Aviation Authority (IAA), they outline that the Applicant should be conditioned by the consenting planning authority to incorporate obstacle warning lighting scheme on the proposed turbines in the interest of aviation safety. As stated in Section 15.2.6.3.2 in Chapter 15, the Proposed Project will comply with the requests by DOD and IAA regarding aviation safety measures.

2.12 Cultural Heritage

This section of the response has been prepared by IAC Archaeology Ltd who prepared Chapter 14 Cultural Heritage of the EIAR.

A number of third-party submissions to the Commission make observations relating to archaeology and cultural heritage, namely concerns regarding direct and indirect effects on local heritage and potential unmapped or buried archaeological feature in the area.

2.12.1 Historical Sites Missed in the EIAR

The Collective in their submission draw attention to “many historical sites of interest which are located in close proximity to the Proposed Wind Farm, but which are not marked on the maps produced by the developer.” The submission lists the following sites:

Former hedge school located at 53.5111716, -8.6734016, which is located 0.7km from turbine 7. It is not marked in the developer’s map but is marked in older ordnance survey maps.

The burial plot of a monk, who according to local knowledge died on a day when there was heavy snow and couldn’t be transported to the graveyard so was buried at 53.5044248, -8.6700220 known as the ‘Bráthar’s Grave’ which is a mere 640m from Turbine 7.

Children’s burial ground located in Cloondahamper, a plaque remembering the children buried there is displayed on the grounds of St. Mary’s Church Killrerin located at 53.5063568, -8.6731834, some 0.4km from Turbine 7 but is not marked in the developer’s map.

Children’s Burial Ground known as the Killaughan which is located 53.5061189 – 8.6587611 which is 0.59km from turbine 9. This is located within a ring fort (centre point 53.5063568 – 8.6591638).

Close proximity to this structure there exists a hill fort at 53.5072892 – 8.6572725 which consists of a hill with two hawthorn bushes on top of it. A stone wall runs up through the middle of the fort. This is 0.67km from turbine 9. Only one of these forts is marked in the developer’s map.

Remnants of a famine road exist in Cooloo bog, which is barely identifiable today, but very visible in older ordnance survey maps. It is located at 53.4988926 – 8.6496624, some 0.43 km from turbine 9. This is not marked in the developer’s map.

Another submission notes the presence/evidence of an old railway line through the bog from the direction of Turbine 9.

Concerns were raised over the IAC's statement that "previously unknown archaeological sites and features could be directly negatively effected by the construction of the proposed project", lacks confidence that historical remains will be protected and recorded once the construction phase commences.

Response

A building is marked on the 1837 OS map at the location of the former hedge school described in the submission. The building is removed by the time of the 1892 OS map and there are no upstanding remains visible on aerial photography. As the building is located outside of the Proposed Project and is located in private land, it was not subject to a field inspection. If the building is still standing, as suggested by the Collective, it has a medium sensitivity. The nearest turbine (T07) is located c. 0.9km to the south-southeast, which will have an indirect negative effect on the building during the operation of the proposed wind farm site. The magnitude of this effect is low, which will result in a slight significance of effect.

The submission describes the burial plot of a monk, known as 'Bráthar's Grave'. No specific information relating to this site can be found and it is not recorded on published registers. The information in the submission is contradictory when describing its location. The provided grid reference is c. 190m to the north of T07, but the submission notes that it is 640m from T07. Without further information the location cannot be determined. The site is not shown on the cartographic sources at the grid reference provided in the submission. The nature of the site is also not described, and it is unclear if there is a grave marker or associated features. Without further information it is not possible to accurately assess likely effects, although it should be noted that the effects are unlikely to be significant.

The submission describes a children's burial ground in Cloondahamper townland. A roughly circular anomaly is visible on aerial photography c. 40m to the north of the location provided in the submission.

This may be the children's burial ground referred to, although it is not recorded on any of the cartographic sources or published registers of sites used in the compilation of the chapter. If this is the location of a children's burial ground, it has a high sensitivity. The nearest turbine (T07) is located c. 0.5km to the southeast of the site, which will have an indirect negative effect of medium magnitude building during the operation of the proposed wind farm site. This will result in a moderate significance of effect.

The submission describes a second children's burial ground, located in Cloonascragh townland and known as Killaguhan. This site is recorded in the chapter as AH93, which consists of the following recorded monuments: children's burial ground; ecclesiastical enclosure; bullaun stone. AH93 has a high sensitivity, and the nearest turbine (T07) is located c. 0.8km to the southwest of the site, which will have an indirect negative effect of medium magnitude building during the operation of the proposed wind farm site. This will result in a moderate significance of effect.

The submission describes a hill fort. The site described is a ringfort, recorded in the chapter as AH92. AH92 has a high sensitivity, and the nearest turbine (T07) is located c. 0.9km to the southwest of the site, which will have an indirect negative effect of medium magnitude building during the operation of the proposed wind farm site. This will result in a moderate significance of effect.

The submission describes a famine road in Cooloo Bog. An ephemeral track can be seen at this location on aerial photography, shown to be leading to an area of peat cutting and measuring c. 50m in length. As assessment of the cartographic sources used in the compilation of the chapter, including the historic Ordnance Survey maps, do not show tracks or roads at this location. As the track is not depicted on the cartographic sources its age cannot be determined. If the track seen on aerial photography is an unmarked famine road it has a medium sensitivity, and the operation of the proposed wind farm site will have an indirect negative effect of medium magnitude. This will result in a moderate significance of effect.

The submission also describes an old railway line that passes through the bog from T09. This is not shown on the cartographic sources or published registers at the location described in the submission.

This location was visited during the site inspection, and no evidence of a railway line was seen.

In relation to proposed mitigation measures, It is not possible to know the extent of potential previously unrecorded sub-surface archaeological features with no surface expression, and it is possible that there are previously unrecorded features within the proposed wind farm site. This statement applies to all greenfield

sites throughout the country, due to the nature of buried archaeological features. The Proposed Project does not directly affect any recorded archaeological monuments.

In chapter 14 Section 14.4.2, Several appropriate mitigation measures have been proposed to ensure that any potential sub-surface archaeological features are identified and recorded/preserved. The proposed mitigation strategy of test trenching prior to construction, as well as monitoring of ground disturbances, is appropriate for the development and the impacts identified. As noted in the chapter, further mitigation may be required, such as preservation by record or in-situ and/or archaeological monitoring. Any further mitigation will require agreement from the DHLGH (Department of Housing, Local Government and Heritage). These mitigation measures form part of all large-scale developments in the country, including other wind farm developments, and the developer has committed to the mitigation.

It is also noted that in the response from the Department of Housing, Local Government and Heritage (DoHLGH) and GCC that they are in agreement with the mitigation as laid out in the chapter.

As identified in Section 14.4.2 of Chapter 14 of the EIAR it is the view of MKO that the significance of effects associated with the construction of the Proposed Project remains as such "Following the completion of the mitigation measures, there will be no significant negative residual effects on the archaeological, architectural and cultural heritage resource."

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.

Response from MLavelle: The Cooloo Bog is part of the Cultural Heritage of the area. The bog is a 10,000 year old feature from the last ice age. It represents a way of life for centuries as the harvested turf provided heating & cooking plus light. The installation of a windfarm with foundations, structures, roads, etc. destroys this culture.

2.13 Traffic and Road Safety

In addition to the Collective, several third-party observations are made regarding concerns over road safety and traffic impacts as a result of the Proposed Project. Observations are made under the following themes:

- Traffic and transport assessment
- Damage to Local Roads
- Road safety
- Disruption to Local Traffic
- Road Labelling

This section of the response document was prepared by MKO in consultation with Alan Lipscombe Traffic and Transport Consultants Ltd, whom together prepared Chapter 15.1 – Traffic and Transport, of the EIAR.

2.13.1 Traffic and Transport Assessment

Several submissions including noted that the traffic and transport assessment included within the EIAR was insufficient, and raised concerns over the traffic count surveys conducted over one day during the summer months (i.e., during the school holidays) results in a defective baseline and that the EIAR understates the impact on local road users as school traffic was not accounted for within the assessment.

They state that the traffic management plan (TMP) omits quantitative data such as expected abnormal load numbers, peak-phase traffic volumes, and route-specific scheduling required to evaluate construction impacts. The observations also claim the TMP fails to model cumulative or worst-case haulage scenarios, nor does it include enforceable mitigation measures for school transport, farm access or local business continuity.

Response

The traffic and transport section of the EIAR (Chapter 15.1) has been completed in accordance with the EIA guidance set out in Chapter 1 Section 1.2. The assessment uses standard terminology to describe the likely significant effects associated with the Proposed Project. Further information on the classification of effects used in this assessment is presented in Section 1.7.2 of this EIAR. With respect to the assessment of traffic effects, all relevant TII guidelines and policies have been taken into account in the preparation of the traffic and transport assessment included in Chapter 15 of the EIAR, including the following;

PE-PDV-02045, Traffic and Transport Assessment Guidelines, Transport Infrastructure Ireland, May 2014

PE-PAG-02017, Project Appraisal Guidelines, Unit 5.3, Travel Demand Projections, Transport Infrastructure Ireland, October 2021

DN-GEO-03060, Geometric Design of junctions, Transport Infrastructure Ireland, May 2023.

The traffic and transport assessment of the Proposed Project is therefore considered robust and adequate in line with best practice guidance for inclusion within the EIAR.

As detailed in Section 15.1.3 in the EIAR, traffic counts were obtained from **24 hour classified turning count** surveys undertaken at the N63 south of Annagh Cross, N63 east of Annagh Cross, N63 south of Brierfield and R332 approaching the Proposed Wind Farm site. The counts were undertaken on **Tuesday 8th July, 2025** by Traffinomics Ltd.

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 site entrances. No reliance can be made on the traffic guesswork submitted.

A 24 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.

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.

All base year 2025 traffic count data is included as Appendix 15-1 of the EIAR. The base year 2025 traffic volumes on the turbine delivery route (TDR), haul routes and Proposed Grid Connection were observed from the traffic surveys in July 2025. The background traffic forecasts for the construction year 2028 were determined from TII growth forecasts and are detailed in Section 15.1.3.2 of the EIAR.

The issue of traffic counts that may be suitable to use as baseline data for the traffic assessment presented in the EIAR is mentioned under the headings “2.3.1 Scoping” and “2.6 Useful Transport Data Sources” in TII’s Traffic and Transport Assessment Guidelines (PE-PDV-02045, May 2014).

The relevant points to note are that the assessment/counts;

Should take account of the nature of the development and the likely peak periods of trip generation.

o On this point it is noted that while traffic in urban areas may peak during school term, in rural areas trips may peak at other times due to other trip purposes (tourism, agriculture activity etc), May use the TII automatic

traffic count sites to identify suitable survey periods (or if required apply a seasonal adjustment), and, May be collected using classified turning counts, as was the case for the EIAR.

Based on the above, the Proposed Wind Farm site is located in a rural area and as such is not expected to incur the same impacts of school related traffic as urban areas. As indicated as a valid data source in the guidelines a TII Automatic Count Site located near the Proposed Wind Farm site (N63 at Derreen between Roscommon and Claregalway) was used to assess the seasonal variation in traffic volumes adjacent to the site. An assessment of the TII data on the N63 indicates that traffic volumes observed during July were the 4th highest month of the year, and that they were higher than many of the peak school months, and also higher than the average month. On this basis it was considered that the base year traffic data collected in July was valid and that no seasonal adjustment was required.

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
- If 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 to 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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 Most people we meet hate turbines
 Potential visitors are put off because the inland areas they visit have been blighted by wind-turbines
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 Will direct investment to other parts of the country
 People come to Northumberland to 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!
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 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

5.4.2 Health

Estimates of the additional traffic volumes that will be generated by the Proposed Project are set out in Section 15.1.4.1 of the EIAR for the construction and operational phase, inclusive of total truck loads for all Proposed Project elements and abnormal load deliveries associated with proposed turbines. An assessment of the impacts on link capacity on the TDR and construction materials transport routes is set out for the construction phase in Sections 15.1.6.1 to 15.1.6.3, with a detailed junction capacity assessment of the impacts of the Proposed Project on the junction that will be most affected by the Proposed Project, the N63/R332 junction, included in Section 15.1.6.3. The same information for the operational phase is provided in Sections 15.1.6.4 with respect to the impacts on link flows.

Traffic impacts and diversion routes identified for the Proposed Grid Connection works are included in Section 15.1.7 of the EIAR. Sections along the Proposed Grid Connection where there will be road and pedestrian footpath closures and traffic diversions are identified. An inspection of the route would indicate that the significant majority of the route will require a road closure at the point of construction during the construction of the underground cable route. A precautionary scenario where a road closure will be required for the entire route is assumed for the purpose of the assessment. For the diversion routes shown identified in Section 15.1.7 of the EIAR, the temporary additional trip length incurred by drivers during the construction of the Proposed Grid Connection will range from a minimum of 0.9km to a maximum of 13.7km. It should also be noted that the length of the diversion routes shown for the various sections of the Proposed Grid Connection are the longest that may be incurred, measured from either end of the section being constructed, and that in practice, many drivers undertaking longer trips will divert onto other parallel routes further afield to avoid the closure, incurring shorter actual diversions.

An assessment of cumulative effects on traffic is outlined in Chapter 15 Section 15.1.12.7 of the EIAR following the TII Traffic and Transport Assessment Guidelines, PE-PDV-02045, May 2014 to determine which of the developments will have a cumulative impact with the Proposed Project, which is a function of the level of increase on traffic volumes that may be experienced on a common road network. Of the 4 no. other permitted and proposed wind farm developments within a 25 km buffer zone around the Proposed Project considered to have potential traffic related cumulative impacts as set out in Table 15- 28, one development (permitted Cloonlusk Wind Farm) has high potential for cumulative impacts with the Proposed Project, due to the high level of overlap of the turbine delivery and general construction routes. It is therefore proposed that the

construction phase of the Proposed Project will be scheduled, where possible, to avoid the construction phases of this development. This will ensure that the potential for cumulative effects is minimised. In the event that the construction phase of the Proposed Project overlaps with that of the Cloonlusk Wind Farm it is estimated that the cumulative impacts will be negative, short term and will be slight, which is not significant. The purpose of the TMP is to set out traffic management measures that the Applicant will commit to provide during the construction stage of the Proposed Project. The successful completion of the Proposed Project will require significant coordination and planning and a comprehensive set of mitigation measures will be put in place before, and during the construction stage, in order to minimise the effects of the additional traffic generated on the surrounding road network. Quantitative data including abnormal load numbers and peak-phase traffic volumes are outlined in Chapter 15 Section 15.1.6 of the EIAR, which has formed the basis of the identified traffic management measures within the TMP.

A detailed TMP will be finalised and confirmatory detailed provisions in respect of traffic management agreed with the Roads Authorities and An Garda Síochána prior to construction works commencing on site. The implementation of the mitigation measures included in the proposed TMP will ensure a controlled and efficient operation during the construction phase, and minimise the impacts on local road users.

2.13.2 Damage to Local Roads

Several third-party observations raised concerns with the damage to local roads due to abnormal loads associated with construction of the Proposed Project and claim that there is no robust plan for road strengthening, maintenance or reinstatement despite the vulnerability of the narrow rural road network near Barnaderg and Cooloo which lack the capacity for large turbine transport without pre-works strengthening or verge reinforcement.

Response

The turbine delivery vehicles for the construction phase of the Proposed Project have been modelled in the swept path assessments for the Site, as detailed in Chapter 15 of the EIAR. It should also **be noted that while there will be abnormally sized vehicles associated with the Proposed Project, all axle loads will be within weight accepted limits.**

As outlined in Table 15-1a of Chapter 15 of the EIAR, roads condition surveys pre-construction surveys will be completed in accordance with TII recommendations and requirements of GCC Roads Department. A pre-condition survey of roads associated with the Proposed Project will be carried out prior to construction commencement to record the condition of the roads. A post construction survey will be carried out after works are completed. Where required the extent and timing of these surveys will be agreed with the local authority, as set out in the Traffic Management Measures, included set out in Section 15.1.12.5 of Chapter 15 of the EIAR. All road surfaces and boundaries will be re-instated to pre-development condition, as agreed with the local authority engineers. All works will be done in accordance with the Guidelines for the Opening, Backfilling and Reinstatement of Openings in Public Roads, DTToS, September 2015.

It is noted that a financial security to secure the reinstatement of public roads which may be damaged by the transport of materials to the site is typically conditioned should the Commission decide to grant permission. The Applicant welcomes any such condition should permission be granted.

2.13.3 Road Safety

2.13.3.1 Abnormal Loads

A number of third-party observations contained concerns about the movement of abnormal loads and construction machinery on rural road network, and claim no clear evidence has been provided to demonstrate that the local road network is physically capable of safely accommodating the delivery of abnormal turbine components, nor that alternative haul routes were properly considered or discounted.

Response

With regard to the geometric assessment of the road network, a detailed swept path analysis, using specialist software, was undertaken for the blade and tower transport vehicles at all potential pinch points on the TDR, from the port of arrival in Galway to the construction phase site entrance. The locations included in the assessment are shown in Figure 15-1b of the EIAR, with the results of the assessment for the 16 locations on

the route included in Figures 15-7 to 15-16 and discussed in Section 15.1.9 of the EIAR. An assessment of the locations in Galway City are also included as Appendix 15-3 of the EIAR.

The assessment establishes the locations where the abnormally sized loads will be accommodated with no impacts, **the locations where oversail of the blade tip or overhang of the blade body are required, and the locations where temporary over-runs are required.**

Alternative transport routes are detailed within Chapter 3 Section 3.5.5 of the EIAR. An assessment of the options was carried out, taking account of criteria such as third-party land requirements, existing road upgrades, new road construction requirements and associated environmental effects. The chosen TDR was selected as it was the shortest delivery route to the Proposed Wind Farm site and reduced number of required accommodation areas at identified pinch points.

Construction materials will be delivered to the Site via selected haul routes that will be determined based on the source from local, appropriately authorised quarries. For the purposes of assessment within the EIAR, 4 no. quarries within a 20km range of the Proposed Wind Farm site that could potentially provide stone and concrete have been assessed, with the locations of these quarries and potential delivery routes to the Proposed Project, shown in Figure 15-2a. It is noted that these additional routes converge on the M17 junction 19 with the N63, so from this location to the Proposed Wind Farm site access on the R332 is the section of the delivery route that will be under most pressure and is the focus of the traffic impact assessment as discussed in Section 15.1.9 of the EIAR.

In conclusion, it is considered that the issue of road capacity is adequately and robustly addressed in the EIAR. It has been adequately demonstrated through detailed swept path analysis that the public road network has the capacity, width and alignment to safely provide for the additional traffic that will be generated by the Proposed Project. Alternative have been considered in selecting the optimum transport route to the Proposed Wind Farm site, and haul routes from several potential quarries are assessed in the context of road capacity and traffic safety.

2.13.3.2 Abnormal Loads and Site Access

A number of third-party observations raise safety concerns regarding site access and abnormal load delivery for the Proposed Project, including restricted forward sighting distance and visibility splays at the proposed site entrance along the R332 regional road, inadequate visibility splays at the L6505 local road crossing and restricted access along the R332/N63 junction accommodation area.

One third-party submission queries whether landowner consent has been sought to trim bushes/shrubs on the south side of the R332 Regional Road in order to maximise forward visibility and states that a 3m setback for heavy goods vehicles (HGVs) is not adequate and it should be increased to 4.5m.

The R332 construction phase site entrance will be subject to traffic management measures for the duration of the construction phase and is not intended for use during the operational phase except in the unlikely event of an abnormally sized load being delivered for maintenance purposes. The proposed construction site entrance for the Proposed Project was subject to geometric assessment to identify the turning area required and to ensure the safe egress of traffic in accordance with TII DNGeo- 03060, as described in Section 15.1.10 of Chapter 15 of the EIAR.

As a result, a detailed TMP incorporating all the mitigation measures is included as Appendix 15-2 of this EIAR, which will be finalised and confirmatory detailed provisions in respect of traffic management agreed with the Road Section of GCC prior to construction and contact will be maintained with the Road and Traffic Section throughout the construction phase. Mitigation measures outlined in Appendix 15-2 include the following: The bush / shrubs on the south side of the R332 are trimmed in order to maximise forward visibility. It is estimated that a forward visibility of approximately 140m may be achieved by trimming the roadside bushes alone.

An application to Galway County Council for a temporary reduction of the speed limit on this section of the [R332]* to 60 km/h during the 18 month construction phase of the Proposed Project, The introduction of Traffic signs in accordance with the “Traffic Signs Manual, Section 8 – Temporary Traffic Measures and Signs for Road Works” (DoT now DoTT&S) and “Guidance for the Control and Management of Traffic at Roadworks” (DoTT&S).

The proposed traffic management measures will be submitted to Galway County Council's Roads section for agreement prior to the construction phase.

The provision of a flagman at all times that the proposed access junction is in use during the construction phase.

The closure of the site access by means of temporary fencing and gates during periods when the access is not in use, including evenings during the construction phase.

The permanent closure of the site access junction on completion of the construction phase. This junction will only be opened for the purpose of the replacement of large component parts.

*It is acknowledged that an incorrect reference was made to the R328 in the mitigation measures outlined in Chapter 15 Section 15.1.10 of the EIAR and Section 4 of the TMP included as Appendix 15-2. See Section 2.13.5 of this response document below. The text above has been amended to correctly reference the R332.

As the proposed site entrance off the R332 will be managed in accordance with the above and will only be in use during the construction phase, letters of consent from adjoining landowners and relevant third parties and revised site layout plans depicting permanent sightlines are not considered to be required.

The delivery of abnormal loads will also be carried out at night and under Garda escort and therefore the visibility splay and forward visibility requirements do not apply.

As detailed in Chapter 4 Section 4.5.2.11 a temporary track is required in a field west of the N63/R332 junction, in the townland of Slievegorm, in order to facilitate the movement of wind turbine vehicles through this junction. It is noted that the standard road markings and visibility splays are not required at the access off the N63, or the exit onto the R332, as the temporary access road will only be used for the transportation of abnormally sized loads, which will be delivered with a Garda escort and transient traffic management vehicles operated by the haulage company. This road will not be available for any other traffic and will be closed off and opened only for the delivery of the abnormally sized loads.

Upon the completion of the construction phase, the temporary road will be covered with a layer of topsoil and reseeded and will only be used again in the unlikely event that an oversized delivery was required for wind turbine maintenance purposes. Traffic effects on the junction during construction are outlined in Chapter 15 Section 15.1.10. During the PM peak hour it is forecast that the left turn from the N63 onto the R332 towards the Proposed Wind Farm site the ratio of flow to capacity (RFC) will be 11.7% for the no development scenario, increasing to 12.0% with the inclusion of the Proposed Wind Farm construction traffic.

The results of the junction capacity tests are set out in Table 15-25 and show that the additional traffic movements passing through the junction will be accommodated and have a minor effect on the operation of the junction. The assessment shows that the junction is forecast to operate well within the acceptable limit of 85% in accordance with TII guidelines.

Following the implementation of all mitigation measures outlined above and in Chapter 15.1.12, will ensure a controlled and efficient operation during this stage, and minimise the impacts on local road users by safeguarding the carrying capacity and safety of the regional and local road network.

2.13.4 Disruption to Local Traffic

Several third-party observations raise concerns over disruptions to local road and access track users, notably for farmers and residents utilising roads within the Proposed Wind Farm Site and road users along the Proposed Grid Connection during both the construction and operation of the Proposed Project. It is claimed that heavy machinery, road closures, noise, vibration, and restricted access will seriously interfere with livestock management and daily farming operation as well as local road network users including school children.

Observations regarding noise and vibration considerations are addressed above in Section 2.11 and Appendix 3 of this response document.

Response

As detailed in Chapter 15 Section 15.1.12.2 of the EIAR, during the 9 days when the concrete foundations are poured, On the delivery route it is forecast that the increase in traffic volumes on these days will range from between +6.5% and +11.8% on the N63 (Links 1 to 3). On the R332 leading to the Proposed Wind Farm site (Link 4) where background traffic flows are lower, it is forecast that traffic flows will increase by 30.4%. Prior to

mitigation, on these busiest 9 days it is estimated that the disruptions to local traffic will have a temporary, negative and slight effect on the N63 and R332 which is not significant.

During the remaining 341 days when the construction of the Proposed Wind Farm continues, including the site preparation and groundworks and construction of the onsite 110kV substation and BESS, the increase in traffic volumes on these days will be between +3.6% and 6.7% on the N63 (Links 1 to 3). On the R332 leading to the Proposed Wind Farm site (Link 4) it is forecast that traffic flows will increase by 17%. Prior to mitigation, on these days it is estimated that this will have a temporary, negative and slight effect on the N63 and R332 leading to the Proposed Wind Farm site which is not significant.

As detailed in Chapter 15 Section 15.1.12.6, during the 18 month construction stage of the Proposed Project, it is forecast that the additional traffic that will travel on the public road network serving the Site will have a short-term slight negative effect on existing road users on the delivery route. While the severity of the traffic effects relates to the additional volumes of traffic movements generated during the construction of the Proposed Project, the implementation of the mitigation measures included in the TMP (Appendix 15-2) will ensure a controlled and efficient operation during this stage, and minimise the impacts on local road users.

For the diversion routes shown in Chapter 15 Figure 15-6b of the EIAR, the temporary additional trip length incurred by drivers during the construction of the Proposed Grid Connection will range from a minimum of 0.9km to a maximum of 13.7km. It should be noted that the length of the diversion routes shown for the various sections of the Proposed Grid Connection are the longest that may be incurred, measured from either end of the section being constructed, and that in practice, many drivers undertaking longer trips will divert onto other parallel routes further afield to avoid the closure, incurring shorter actual diversions.

As detailed in Chapter 4 Section 4.5.1 of the EIAR, the Proposed Wind Farm site will only be accessible during the operational phase at 3 no. locations which are shown in Figure 4-21. **Once operational it is estimated that there will be 3 staff members employed on site with a similar number of vehicle trips, that is 3 car/lgv trips to and from the site per day.** The new operational access east of the L6506 local road and the upgraded existing access track operational access points will also be used by EirGrid for maintenance access to the 110kV substation as part of the Proposed Grid Connection. It is considered that the traffic impact during the operation phase will be negligible. Additionally, it is noted that site roadways will be used during the operational phase by farm machinery and existing access will be retained where requested by involved landowners to facilitate these activities. This will result in no significant disruption to farming activities within the Proposed Wind Farm site during operation.

2.13.5 Road Labelling

One submission notes reference to R328 regional road within the mitigation measures outlined in Chapter 15 Section 15.1.10 of the EIAR.

Response

It is acknowledged that this should refer to the R332 regional road and that reference to the R328 was incorrectly included in mitigation measures outlined in Chapter 15 Section 15.1.10 of the EIAR and Section 4 of the TMP included as Appendix 15-2.

2.14 Telecommunications

Several third-party observations are made regarding concerns over telecommunications impacts as a result of the Proposed Project. Observations are made under the following themes:

Three Ireland PTP and ESB Network
TERTA Emergency Services

2.14.1 Three Ireland PTP and ESB Network

Several third-party observations raised concerns over the assessment of telecommunications impacts in the submitted EIAR. It is raised Three Ireland and ESB links traverse the Proposed Wind Farm site and that the Telecommunication Impact Assessment (TIA) does not confirm acceptable clearances to the Three Ireland link and provided mitigation measures (e.g., relays) remain subject to further consultation, providing no current protection guarantee.

Response

It is noted that the proposed turbine T07 is approx. 11.4m from the 2nd Fresnel Zone of the Three Ireland link. The TIA provides further mitigation measures following consultation with Three Ireland, including redirecting the link via an existing telecoms mast in Creevagh. Prior to construction, the Applicant will seek an agreement with Three Ireland to ensure the Proposed Wind Farm will not interfere with the existing Three Ireland radio link. Following the implementation of the measures outlined in the TIA, the Proposed Wind Farm will not have a significant effect on the existing ESB and Three Ireland telecoms network.

In order to address the potential impact on the Three Ireland link, the following mitigation measures are proposed:

Relay the Three Ireland radio link between Cloonriddia and Moylough via an existing Telecoms Mast (i.e. Creevagh). This would involve the installation of two microwave radio links:

- o PTP radio between Cloonriddia and Creevagh
- o PTP radio between Creevagh and Moylough

Once-off installation of two microwave radio links to be covered by the wind farm developer are estimated to be in the order of €10,000 - €15,000

The proposed mitigation measure would involve supply and provisioning of the

- o 2 no microwave radio links including radio antennas, cables connectors, etc.
- o Rigging and Installation Services
- o Design & Commissioning Services

Should the Proposed Project receive a grant of permission, the Applicant will continue consultation and seek an agreement with Three Ireland in advance of the construction and operation of the Proposed Project. A protocol agreement will be signed between 2rn and the Applicant. The Protocol Document ensures that in the event of any interference occurring to television or radio reception due to operation of the Proposed Wind Farm, the required measures, as set out in the Protocol Document, will be carried out by the Applicant to rectify this. The Protocol Document ensures that the appropriate mitigation is carried out in the event of unanticipated broadcast interference arising to television or radio reception as a result of the Proposed Wind Farm.

The exclusion zone identified by ESB was also considered in the context of the TIA. Further to their assessment conclusions, a letter of reliance from Ai Bridges is included as part of the TIA included in Appendix 15-4 which concludes the most technically viable Mitigation Measure Solutions available to offset any potential impact due to the proposed turbines are considered for the Proposed Project and will result in no residual adverse effects on the existing network infrastructure.

2.14.2 TETRA Emergency Services

Several third-party observations raised concerns that the EIAR fails to adequately assess the potential telecommunications impacts of the Proposed Wind Farm on critical emergency-services communications, including TETRA.

Response

As detailed in Chapter 15 Section 15.2.4.3 of the EIAR, consultation was carried out with ComReg in February 2024 in order to identify any other additional licenced operators in the vicinity of the Proposed Wind Farm site to be contacted, who may not have been on the list of main operators previously contacted in April 2023. TETRA was contacted in both consultation periods and responded in April 2023 noting that they do not anticipate impacts from the Proposed Project. No response was received in the February 2024 consultation period. Copies of the scoping responses are included in Appendix 2-1 of the EIAR.

2.15 Major Accidents and Natural Disasters

Several third-party observations were made in relation to the risk of Major Accidents and Natural Disasters from the Proposed Project. The areas which were raised within the observations include:

- Peat Stability
- Risk of Fire
- Flooding and Storm Events

Response

Peat Stability

A Peat Stability Risk Assessment (PRSA), included as Appendix 8-1 of the EIAR, outlines a quantitative peat stability risk assessment rating in line with the Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments (PLHRAG, Scottish Government, 2017) for the proposed permanent development footprint. A desk study, site walkovers, ground investigation campaigns, stability analyses and a risk assessment were carried out to assess the risks posed by peat failures within the Proposed Wind Farm site. The risks were assessed following the principles in Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments (Scottish Executive, 2017). The stability analysis aims to determine the Factor of Safety (FoS) of the peat slopes. The FoS provides a direct measure of the degree of stability of a peat slope. A FoS of less than 1.0 indicates that a slope is unstable; a target FoS for slopes is 1.3 or greater. A risk assessment was carried out considering the FoS value calculated in the stability analysis and other factors that could influence peat stability, considering how damaging a peat slide would be to this site's environment. The PSRA has been performed for all Proposed Wind Farm infrastructure elements (including turbines, hardstands, access tracks, temporary construction compound and meteorological mast) as well as the substation/BESS compound, with the resulting peat stability risk identified as negligible at all locations. Mitigation measures have been proposed in Section 6 of the PRSA.

In Section 4.5 of the PRSA the interpretation and assessment of the FoS results are provided. In all the modelled FoS scenarios, areas of $\text{FoS} < 1.3$ are rare, and are generally localised to peat cut faces of banks or linear features such as ditches or land drains. The Proposed Wind Farm layout avoids all areas of $\text{FoS} < 1.3$ in all scenarios, with the exception of one localised section of the access track between T5 and T6 (AL5b). This access track interacts with a very small area of $1 < \text{FoS} < 1.3$ at a minor water crossing. This location is discussed in further detail in Table 4-3 of the PRSA. Localised areas of the Proposed Wind Farm site contain flat-lying, deep peat with active peat cutting. Steep peat cuttings of $< 1\text{m}$ generate low factors of safety but are generally considered low landslide risk. Raised bog environments like this site may be susceptible to bog burst type failures, which can occur at very low slope angles and may not be fully quantified by the FoS calculation, as they are driven by hydrological factors rather than slope-driven. For this reason, the locations were assessed on-site and 'ground-truthed' to identify true hazards. GDG site walkovers identified no evidence of significant bog burst features.

The lack of evidence for historical bog bursts does not preclude the possibility that these may occur. Further inspection will be required during the detailed design and construction stage to inspect for peat instabilities, including bog burst features. This will be carried out by the detailed Designer and the Contractor's team. The design team shall develop their own inspection and testing criteria to satisfy and de-risk the possibility of peat landslides at these locations.

As stated in Section 6 of the PRSA, based on the available data, the fieldwork, and GDG's professional judgement, it is concluded that significant peat slides are unlikely on the Proposed Wind Farm site with diligent peat management and careful consideration of the peat conditions at the Proposed Wind Farm site at the design and construction stage. A deterministic FoS was calculated across the proposed element locations, and from this, a robust peat stability risk assessment (PSRA) was performed. The findings of the peat assessment showed that the Proposed Wind Farm site has an acceptable margin of safety and is suitable for the Proposed Wind Farm, provided appropriate mitigation measures, as outlined in Section 6, are implemented. The peat stability risk for the proposed infrastructure is negligible in all locations. The results of the FoS deterministic calculation and the site walkover allowed for the identification of SBZs outlined in Section 4.6 and shown in Appendix M 'Safety Buffer Zones and Peat Stockpile Restriction Areas' of the PRSA. These must be adhered to in future stages of the Proposed Project. To minimise the risk of construction activity causing potential peat instability the Construction Method Statements (CMSs) for the project will implement in full, but not be limited to, the recommendations above. Construction works shall follow the recommendations of the Peat and Spoil Management Plan which is included as Appendix 4-2 of the EIAR. During construction, it is strongly recommended to carry out frequent monitoring works, especially after heavy rainfall events or prolonged rainfall.

Risk of Fire

The likelihood of fire or explosion occurring at the Proposed Project is anticipated to be low. The likelihood of fire or explosion occurring will be further lowered by the implementation of good site management practices during the construction, operational and decommissioning phases. As outlined in Section 16.2.1 above, the scope of this assessment has been based on the understanding that the Proposed Project will be designed, built and operated in line with current best practice. Further, in accordance with Chapter 19 of the Safety, Health and Welfare at Work Acts 2005 to 2014, the Proposed Project shall be subject to a fire safety risk assessment which will assist in the identification of any major risks of fire on Proposed Project, and mitigation of the same during operation.

Flooding and Storm Events

As part of the Local Area Climate Action Plan for County Galway (Galway LACAP) a climate change risk assessment was carried out for County Galway. A profile of historical climate hazards in County Galway and assessment on future climate hazards is provided in the Galway LACAP. Severe storm events were identified as the most significant climate hazard over the period 1973-2022, with river and pluvial flooding, heatwaves and drought, coastal erosion and flooding also affecting the County on a number of occasions. Cold spells, heavy snowfall and groundwater flooding, have also impacted County Galway, but less frequently. Future projections of climate change indicate that Above Average Precipitation, Prolonged Cold Periods and Heavy Snowfall will remain consistent with existing conditions. **However, risk is predicted to increase for all other identified climate hazards (i.e., Severe Windstorm, Extreme Precipitation, Pluvial Flooding, Heatwave, Drought, and Above Average Surface Temperature),** with River Flooding remaining the perceived highest risk to County Galway. The climate change risk assessments included in the Galway LACAP detail the major risks posed from climate change being river flooding, severe windstorms, extreme precipitation, and drought. The changes in frequency in intensity of weather patterns as a result of climate change will continue to influence the wide range of functions carried out by Local Authorities. The identification of future risks is critical to enable the progression of adaptation and mitigation measures in the development and execution of plans and policies. Potential impacts that may occur on the identified road networks could be caused by an accident during the delivery of the turbines, collisions onsite and offsite with vehicles involved in construction and operation of Proposed Project, and damage to critical transport infrastructure caused by extreme weather i.e., periods of heavy rainfall, taking into account climate change and strong winds.

A Flood Risk Assessment (FRA) has been prepared as part of the submitted EIAR and has been included as Appendix 9-1. FRA is carried out in accordance with 'The Planning System and Flood Risk Management Guidelines for Planning Authorities' (DoEHLG, 2009). The assessment methodology involves researching and collating flood related information from the following data sources:

OPW Flood Studies Update (FSU) Web Portal;

Geological Survey of Ireland (GSI) maps on superficial deposits;

EPA/WFD hydrology maps;

OPW National Indicative Fluvial Mapping (NIFM) and CFRAM mapping;

Galway County Development Plan 2022 – 2028 (including Strategic Flood Risk Assessment);

Lidar data for the project site; and;

Site walkovers and surveys conducted by HES on 15th August and 24th October 2022, 23rd and 28th March 2023, 20th and 21st August 2024, 22nd May and 8th July 2025.

As outlined in Section 6 of the FRA, the report concludes that the Proposed Project is appropriate from a flood risk perspective and the FRA fulfils the requirements for a site-specific flood risk assessment and is consistent with the recommendations made in the Galway County Development Plan 2022-2028. The findings of the FRA includes:

No instances of historical flooding were identified in historic OS maps within the Proposed Wind Farm site;

No instances of recurring flooding were identified on OPW maps within the Proposed Wind Farm site;

The GSI Winter 2015/2016 Surface Water Flooding and Groundwater flood Mapping provides no evidence of historical flooding at the Proposed Wind Farm site;

No CFRAM or NIFM fluvial flood zones are mapped within the Proposed Wind Farm site; Sections of the Proposed Grid Connection pass through NIFM flood zones but this has no consequence or risk for the Proposed Project due to the underground nature of the infrastructure. The onsite 110kV substation element of the Proposed Grid Connection is located in Flood Zone C at the Proposed Wind Farm site.

As stated in Section 16.4.2 of Chapter 16 in the EIAR, it is proposed that the Proposed Project will be designed and built in line with current best practice and, as such, mitigation against the risk of major accidents and/or disasters will be embedded through the design. In accordance with the provision of the European Commission 'Guidance on the preparation of Environmental Impact Assessment Reports', a Risk Management Plan will be prepared and implemented at the Proposed Project to ensure an effective response to disasters or the risk of accidents. The plan will include sufficient preparedness and emergency planning measures. Furthermore, a CEMP has been prepared for the Proposed Project and is included in Appendix 4-5 of the EIAR. Upon a grant of planning permission for the Proposed Project, the CEMP will be updated to reflect the conditions stipulated in the consent prior to the commencement of the development. The CEMP will be a live document maintained by the contractor that will work to ensure that potential risks of major accident and/or disaster are identified, avoided and mitigated, as necessary.

2.16 Decommissioning

Several third-party observations are made regarding the decommissioning stage of the Proposed Project. Observations are made under the following themes:

Financial Security

In-situ infrastructure

Observations regarding the permanent infrastructure associated with the Proposed Grid Connection to remain in place after decommissioning of the Proposed Wind Farm are addressed in Section 2.4.2 of this response document.

2.16.1 Financial Security

A number of third-party observations that pointed out that there is no estimated cost provided for decommissioning. There is no financial bond or guarantee mechanism described. There is no timeline for financial security review and update. There is also no contingency plan for developer insolvency.

Response

It is noted that financial security regarding the decommissioning of the Proposed Project is typically addressed via a condition should the Commission decide to grant permission, which the Applicant accepts.

2.16.2 In-situ Infrastructure

A number of third-party observations raised concern that as a result large concrete turbine foundations would remain in place after decommissioning, this would result in unacceptable and permanent damage to the landscape. Claims are made that the proposed turbines have a relatively short service lifetime and decommissioning will cause as much or if not more pollution to the area than the construction phase.

Response

A Decommissioning Plan is included as Appendix 4-6 of the EIAR. The Decommissioning Plan will be updated prior to the end of the operational period in line with decommissioning methodologies that may exist at the time and will agree with the competent authority at that time. The potential for effects during the decommissioning phase of the Proposed Wind Farm has been fully assessed in the EIAR.

As construction will be completed, elements of the Proposed Project that will be developed as a temporary facilitator will either be removed, restored to its original condition, or will naturally revegetate. All access roads and hardstanding areas forming part of a site roadway network will be required by the ongoing farming operations and therefore will be left in situ for future use. On the dismantling of turbines and met mast, it is not intended to remove the concrete foundation from the ground. It is considered that its removal will be the least preferred options in terms of potential effects on the environment. Therefore, the foundations of the 9 no. turbine and met mast will be covered with soil material.

Given the nature of the Proposed Wind Farm elements to be decommissioned, the EIAR considers the any effect and consequential effect that occurs during the decommissioning phase will be similar to that which occurs during the construction phase, however to a lesser extent, and the mitigation measures outlined during the construction phase will be implemented during the decommissioning phase also.

3. RESPONSE TO PRESCRIBED BODIES

The following section provides responses to each of the Prescribed Bodies observations made on the Proposed Project.

There were 6 no. statutory bodies who made a submission on the planning application as follows:

Department of Defence.

Department of Housing, Local Government and Heritage.

Irish Aviation Authority (IAA).

Inland Fisheries Ireland.

National Office for Environmental Health Services (HSE).

Office of Public Works.

Transport Infrastructure Ireland.

Uisce Éireann.

3.1 Department of Defence

The Department of Defence (DoD) made a submission on the planning application for the Proposed Project and identify that the Air Corps were consulted to input into their submission.

Technical specifications on Obstacle lighting were provided. Following DoD consultations with Air Corps (IAC) at Casement Aerodrome, the Department of Defence made the following observations.

All turbines should be illuminated by Type C, Medium intensity, Fixed Red obstacle lighting with a minimum output of 2,000 candela to be visible in all directions of azimuth and to be operational H24/7 days a week, Obstacle lighting may be incandescent. If LED or other lighting types are used should be a type visible to Night Vision equipment, Obstacle lighting must emit light at the near Infra-Red (IR) range of the electromagnetic spectrum, specifically at or near 850 nanometres (nm) of wavelength.

Light intensity to be of similar value to that emitted in the visible spectrum of light, In the event of negative impacts on future military radar systems, the owner will engage with the Department of Defence and will provide suitable mitigations as soon as practical.

Response

The potential effects of the Proposed Project on aviation were assessed in Chapter 15 Material Assets, Section 15.2 of the submitted EIAR. In Section 15.2.4.4.2 Aviation, the scoping response from the DoD received on the 5th of May 2023 provided guidance for mitigation measures to be observed by the developer. The observations provided were as follows:

All turbines should be illuminated by Type C, Medium intensity, Fixed Red obstacle lighting with a minimum output of 2,000 candela to be visible in all directions of azimuth and to be operational H24/7 days a week. Obstacle lighting should be incandescent. If LED or other lighting types are used, should be a type visible to Night Vision equipment. Obstacle lighting must emit light at the near Infra-Red (IR) range of the electromagnetic spectrum, specifically at or near 850 nanometres (nm) of wavelength.

Light intensity to be of similar value to that emitted in the visible spectrum of light. Any Irish Air Corps (IAC) requirements are separate to Irish Aviation Authority (IAA) requirements.

In line with those observations made by the DoD the EIAR states. "In response to the lighting requirements requested by the DoD, the proposed turbines will be included on mapping, fitted with obstruction lighting and entered into aircraft navigation databases to ensure they will be avoided during flight."

Furthermore, in Section 15.2.6.3.2 the EIAR states under "Likely Significant Effects and Associated Mitigation Measures" the following, "Residual Effect With the implementation of the above, the Proposed Project will have a long-term imperceptible neutral residual effect on aviation assets which is Not Significant." Continued,

"Significance of Effects

There will be no significant effects on aviation operations as a result the Proposed Project."

As such in accordance with the above it was confirmed in Chapter 15 (various sections) of the EIAR that these requirements were considered and would be adhered to.

3.2 Irish Aviation Authority (IAA)

The Irish Aviation Authority (IAA) made a submission on the planning application for the Proposed Project. The IAA raised no objections to the Proposed Project and requested that the following conditions are adhered to. In the event of planning consent being granted, the Applicant should be conditioned to contacting the IAA to:

agree an aeronautical obstacle warning lighting scheme for the wind farm development, provide as-constructed coordinates in WGS-84 format together with ground and blade tip height elevations at each wind turbine location and; notify the Authority of intention to commence crane operations with at least 30 days prior notification of their erection in accordance with S.1.215 of 2005 Irish Aviation Authority (Obstacles to Aircraft in Flight) Order.

Response

The potential effects of the Proposed Project on aviation were assessed in Chapter 15 Material Assets, Section 15.2 of the submitted EIAR. In Section 15.2.4.4.2 Aviation, the scoping response from the IAA received on the 13th of June 2023 provided guidance for mitigation measures to be observed by the developer. The observations provided were as follows:

“In the event of planning consent being granted, the Applicant should be conditioned to contact the Irish Aviation Authority to: agree an aeronautical obstacle warning light scheme for the wind turbine development, provide as-constructed coordinates in WGS84 format together with ground and tip height elevations at each wind turbine location and notify the Authority of intention to commence crane operations with at least 30 days prior notification of their erection.”

Section 15.2.6.3.2 the EIAR states under “Likely Significant Effects and Associated Mitigation Measures” the following, “Residual Effect With the implementation of the above, the Proposed Project will have a long-term imperceptible neutral residual effect on aviation assets which is Not Significant.” Continued,

“Significance of Effects

There will be no significant effects on aviation operations as a result the Proposed Project.”

As such in accordance with the above it was confirmed in Chapter 15 (various sections) of the EIAR that these requirements were considered and would be adhered to.

The Applicant confirms its agreement to these conditions should the Commission decide to grant planning permission for the Proposed Project.

3.3 Department of Housing, Local Government and Heritage

The Department of Housing, Local Government and Heritage (Department) made a submission on the application which has been categorised under the following themes:

Nature conservation

Archaeology

The observations made by the Department are discussed and have been responded in the following sections and under the same headings as listed above.

3.3.1 Nature Conservation

3.3.1.1 European Sites

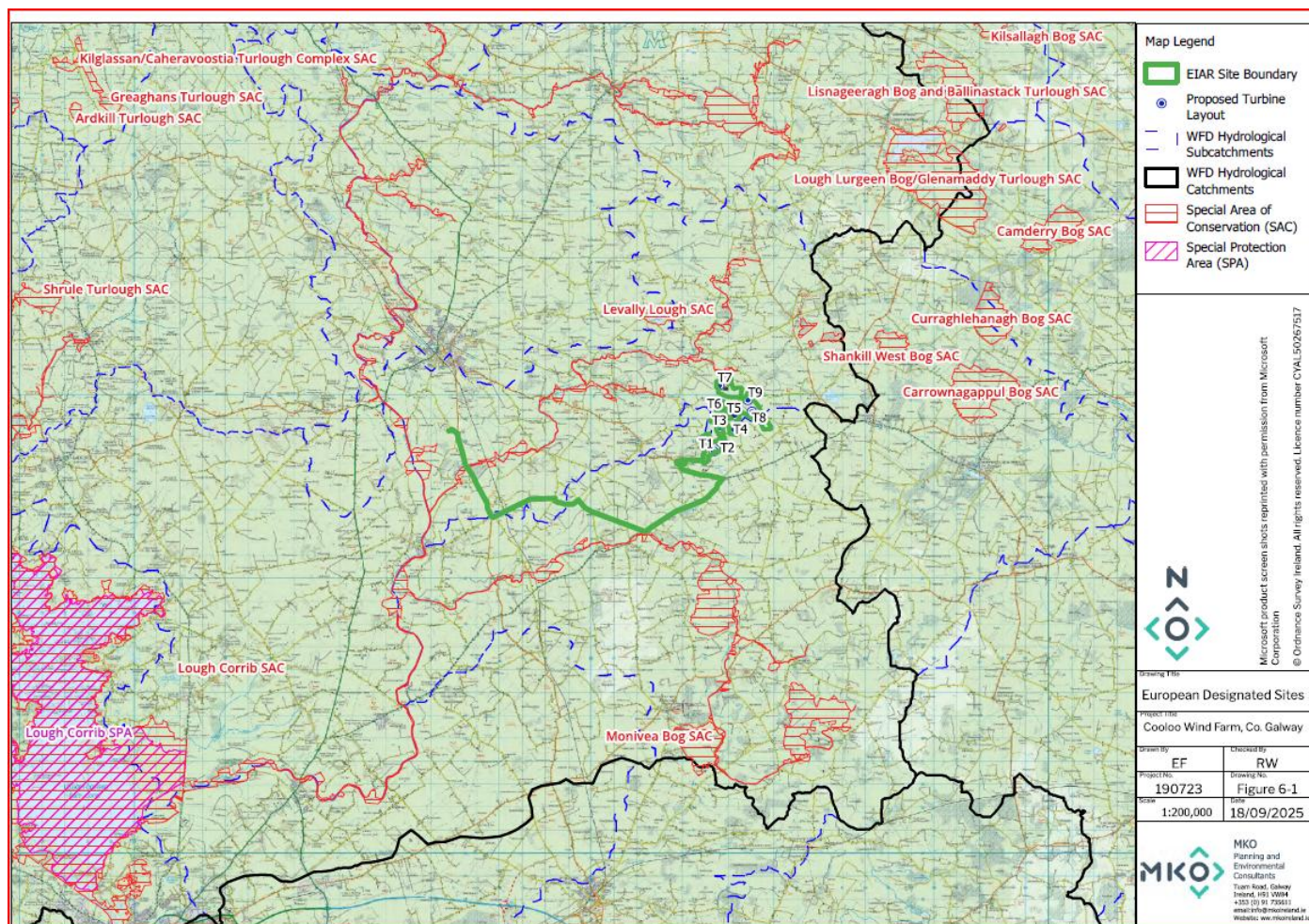
The Department makes observations on in relation to identifying potential impacts on European sites, other nature conservation sites, and biodiversity and environmental protection in general. The Department notes the north of the Site (Proposed Grid Connection) is adjacent to the Lough Corrib SAC, with one river crossing on the Grange River falling within the SAC.

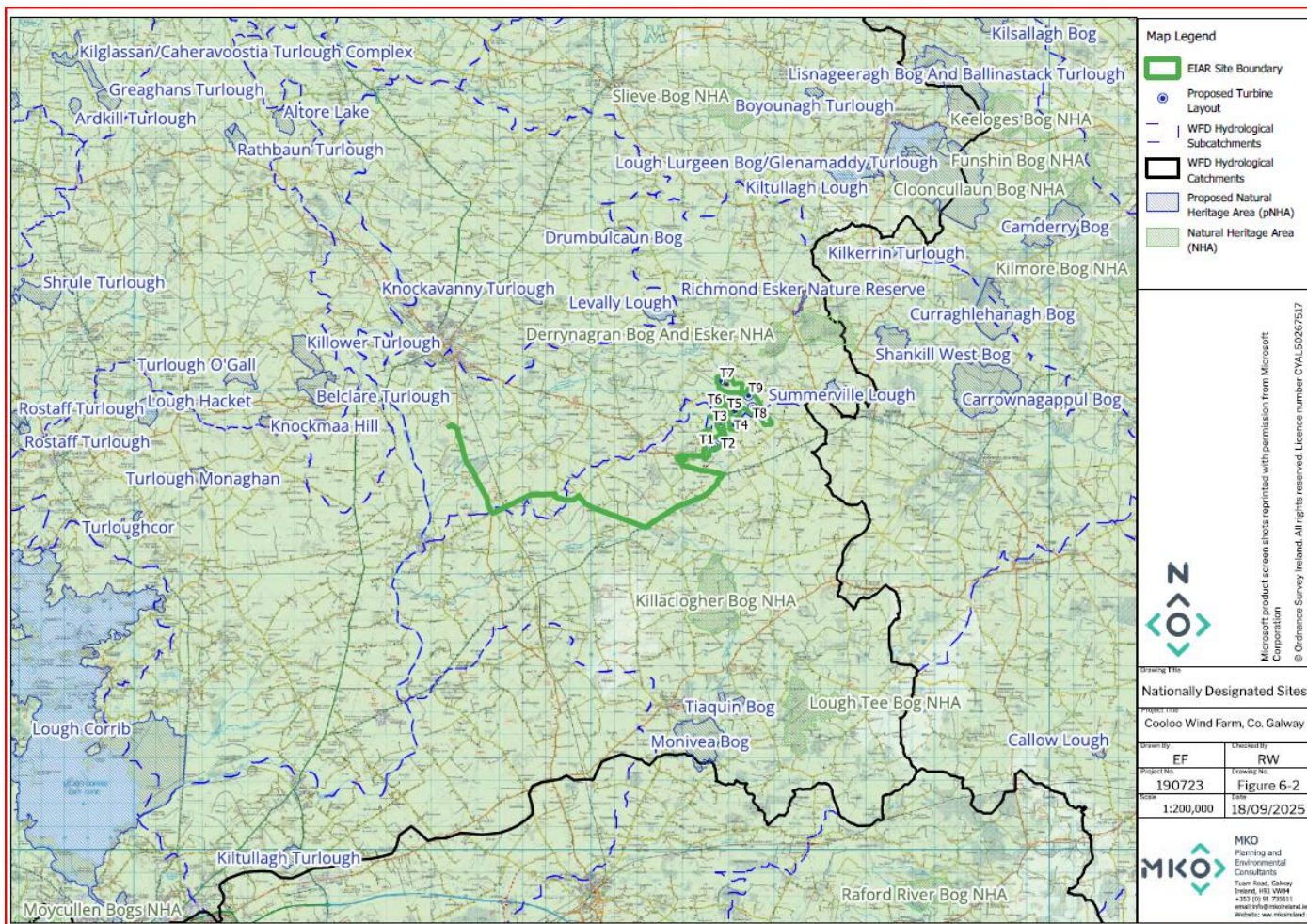
Response

The Natura Impact Statement (NIS) produced for the Proposed Wind Farm has addressed the potential for indirect effects on the Lough Corrib SAC and Lough Corrib SPA. None of the Proposed Wind Farm is located within the SAC boundaries, however the proposed grid connection crosses the SAC at the Grange River

(Ballinderry Bridge), an existing watercourse crossing in one location, as detailed in Figure 4-1 of the NIS. Mitigation has been provided for construction phase hydrological impacts in Section 6.2.3, which provides a suite of mitigation to prevent any adverse effects on the SAC and SPA, located downstream of the Proposed Wind Farm. Mitigation has also been provided for the potential effects from the removal of vegetation cover and progressive replacement of natural surface with low permeability surfaces during the operation phase, in Section 6.2.3.1.1 of the NIS.

Figure 6-1 and Figure 6-2 of Chapter 6 of the submitted EIAR is shown below and shows the European designated and nationally designated sites in proximity to the Site. It is noted that these figures are not included in the digital copy of Chapter 6 but are included in the hard copy of the EIAR, which is publicly available at the offices of both the Commission and GCC. The figures are a visual representation of the information included in Chapter 6, Section 6.3.1.2, of the submitted EIAR and does not present any new or additional information. Following the implementation of the mitigation measures provided within Section 6 of the NIS, it is concluded in view of best scientific knowledge, on the basis of objective information that the Proposed Project will not adversely affect the Qualifying Interests/Special Conservation Interests associated with any European Site.





3.3.1.2 Birds

Observations on a number of ornithological species are raised by the Department, with particular focus on golden plover.

Response

It is acknowledged that there has not been opportunity to test the effectiveness of tethered bird control kites in reducing collisions at wind farms. This method has been tested more extensively in deterring birds for crop protection and at reducing bird numbers/flyovers in airfields and landfill sites. However, the purpose of the kites is to deter golden plover from foraging or roosting on grassland within the turbine area, therefore such research applies in this context. To quantify the reduction in the number of collisions, the golden plover 'random' collision risk model was run again (Scenario V163; full details of the methodology for the original golden plover random model are presented in the EIAR Chapter 7 Appendix 7-6). **The workings below (Table 3-1) show how much the numbers of collisions will potentially be reduced by the kites.**

The purpose of the kites is to deter golden plover from foraging or roosting on grassland in the turbine area. If there are no landed birds or attractive foraging/roosting sites, golden plover will not engage in social information gathering flight activity in the airspace above. All golden plover foraging flights and information gathering flights in the area in which the kites are proposed were subset in the data. These flights amounted to 6,925,116 'bird seconds' (i.e., birds in flight at potential collision height calculated by multiplying the number of birds observed per flight by the duration of the flight spent within potential collision height).

In the second model run, all input values and methods remained the same as the first run apart from the input number of bird seconds. The bird seconds subset above were subtracted from the bird seconds used in the first run, as shown in the table below (all were associated with VP2, as this vantage point overlooked the area in which the kites are proposed). Note that other flight behaviours, such as birds travelling over the area were retained, as the kites are not intended to influence these.

Table 3-1 Golden Plover 'Random' Collision Risk Model Workings

Model Run	VP1 bird seconds	VP2 bird seconds	VP3 bird seconds
First run	2,184,577	7,018,291	1,960,800
Second run	2,184,577	93,175	1,960,800

The second run of the model estimated 56.627 collisions per year (55.017 collisions associated with random flight activity and 1.610 associated with regular flight activity of birds travelling to or from Horseleap Lough). Annual mortality of adult golden plover has been calculated at 27% per annum (Sandercock, 2003). If 96.722 collisions were to occur per year, it would mean that the losses at the Proposed Wind Farm would increase the annual mortality of the county population (c.5,895) by 3.6%.

The magnitude of this predicted collision risk is 'low', following Percival (2003). While the 1% increase in background mortality referenced in Percival (2003) is often set as the threshold for judging significance, it is likely quite conservative. The threshold likely originates from a hunting threshold set by the European Commission and was not intended to indicate that all increases in mortality above 1% were significant. Among other reasons, the threshold was set at 1% by the European Commission because such losses are so low that they are within the margin of error from a mathematical point of view in population dynamics modelling studies.

As such, the increase in the annual mortality of the county population has reduced from 12% to 3.6%.

The magnitude of the predicted collision risk has reduced from 'medium' to 'low', and no significant effects of collision risk are predicted, following mitigation.

Reporting on the effectiveness of the kites to the Planning Authority and the National Parks and Wildlife Service at the end of each prescribed monitoring year is proposed as part of the Bird Monitoring Programme (EIAR Appendix 7-8). This will include the results of kite field inspections, report on adherence to the Bird Mitigation plan actions and make any additional associated recommendations for adaptive management. Additionally, as part of the Bird Monitoring Programme, collision monitoring surveys will be conducted by a trained dog and handler at all turbine bases. If golden plover carcasses are found during collision monitoring surveys, the significance of the effect on the county population will be evaluated and any necessary recommendations or adaptations made.

For more information on Birds please see section 2.6.3 above.

3.3.1.3 Bats

"Regarding bat mitigation, the Department notes "White light sources will have a "warm" colour temperature (less than 3000K)" has been proposed and recommends using warm white lighting with a Correlated Colour Temperature (CCT) of below 2700 kelvins.

The Department takes this opportunity to remind the competent authority of their obligations under Article 6 of the Habitats Directive (92/43/EEC). Competent national authorities are to authorise activity only if they have made certain that it will not adversely affect the integrity of a European site and, consequently, not likely to give rise to deterioration or significant disturbances within the meaning of Article 6(2). Any matters raised above should also be considered in the planning policy context for the proposed development, including the protective natural heritage and biodiversity objectives and policies in the Galway County Development Plan."

Response

The EIAR commits to the use of bat-sensitive lighting in accordance with ILP Guidance Note 08/23: Bats and Artificial Lighting at Night. Where lighting is required during construction and operation, directional lighting will be used to prevent overspill onto woodland and forestry edges and other linear features used by commuting and foraging bats. Luminaires will be designed to minimise upward and lateral light spill, with appropriate shielding and directional accessories, and lighting will be directed away from mature trees and treelines. The Applicant also commits to the Dark Sky Ireland lighting principles, including that lighting will be justified, used only where necessary, directed where required, and of the minimum intensity appropriate for safety and operational needs. In this context, the Department of Housing, Local Government and Heritage's

recommendation to specify warm white lighting with a correlated colour temperature (CCT) of $\leq 2700\text{K}$, rather than the more general “warm white” specification ($<3000\text{K}$) referenced in Dark Sky Ireland guidance, is welcomed and will be incorporated into the detailed lighting design where practicable and subject to safety and operational requirements.

MKO considers the proposed mitigation and monitoring plan outlined in Sections 6.1 and 6.2 of Appendix 6-2 of the EIAR to be appropriate and in line with best practice guidance to ensure no significant impacts on local bat populations occurs during the operational phase. Provided the Proposed Project is operated in line with the proposed mitigation and monitoring plan, no residual significant effects on bats is anticipated.

3.3.1.4 Marsh Fritillary

Marsh Fritillary habitat is present in the area. A larval web recorded is approximately 17m north of the hardstand/new access road associated with T5. There is potential that the proposed new access roads, hardstands and associated infrastructure at T5 may result in changes in the hydrological regime of the cutover bog (PB1) habitat, which may result in an alteration in habitat. This has potential to render the habitat no longer suitable for the food plant of Marsh Fritillary, thus impacting habitat availability.

Response

The potential for significant effect on Marsh Fritillary breeding habitat is assessed in Section 6.5.2.2.5 of the EIAR, with mitigation provided to prevent loss of breeding habitat and dust mitigation during the construction phases of the Proposed Development. The potential for any hydrological impacts has also been considered in Section 9.5.2.16 of Chapter 9 ‘Hydrology and Hydrogeology’ and it was determined that “due to the already cutover nature and existing extensive drainage at these locations, no significant additional effects on remaining areas of intact bog nearby.”

Similarly, the potential for any impacts on breeding marsh fritillary during the operational phase of the Proposed Project has been considered in Section 6.5.3.2, stating: “it is not anticipated that the operation of the Proposed Project will have any effect on marsh fritillary or habitat for the species during the operation of the Proposed Project.

Implementation of the BMEP measures during the operational phase of the development will ensure that habitats are managed for marsh fritillary during the operational life of the Proposed Project having a positive impact on this species as well as other local invertebrate/pollinator species.”

The BMEP (Appendix 6-4 of the EIAR) also outlines measures for the protection of Marsh Fritillary during the construction phase of the Proposed Project, as well as measures to enhance existing, and create additional habitat for marsh fritillary.

As outlined in Section 3.1 of the BMEP, known marsh fritillary suitable habitat containing larval webs (including the larval web identified within proximity of T5) identified during 2024 surveys. The fencing will contain signage strictly prohibiting entry to these areas. This will denote the area where strictly no machinery, storage of materials or entry of construction site personnel will be permitted. The protective fencing will be inspected and signed off by the supervising Ecological Clerk of Works (ECoW) prior to commencement of the Proposed Project. Section 3.1.2. outlines a suite of measures designed to protect and maintain the existing identified marsh fritillary breeding habitat within the Proposed Project boundaries. None of these identified areas have any proposed infrastructure located within the known breeding habitat areas. Section 3.4.2 of the BMEP also proposed to create an additional 12.76ha of suitable marsh fritillary habitat within the Proposed Project site boundaries. A management regime to maintain this newly created habitat has also been provided in Section 3.4.2.1 of the BMEP.

3.3.1.5 Raised Bog

The northwest side of the Proposed Wind Farm site is mapped Annex I Active Raised Bog [7110]. A section of approximately 580m of a proposed floating road between T7-T9 will be located within the mapped Article 17 habitat. Approximately 285m of the proposed new floating access road between T7 and T9 corresponds to the Annex 1 habitat Degraded raised bogs still capable of natural regeneration (7120).

Response

As outlined in Section 6.4.1.3, all margins of the mapped Article 17 Raised Bog habitat have been cut since at least the mid-1990s as evidenced from historic aerial imagery, with turbary cutting ongoing in a large part of the mapped Article 17 habitat area, as well as drainage throughout the habitat area. The entire high bog area is surrounded by either historical or active peat extraction, with small pockets of uncut areas that have not been drained, however this area is not considered an intact raised bog habitat due to the extensive extraction and drainage that has been ongoing within this area.

The peatland habitats identified within the Proposed Project have been described in full in sections 6.4.1.3 (6.4.1.3.2 and 6.4.1.3.1). The existing drainage activities has also been detailed in Section 9.3.1 of Chapter 9 of this EIAR. Detailed releves were taken along the proposed new floating access road, which are fully detailed within Appendix 6-1 (Section 3.3) of this EIAR.

The potential for significant effects on these habitats has been assessed within Section 6.5.2.1.2 of the EIAR. Mitigation provided includes alteration of surface water hydrochemistry (mitigation by design), mitigation to prevent significant effects via air quality impacts and dust emissions. It is concluded within the EIAR that with all mitigation measures prescribed in Section 6.5.2.1.2, there will be no residual significant impacts on peatland habitats adjacent to the development footprint. However, it has been concluded that there is potential for significant residual effects peatland habitats at a County level.

Additionally, there will also be a residual effect in relation to the alteration of drainage within approx. 50-100m distance of the proposed turbine T7 to T9 access road. Residual significant effects are anticipated at the County level.

There is a total area of habitat identified as raised bog (PB1) within the site boundary is approximately 32.29ha, while the identified cutover bog habitat areas are approximately 42.00ha. The proposed floating access road between T7 and T9 will result in the loss of approximately 0.18ha of raised bog (PB1), amounting to 0.54% of the total habitat area within the site. While this is still considered a significant residual effect due to the mapped Article 17 habitat within the location, the area to be lost is relatively small in comparison to the larger raise bog habitat area within the site boundaries.

3.3.2 Archaeology

The Department of Housing, Local Government and Heritage (Department) made a submission on the application in relation to archaeology. The Department advises that advance archaeological test excavation of all accessible areas should be carried out in advance of any development in order to adequately establish the baseline archaeological environment. Where previously unrecorded archaeological features / materials are shown to be present, additional mitigation measures to ensure the preservation in situ or preservation by record (i.e. full archaeological excavation) of such features / material will be necessary. The Department advises that this can be addressed by the inclusion of an appropriate archaeological condition in any grant of planning permission that may issue.

Conditions recommended as follows:

1. All mitigation measures in relation to archaeology and cultural heritage as set out in Chapter 14 of the IAR (IAC Ltd; date 26 September 2025) 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.

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 maybe required

Any further archaeological mitigation requirements specified by the planning authority, following consultation with the Department of Housing, Loca Government and Heritage, shall be complied with by the developer.

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. The Construction Environment Management Plan (CEMP) shall include the location of any and all archaeological or cultural heritage constraints relevant to the Proposed Project as set out in Chapter 14 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.

4. 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.

Response

The following response has been prepared by IAC Archaeology.

The mitigation measures outlined in Chapter 14, Section 14.4.2 of the EIAR, include a commitment to pre-construction archaeological testing in order to identify sub-surface archaeological features. The specific mitigation steps, from Chapter 14, Section 14.4.2 (Construction Phase (Indirect and Direct)), of the EIAR are reproduced below for clarity.

“Prior to the commencement of construction, a programme of targeted geophysical survey will be carried out at the location of the proposed temporary construction compound to investigate CH63, a curvilinear anomaly identified from aerial photography. The geophysical survey will be carried out under licence to the National Monuments Service of the DHLGH. Dependent on the results of the geophysical survey, further mitigation may be required. Any further mitigation will require agreement from the DHLGH.

Prior to the commencement of construction, a programme of targeted archaeological test trenching will be carried out at the accessible locations of proposed infrastructure, including the proposed turbine hardstands, temporary construction compound, 110kV substation and BESS compound and along the access roads and TDR accommodation area. Archaeological test trenching will also assess the site of previously unidentified cultural heritage receptor CH58. Archaeological test trenching will be carried out under licence to the National Monuments Service of the DHLGH. Dependent on the results of the testing assessment, further mitigation may be required, such as preservation by record or in-situ and/or archaeological monitoring. Any further mitigation will require agreement from the DHLGH.

All interventions that are required along townland boundaries, as part of the construction of the Proposed Project, will be subject to archaeological monitoring, to include a full record of the sections of townland boundaries that are removed. This work will be carried out under licence to the National Monuments Service of the DHLGH.

All topsoil stripping associated with the Proposed Wind Farm, including site investigation, will be subject to archaeological monitoring. This work will be carried out under licence to the National Monuments Service of the DHLGH. If archaeological remains are identified during the course of these works further mitigation may be required, such as preservation by record or in-situ. Any further mitigation will require agreement from the DHLGH.

The excavation of the Proposed Grid Connection within the Zone of Notification of AH2 and AH3 will be monitored. This work will be carried out under licence to the National Monuments Service of the DHLGH. If archaeological remains are identified during the course of these works further mitigation may be required, such as preservation by record or in-situ.

Any further mitigation will require agreement from the DHLGH.

Upstanding elements of cultural heritage receptors subject to direct, negative (permanent) impacts (CH14, CH40, CH58) will be surveyed and a written and photographic record compiled prior to the commencement of construction.”

These mitigation measures are also addressed in Appendix 4.5 Construction and Environmental Management Plan, Section 3.3 Archaeological Management as well as “Table 4 Proposed Mitigation Measures” of same document

The above mitigation is deemed sufficient to address the recommendation from the Department and the Applicant would welcome a condition relating to the same on any grant of planning permission from the Commission.

3.4 Inland Fisheries Ireland

A response to the observations from Inland Fisheries Ireland is provided by HES in Appendix 2.

3.5 National Office for Environmental Health Services (HSE)

3.5.1 Ground and Surface Water

In their observation, the National Office for Environmental Health Services (HSE) state they concur with the conclusions that there is adequate protection of surface and ground water during construction and operation of the proposed development if all the mitigation identified is implemented in full. This would include drinking water sources identified in the EIAR.

Response

The mitigation measures proposed within the EIAR have been designed to protect surface and groundwater during all stages of the project – construction, operation and decommissioning. The Applicant is committed to these mitigation measures. As outlined in Section 4 of the CEMP (Appendix 4-5), an Environmental Clerk of Works (ECoW) will be appointed to oversee the Project Contractor’s effective implementation of the Proposed Project’s environmental requirements and obligations, as captured in the CEMP. The ECoW will be responsible for monitoring the works of the Project Contractor from an environmental perspective on behalf of the Project Developer. For the sake of expediency, the ECoW will report their ongoing audit findings, monitoring results and site observations to both the Project Developer and the Project Contractor, having been nominated by the developer to fulfil the role. The ECoW will have the power to halt the works, should the need arise and will be supported by the developer to ensure the contractor adheres to such an instruction. The ECoW will also have to call upon the Project Ecologist, Project Hydrologist, or other members of the Project Developer’s design team, as required, to oversee the contractor’s works on-site.

3.5.2 Noise

A response to the noise observations from HSE is provided by TNEI in Appendix 3.

3.6 Office of Public Works (OPW)

In the observation received from the Office of Public Works (OPW), they state that the photomontages do not include the impact from the 9-no. nationally important receptors they list in Section 3.0 of the observation. They further state that the application does not provide evidence of assessment of national monuments through ZTV mapping or baseline photos.

Response

As stated in Section 1.6.1 of Appendix 13-1 LVIA Methodology, the selection process of viewpoints to include in photomontage imagery is included. The viewpoints, or locations of photomontage imagery capture, were selected following the 2006 Guidelines and draft 2019 Guidelines, the GLVIA3 (LI & IEMA, 2013) and the SNH Guidance v.2.2. The selection of viewpoints is designed to provide a representative range of views of the proposed turbines. Viewpoints were chosen after compiling the “Visual Baseline” (Section 13.5 of Chapter 13). The main purpose of establishing the visual baseline was to identify the key visual receptors that should be considered for viewpoint selection. To this end the following seven types of receptors were searched in the LVIA Study Area:

Designated Scenic Routes and Views

OSi viewing Areas

Settlements

Recreational routes

o Waymarked walking routes

o Cycle routes

- o Scenic drives

- o Tourist routes

Recreational, cultural and tourist destinations

Transport routes

Residential receptors

After all key visual receptors were identified, a Visual Receptor Preliminary Analysis was carried out to scope out selected visual receptors from further assessment due to the following reasons:

Receptors which have none or very limited theoretical visibility according to ZTV mapping.

Receptors comprising designated scenic routes or protected views, or featuring OSi Viewing Areas, that are not directed towards the Proposed Wind Farm.

Receptors visited on-site which have towards the proposed turbines that are either entirely or substantially screened from view (by elements such as forestry and roadside hedgerows and trees, and buildings, as noted in Section 1.5.1 of Appendix 13-1), or for which the distance from the proposed turbines, in combination with screening, would mitigate any potential for “Significant” visual effects.

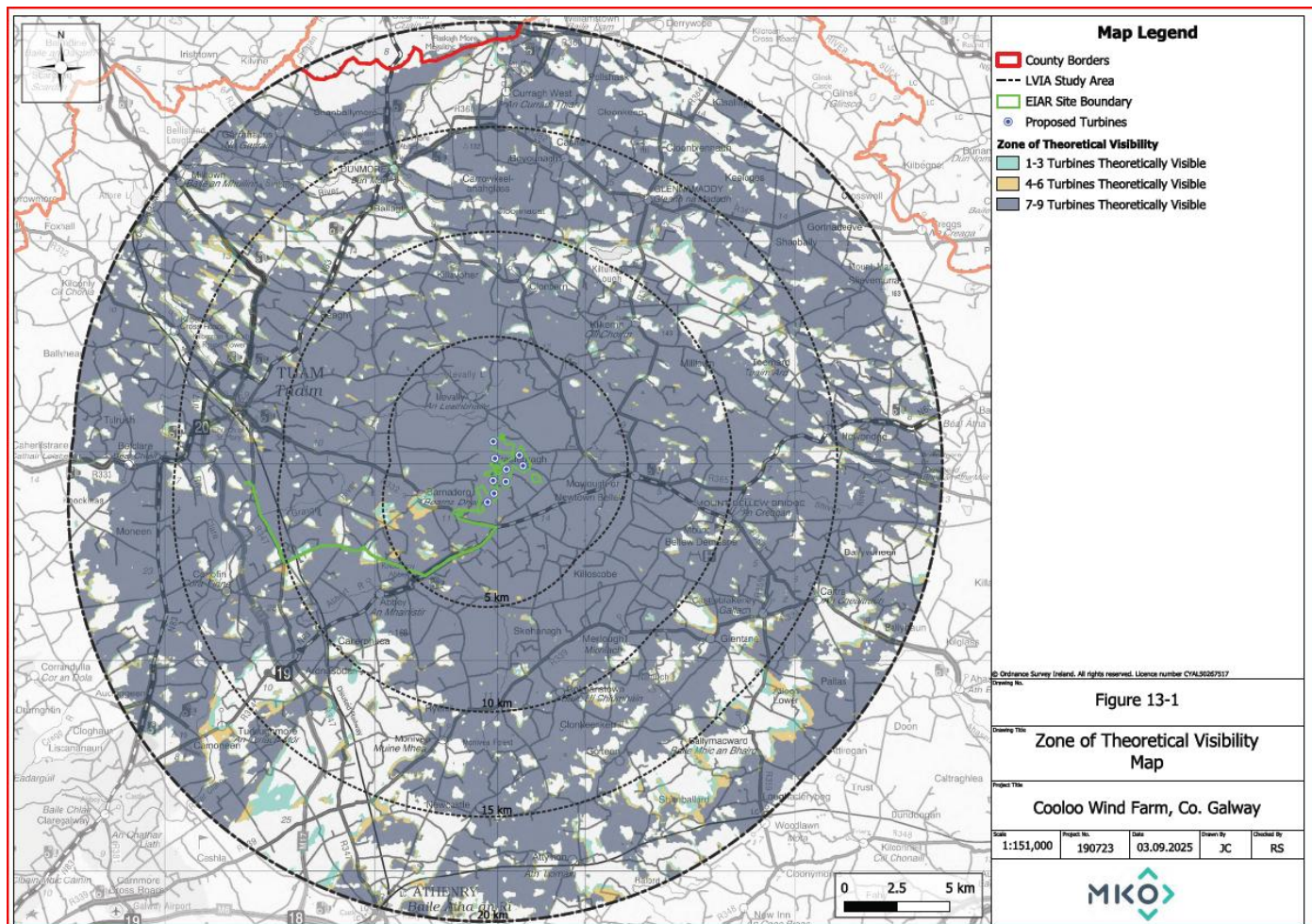
Views from all other key visual receptors were represented in the final selected viewpoint locations.

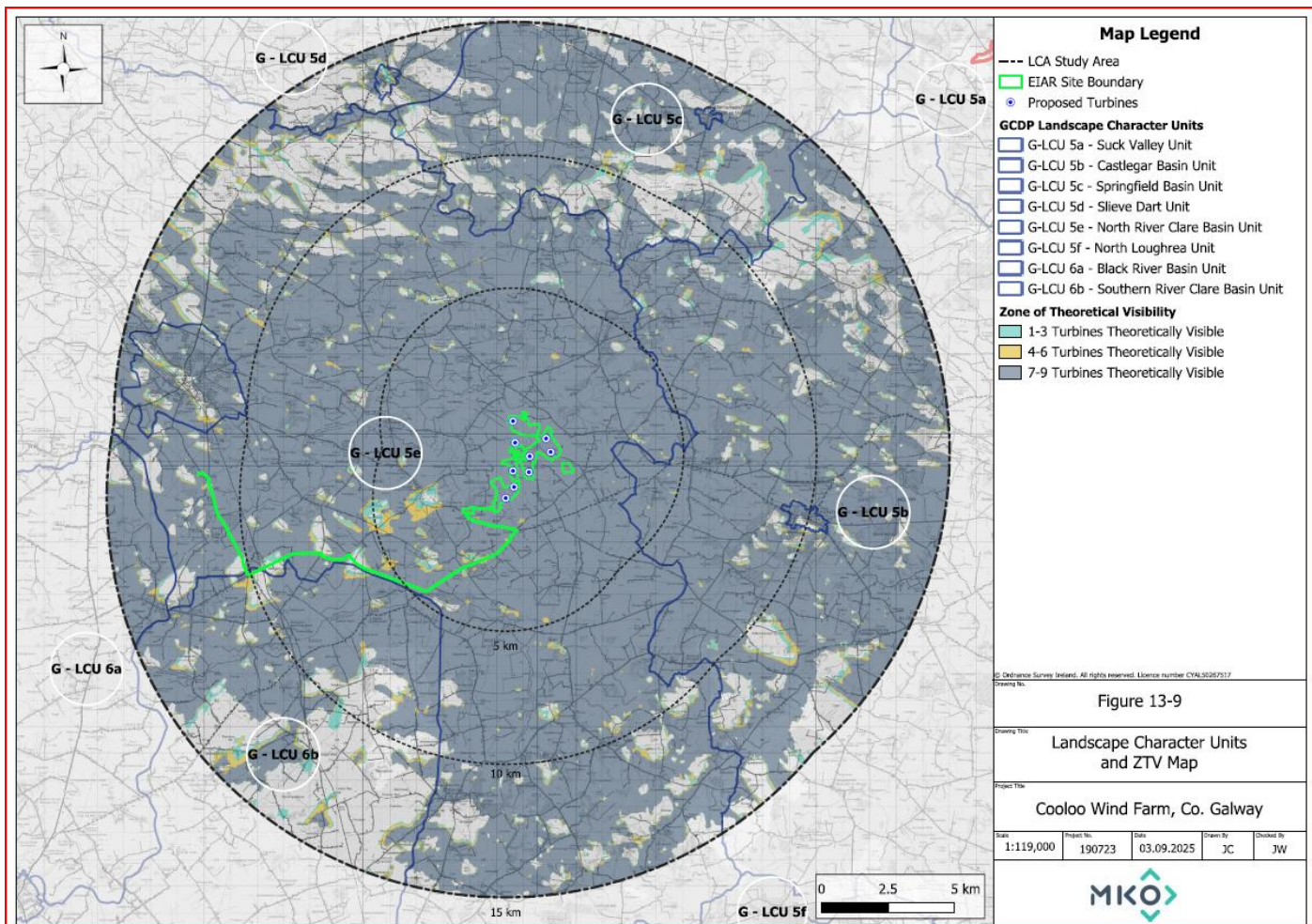
Viewpoints were chosen having regard to the SNH Guidance v.2.2 (2017) which advises that a range of views should be shown at a range of distances, aspects and varying elevations, and that images should illustrate instances where the proposed turbines will be completely visible as well as partially visible.

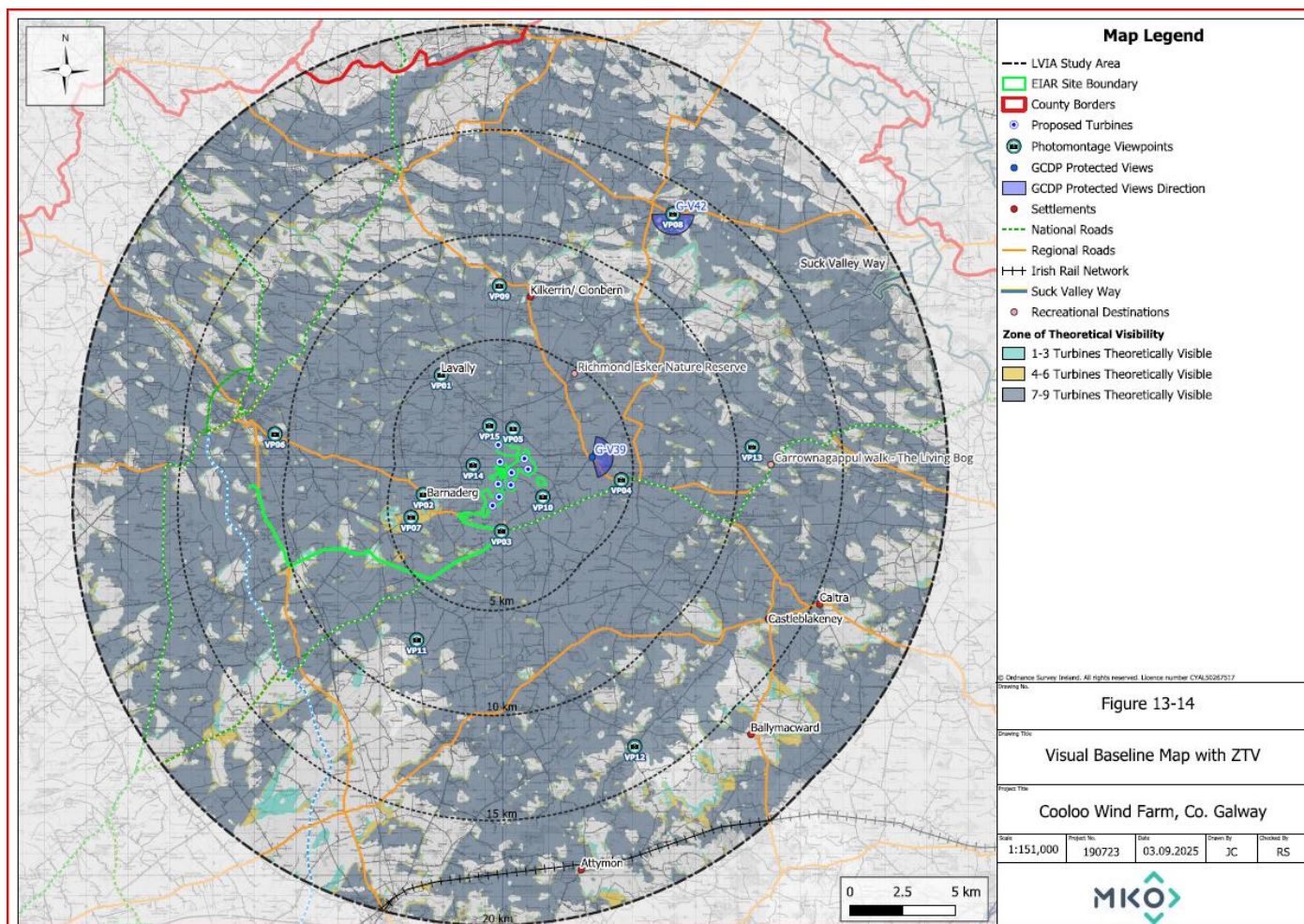
Consideration was also given to ensure that photomontages captured other wind farm developments in the LVIA Study Area in order to assess cumulative landscape and visual effects.

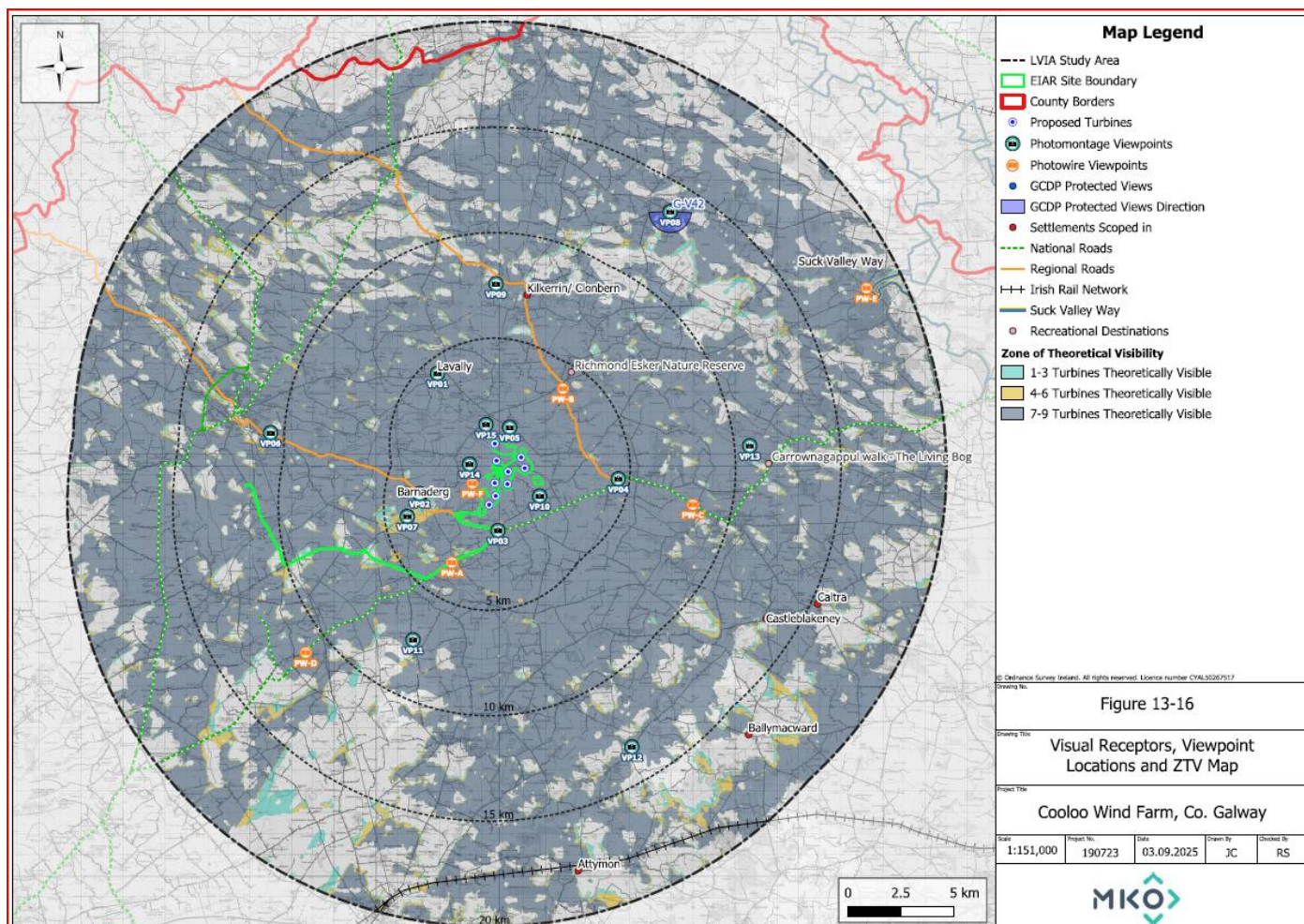
As stated in Chapter 14 Section 14.4.3 of the EIAR, the assessment assumes a long-term effect, rather than permanent, on Sites of national significance within 10km of the proposed turbine layout. Within 10km of the proposed turbines, there are Abbey, Knockmoy (NM166) and Church, Abbert Demense, Knockmoy (NM278) - both of which are included within the OPW observation. In Appendix 14-2 Assessment of Impacts on the Archaeological, Architectural and Cultural Heritage, both NM166 and NM278 are classified as having a ‘Low’ magnitude of Impact and ‘Moderate negative’ Significance of Effect.

Figures 13-1, 13-9, 13-14 and 13-16 of Chapter 13 of the submitted EIAR below show the Zone of Theoretical Visibility (ZTV) (Fig. 13-1), Landscape Character Units and ZTV Map (Fig. 13-9), Visual Baseline Map with ZTV (Fig. 13-14), and the Visual Receptors, Viewpoint Locations and ZTV (Fig. 13- 16) in proximity to the Site. The LVIA Baseline Map included as Appendix 13-4 of the submitted EIAR is also shown below. It is noted that these figures were subject to issues with the compression of the files and as a result did not show the coloured classification areas concerning the ZTV in the digital copy of Chapter 13. The maps were available in the hard copy of the EIAR, which is publicly available at the offices of both the Commission and GCC. The figures are a visual representation of the information included in Chapter 13, Sections 13.3.2, 13.4.1.1.5, 13.5, and 13.7.3.2.1 and Appendix 13-4 of the submitted EIAR and does not present any new or additional information.









3.7.2 Proposed Turbine Component Delivery Route

Response

TII note the requirement for a temporary over-run area in third party land on the southwest corner of the N63 / R332 junction in order to accommodate the abnormally sized loads and that the temporary access road will only be used for the transportation of abnormally sized loads, which will be delivered with a Garda escort and transient traffic management vehicles operated by the haulage company. The road will not be available for any other traffic and will be closed off and opened only for the delivery of the abnormally sized loads. Upon the completion of the construction phase, the temporary road will be covered with a layer of topsoil and reseeded and will only be used again in the unlikely event that an oversized delivery was required for wind turbine maintenance purposes.

TII note the proposed haul route traverses roads managed by a combination of PPP Concessions, Motorway Maintenance and Renewal Contractors (MmaRC) and local authorities (namely, GCC). Consultation between the Applicant and these companies and authorities will be undertaken prior to the commencement of turbine component delivery to confirm the delivery schedule and to ensure that the strategic function of the national road network is maintained. A Traffic Management Plan (TMP), incorporating all the mitigation measures is included as Appendix 15-2 of the EIAR, and will be finalised and confirmatory detailed provisions in respect of traffic management agreed with the road's authority and An Garda Síochána prior to construction works commencing on Site.

TII also highlight that any damage caused to the surface of the national road network due to the turning of abnormally sized loads (such as turbine blade deliveries) shall be rectified in accordance with TII Pavement Standards. As stated in Chapter 15, Section 15.1.12.5, of the EIAR, a pre-condition survey of roads associated with the Proposed Project will be carried out immediately prior to construction commencement to record an accurate condition of the road at the time. A post construction survey will be carried out after works are completed to ensure that any remediation works are carried out to a satisfactory standard. Where required the timing of these surveys will be agreed with the local authority [or other relevant authority]. All road surfaces and boundaries will be re-instated to pre-development condition, as agreed with the local authority engineers. Additionally, the Applicant notes the following TII considerations regarding the proposed temporary overrun areas at the N63 / R332 junction and commits to undertake all considerations should they be deemed required by the Commission.

3.7.3 Structures

Response

It is confirmed that no abnormal weight loads will be associated with the Proposed Project and therefore, a technical load assessment was not deemed necessary as part of the scope of the traffic and transport assessment.

[Response from MLavelle: The weights of blades, nacelles, towers & cranes should be provided to check the bridge/culvert load bearing capacities & to assess the road structure.](#)

Furthermore, as no abnormal weight loads or loads exceeding those permissible under the Road Traffic Regulations will be required during the construction, operation or decommissioning of the Proposed Project, it is not deemed necessary to undertake a full assessment of all structures on the national road network along the turbine delivery route or other construction material haul routes.

It is noted TII recommend the Applicant confirm all national road structures along proposed haul routes can accommodate the proposed load where exceeding that permissible under the Road Traffic Regulations. The Applicant commits to agree full details of transportation of abnormal loads with the planning and road authorities prior to the commencement of any development.

3.7.4 Grid Connection Routing

Response

As noted above in Section 2.1.4, the Proposed Grid Connection is not included in this application and will be subject to a separate application but has been assessed in detail within the EIAR. The construction methodology of providing an underground grid connection cabling route under and along local road networks is well established and accepted nationwide. There are in excess of 300 wind farms currently operational in

Ireland and the majority of these are connected to the national grid via underground cable connections predominantly along the public road networks.

Response from MLavelle:

Based on a construction rate of 100m per day, it is estimated that the grid route will take approximately 210 working days to complete based on one construction crew operating at one location. In practice the construction duration may be significantly reduced using 2 construction crews operating at different locations on the route.

An assessment of the impacts during the construction of the Proposed Grid Connection underground cabling route is set out in Section 15.1.7 of Chapter 15 in the EIAR. The Proposed Grid Connection cabling runs for approximately 21km, of which 4.2km is located within the corridor of the N63 National Secondary Road. As shown in Table 15-26 of Chapter 15 in the EIAR, the construction of the proposed underground grid connection cabling along the N63 would take approximately 42 days. For the purpose of the assessment, a pre-cautionary scenario here a road closure will be required for the entire route is assumed. To facilitate the works along the route, a series of potential diversion routes have been identified which may be used during the construction phase. Prior to the construction of the Proposed Grid Connection, the final diversion routes that will be used during the construction phase will be discussed and agreed with GCC.

In Section 6 of the Traffic Management Plan (Appendix 15-2), included in the EIAR, states the proposed mitigation measures that will be implemented. Included within the suite of proposed mitigation measures is the proposed re-instatement works of all road surfaces and boundaries to predevelopment condition, as agreed with the local authority engineers. All works will be done in accordance with the Guidelines for the Opening, Backfilling and Reinstatement of Openings in Public Roads, DTTOS, September 2015.

In Section 3.5.4 in Chapter 3 of the EIAR, the alternative grid connection options that were considered as part of the assessment was listed and described. Option B would see increased cabling in the national road network compared to the chosen option – Option A. A ‘loop-in’ overhead line option was not considered as part of the assessment due to various landowner negotiations which proved unsuccessful, and therefore it was deemed that the option of a ‘loop-in’ grid connection was not a feasible option at this point in time.

TII note that grid connection works in national roads have the potential to result in technical road safety issues such as differential settlement. Should a future application be granted for an underground grid connection in the public road, reinstatement for concrete and asphalt/bitumen and road sections, will be permanently reinstated in accordance with the specification and to the approval of the Local Authority. Reinstatement will also comply with the requirements of the Local Authority and the Specification for the Reinstatement of Openings in National Roads and Transport Infrastructure Irelands (TIIs) design standards for both hardstandings and verges.

3.7.5 Greenways

It is noted TII recommend consultation with GCC’s internal project and/or design staff in relation to any Greenway or Active Travel proposals in the vicinity of the Proposed Project.

Response

There are no known Greenway or Active Travel proposals within the Site. However, should any proposals emerge in the future that use infrastructure corridors pertaining to the Proposed Project, consultation will be undertaken with GCC.

In summary, the matters raised in the TII submission have been carefully considered and it has been demonstrated in this section, that they have been comprehensively addressed across the robust documentation which accompanied the application.

3.8 Uisce Éireann

Uisce Éireann, should permission be granted by the Commission, request conditions in relation to refuelling areas, geotextile liner, the monitoring of foundation works, the location of temporary cement washout lagoons, drainage runoff, and compliance with relevant directives and best practice guidance.

Response

The recommended conditions raised by Uisce Éireann are reflected through the mitigations measures in the EIAR. These conditions are considered to be acceptable by the Applicant in the event of a grant of permission.

Further response to the submission by Uisce Éireann is addressed by HES in Appendix 2 of this response document.

4. CONCLUSION

This response document has been prepared to address concerns raised in the observations made in respect of planning application reference ABP Ref. 323761 regarding the Proposed Project. The information provided in this document will directly assist the Commission in their ongoing consideration of the planning application. It is re-iterated here that a robust EIAR and NIS were carried out and accompanied the planning application for the Proposed Project, and this is demonstrated by the fact that detail from the EIAR has been reproduced and/or referenced in this document in order to respond to the majority of observations made. It is our view that the information provided within this document is confined to the issues raised within the observations received by the Commission and there is no additional information provided that would be considered 'significant' or 'material'.

The information provided in this document constitutes a full and robust response to the matters raised and we trust that this allows the Commission to progress with their assessment of the Proposed Project.

APPENDIX 1 Gavin & Doherty Geosolutions (GDG) Submissions Response

1 PEAT STABILITY

This section presents the applicant's response to submissions pertaining to peat stability, and the Peat Stability Risk Assessment (Technical Appendix 8-1 of the EIAR), and has been prepared by GDG.

The responses outlined below address the following themes:

- Assertions of inadequate peat stability risk assessment;
- Concerns regarding construction of floated access tracks.

All of the matters raised in the submissions are addressed in Chapter 8 of the EIAR, in particular through the comprehensive suite of mitigations outlined in Section 8.5 (Mitigation Measures), and in Appendix 8-1 (Peat Stability Risk Assessment) and Appendix 4-2 (Peat and Spoil Management Plan).

However, the key issues raised in the submissions are summarised and addressed in the following sections.

1.1 PEAT STABILITY RISK ASSESSMENT METHODOLOGY

1.1.1 SUBMISSIONS

Submissions by several 3rd parties, including North East Galway Environmental Protection contend that the peat stability risk assessment presented in Appendix 8-1 (Peat Stability Risk Assessment) is inadequate. Several Submissions raise points taken from an unattributed "Technical Review Report - Chapter 8: Land, Soils & Geology (Cooloo Wind Farm EIAR)". The points relevant to the Peat Stability Risk Assessment/Peat Management Plan are summarised below:

- *"The investigation relies on only two boreholes for deep surface stratigraphy in a 9-turbine site, which is inadequate given the varying peat depths and subsurface complexity. The sampling density is insufficient in key areas (e.g. near turbine bases, along access roads crossing bog) to establish confidence in peat/geotechnical stability."*
- *"The PSRA uses a deterministic 2-D infinite-slope model with a FoS ≥ 1.3 threshold and undrained shear strength of 5 kPa. No transient rainfall or coupled hydro-geotechnical modelling was undertaken. Risks are described as 'low to medium' but this conclusion lacks quantitative verification."*
- *"Key deficiencies include*
 - *Over-reliance on 2-D infinite-slope model, unsuitable for complex peat terrain.*
 - *Absence of rainfall or drainage event sensitivity analysis,*
 - *FoS sensitivity to 2–3 kPa not tested*
 - *Deferred monitoring contrary to Derrybrien precedent. "*

Similar concerns were raised in a submission by North East Galway Environmental Protection CGL (NEGEP).

This submission also raised concerns about the use of the Scottish Government (2017) Best Practice

Guidelines for assessment of peat stability in Ireland, arguing that *"the developers risk using a standard that is*

less stringent, or less appropriate for the specific characteristics of Irish peat soils, than that typically required by Irish regulators (like the EPA or NPWS)."

The NEGEP submission also raised concerns about the inclusion of the statement "Further inspection will be required during the detailed design and construction stage to inspect for peat instabilities, including bog burst features" (PSRA Section 4.5). The submission asserts that this *"indicates the report has gaps and lacks complete, precise and definitive findings and conclusions capable of removing all reasonable scientific doubt as to the effects of the works proposed on the Lough Corrib Sac and protected habitats"*

1.1.2 RESPONSE

A Peat Stability Risk Assessment (PSRA) has been undertaken for the site and was included as Appendix 8-1 of the EIAR. The PSRA was conducted in accordance with "Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments" (PLHRAG, Scottish Government, 2017). The PSRA included the following studies and investigations to determine the peat risk on the site:

- Desk Study, including review of historic landslides, mapping (geology, hydrology, hydrogeology, topography), current and historic aerial imagery
- Site Reconnaissance and Walkover
- Ground Investigation
- Peat Stability Assessment – quantitative assessment of peat landslide hazard, using the infinite slope model to generate a Factor of Safety (FoS) for each 5m pixel across the Proposed Development site, in line with the Scottish Government PLHRAG (2017)
- Risk Assessment – quantitative assessment of the peat landslide risk at each infrastructure location, combining hazard assessment (including the quantitative FoS and assessment of qualitative hazard factors, scored using expert judgement) and adverse consequences assessment, to calculate an overall risk score at each location.

NEGEP raised concerns that the Scottish Government Best Practice Guidance (2017) is not an Irish document. However, this guidance is the current industry best practice guidance for the assessment of peat landslide risk in Ireland due to the absence of any Irish-specific equivalent guidance.

The PSRA concludes in Section 8 that *"The peat stability risk for the proposed infrastructure is negligible in all locations."* The individual risk rating scores for each infrastructure element are outlined in Section 5.6 and illustrated in full in Appendix M of the PSRA. In each case, the risk score was calculated to be <0.2 (negligible). This is a clear and unambiguous statement of the assessed peat stability risk across the site, following the rigorous peat stability risk assessment.

As outlined above, submissions have queried the adequacy of the methodology used to carry out this assessment. These assertions are refuted and the assessment has been conducted in line with the current best practice guidelines. The full methodology of the peat stability risk assessment undertaken is outlined in Section 4 and Section 5 of Appendix 8-1 (PSRA), and a full summary of the ground investigations undertaken to inform the assessment is outlined in Section 3.

Ground Investigation

The assessment included intrusive ground investigation at 344 locations, including:

- 306no. peat probes;
- 27no. trial pits;
- 6no. hand shear vanes performed in peat; and
- 2no. rotary boreholes.

Considering the topography and low-lying mixed cut-over/drained raised bog environment at the proposed wind farm site, this level of GI is robust, with strong coverage of the key infrastructure locations, particularly in areas of peat soils. As outlined in Section 3, access to some localised forested areas of the site was limited, however, the peat surveys were extensive outside of these very localised areas.

The findings of the peat investigations are summarised in PSRA Section 3.1:

"Review of the published geological information, site observations, and the results of the ground investigation campaigns indicate that the ground conditions at the proposed wind farm site consists of a generally flat to undulating topography, with prominent ridges of glacial material (Drumlins) separating large, flat-lying raised peat bogs, which have been subject to turbary peat harvesting.

Trial pit locations (Appendix K.1) suggest that the peat is typically underlain by granular or cohesive glacial material, with trial pits encountering soft to firm gravelly CLAY/SILT, sandy GRAVELS, and sandy SILT (marl-like silt) underlying the peat. In addition, Petersen Drilling Services Ltd. carried out two boreholes for the purpose of the hydrological assessment (Chapter 9 of the EIAR). These boreholes encountered a similar mix of cohesive and granular glacial tills and encountered limestone bedrock at 4.9m BGL and 2.6m BGL, respectively. The peat thickness encountered by intrusive investigations across the Proposed Wind Farm site varies from 0m (in areas where peat is absent) to a maximum of 7.1m, with an average of 1.3m, and a median of 0.4m recorded. Areas of the Proposed Wind Farm site containing little to no peat, underlain by cohesive or granular glacial tills, include T01, T04, T6-T8, the substation, the construction compound and the southern and central Proposed Wind Farm site access tracks. Much of the remaining proposed infrastructure, including T2-T3, T6-T7 hardstands and T9, the BESS compound and the majority of the northern access tracks, are in areas of cut-over peat, where turbary peat harvesting has removed significant quantities of peat, reducing peat thicknesses. The frequency of different peat thicknesses is shown in **Error! Reference source not found..** In total, 64% of recorded peat depths were under 1m, and 74% were under 2m.

Laterally extensive regions of >3m in depth were encountered in raised bog settings, particularly to the north of T5 (approx. 30m), to the southeast of T7 (approx. 120m from the hardstand), to the west of T9 (approx. 200m) and the north of T2 (approx. 100m). These areas of deep peat are restricted to discrete raised bogs, which all major infrastructure positioning has avoided, aside from the proposed floated track between T7 and T9, which passes across one area of raised bog, with recorded peat depths of up to 6.8m.”

Video footage has been submitted by Barnaderg Cooloo Windfarm Action Collective that purports to provide evidence for peat depths in excess of 10.5m. GI was undertaken at an appropriate density.

However, localised deeper peat pockets can exist beyond the maximum depths identified by the GI and would not have an appreciable impact on the peat stability risk in this case.

Assessment methodology

As outlined in Section 4 of the PSRA (Appendix 8-1), a quantitative assessment of peat stability across the site has been performed, using the infinite slope model to generate a factor of safety (FoS) for each 5m pixel across the site. This analysis has been conducted in line with industry best practice (in particular the **2017** Scottish guidelines), and has considered four different scenarios:

- Undrained conditions;
- Undrained conditions considering 1m of peat surcharge;
- Drained conditions; and
- Drained conditions considering 1m of peat surcharge.

These scenarios simulate a range of potential peat conditions, with consideration of both hydrological factors and loading of the peat due to construction/placement of peat stockpiles, in line with the recommendations of the Scottish best practice guidance (**2017**) and the findings of Lindsay and Bragg (**2004**) – as discussed in the literature review in Section 2.14 of the PSRA.

Selection of the critical parameters, in particular the undrained shear strength (c_u) effective cohesion (c'), and effective friction angle (ϕ') have been discussed at length in Section 4.3 of the PSRA. Several submissions argue that the selected undrained shear strength (c_u) value of 5kPa does not constitute a conservative value, and that sensitivity analysis should have been performed with c_u values of 2- 3kPa. The value of 5kPa was selected as it is significantly lower than the lowest recorded hand shear vane value of 12kPa (1m bgl in HSV-TP15- Section 3.1 of the PSRA) and is based on GDG's experience in the assessment of similar raised peats and values reviewed in the literature, as outlined in Section 2.14 of the PSRA. This methodology is sufficiently conservative to constitute a robust assessment.

As outlined in Section 5 of the PSRA, a further quantitative risk assessment has been performed across the key infrastructure locations, taking into account the factor of safety, and a series of hazard (Section 5.4) and adverse consequence factors (Section 5.5) to produce an overall risk rating at each location prior to mitigation.

Deferred Investigation and Monitoring

Section 4.5 of the PSRA (Appendix 8-1) does state “*The lack of evidence for historical peat slides, and translational and flow slides does not preclude the possibility that these may occur. Further inspection will be required during the detailed design and construction stage to inspect for peat instabilities, including bog burst*

features. The design and construction teams will develop their own inspection and testing criteria to satisfy and de-risk the possibility of peat landslides at these locations. Further mitigation and monitoring measures are outlined in Section 6”.

This statement was included to ensure that best practice is adhered to at detailed design and construction stages. It does not imply that there is uncertainty relating to peat landslide risk on the site. Further detail is provided below:

- “The lack of evidence for historical peat slides, and translational and flow slides does not preclude the possibility that these may occur.” This statement identifies that the lack of historical landslides on the site is not the only indicator of the future risk. The actual risk of future peat instability is determined by the PSRA process.
- “Further inspection will be required during the detailed design and construction stage to inspect for peat instabilities, including bog burst features.” The PSRA is based on current information and site conditions at the time of the assessment. The timeline between EIA and detailed design/construction is often several years. It is therefore good practice to undertake confirmatory inspections of the proposed site at detailed design stage.
- “The design and construction teams will develop their own inspection and testing criteria to satisfy and de-risk the possibility of peat landslides at these locations.” The use of Inspection and Test Plans (ITP) is standard in the construction industry. In this case, ITPs will be used to verify site conditions and parameters such as peat strength, thereby validating the design.

Conclusions

A comprehensive PSRA was carried out for the proposed site. The peat stability risk without mitigation was determined to be negligible. To further reduce the risk, a conservative approach has been taken by including additional mitigation measures. These include identifying Safety Buffer Zones where no infrastructure is located and Peat Stockpile Restriction Areas where no peat deposition is permitted. In accordance with the PLHRAG, Scottish Government, 2017, negligible peat stability risk means the project should proceed with monitoring and mitigating peat landslide hazards at these locations as appropriate. Therefore, best practice has been followed in the PSRA.

Assertions that there is an absence of complete, precise and definitive findings in relation to the peat stability risk on the proposed site are refuted. The PSRA carried out by GDG was carried out by experienced and competent specialists in accordance with best practice guideline and determined conclusively that the peat risk on the site is negligible.

1.2 FLOATED ACCESS TRACKS

1.2.1 SUBMISSIONS

A number of submissions, including by the Barnadeg Cooloo Windfarm Action Collective raise concerns about the construction of floated access track at the proposed wind farm site, especially a “*c.0.6 km floating access road over intact raised bog to turbine T7*”. More than one of these submissions raises the guidance prepared for Scottish Natural Heritage and the wind energy industry (“Floating Roads on Peat – A Report into Good Practice in Design, Construction and Use of Floating Roads on Peat with particular reference to Wind Farm Developments”, Forestry Civil Engineering, 2010) as evidence that construction of floated access tracks is inherently high risk and should never be consented.

Several submissions raise concerns over disruption to the hydrological regime and ecological state of the bog. We emphasise that these issues are not relevant to the scope of our work and will be addressed elsewhere by the appropriate topic experts, as Appendix 8-1 is concerned only with peat stability.

1.2.2 RESPONSE

Concerns were raised regarding the construction of floated access tracks, particularly in the wake of the 2020 Meenbog landslide. The PSRA assessment considers the findings of previous investigations of the Meenbog and Derrybrien failures, and has selected peat parameters appropriate to the site conditions (outlined above). The PSRA factor of safety analysis considers a surcharged scenario designed to simulate peat stockpiling and construction loading, which concluded that all areas of floated track are located in areas of FoS >1.3 in the undrained and drained conditions with application of surcharge.

This approach is aligned with the recommendations of the 2010 “Floating Roads on Peat – A Report into Good Practice in Design, Construction and Use of Floating Roads on Peat with particular reference to Wind Farm Developments” report cited by the submissions. Contrary to the concerns raised in the submissions, the existence of a good practice guidance for construction of floated tracks does not mean that this track type is inherently too high-risk to be safely constructable.

Instead, this document outlines good practices for construction of floated tracks on peat, and outlines key pre-construction considerations, including:

- Carrying out a robust peat landslide hazard assessment;
- Ranking the perceived hazard and risk;
- Taking risk avoidance measures;
- Considering construction methodologies to construct the works, i.e. the “buildability” of the development;
- Identifying mitigation measures and preparing contingency plans to deal with any residual risks

The assessment outlined in the PSRA (Appendix 8-1) provides a robust landslide hazard risk assessment across the site, outlines mitigation measures, and risk avoidance measures, while the Peat and Spoil Management Plan (PSMP, Appendix 4-2) outlines floated track construction methodologies in line with the best practice Scottish guidance (2010 and 2017).

2 KARST RISK ASSESSMENT

This section presents the applicant’s response to submissions pertaining to the Karst Risk Assessment (Technical Appendix 8-2 of the EIAR), and has been prepared by GDG. The responses outlined below address the following themes:

- Concerns regarding lack of consideration of hydrogeology in the Karst Risk Assessment (KRA);
- Concerns regarding the KRA methodology.

All of the matters raised in the submissions are addressed in Chapter 8 and/or Chapter 9 of the EIAR, in particular through the comprehensive suite of mitigations outlined in Section 8.5 (Mitigation Measures), and in Appendix 8-2 (Geotechnical Karst Risk Assessment). However, the key issues raised in the submissions are summarised and addressed in the following sections.

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.

Response from MLavelle: Karstic conduits & vibration cause liquefaction of materials deposited in the underground conduits since the last ice age c10,000 years ago. This potential blockage of conduits can impact the Mid-Galway & Barnaderg spring sources.

2.1 CONSIDERATION OF HYDROGEOLOGY

Multiple submissions voiced concerns that the impact of the development on the hydrogeology, water supply and local aquifers was not sufficiently addressed by the KRA. Section 1.1 of the KRA (Appendix 8-2) states: *“This assessment is limited to consideration of the geotechnical risks posed by karstic features to the Proposed Wind Farm. Consideration of the impact of the Proposed Wind Farm on the hydrology and hydrogeology of the Proposed Wind Farm site is outside the scope of this report.”*

Assessment of the hydrology and hydrogeology is considered in full in Chapter 9 – Hydrology and Hydrogeology. Assessment of the karst features within Appendix 8-2 is limited solely to geotechnical risk.

2.2 KRA METHODOLOGY

2.2.1 SUBMISSIONS

A small number of submissions, and North East Galway Environmental Protection raise concerns over the methodology of geotechnical karst risk assessment, and the quantity of GI across the proposed wind farm site. An additional submission raises concerns about the existence of a Geotechnical Risk Register (Appendix I of the KRA- Appendix 8-2), stating *“This risk assessment reflects 193 impacts under the Precautionary Principle that determines this site is unsuitable for a windfarm”*.

2.2.2 RESPONSE

The KRA (Appendix 8-2) provides a clear summary of the methodology used to classify and quantify karst risk throughout the report, with a summary of the workflow and basis for the assessment in published literature and previous project experience in similar lowland karst environments in Co. Galway outlined in Section 1.5. While no specific standard or best practice guidance for the assessment of geotechnical karst risk exists in Ireland, the methodology employed in the KRA constitutes a robust risk assessment, in line with industry best practice. The KRA included the following studies and investigations to determine the peat risk on the site:

- Desk Study, including review of published mapping (geology, hydrology, hydrogeology, topography) and current and historic aerial imagery (Section 2);
- Site Reconnaissance and Walkover (Section 4);
- Ground Investigation (Section 4); and
- Risk Assessment – quantitative assessment of the geotechnical karst risk at each infrastructure location, combining hazard assessment (assessment of qualitative hazard factors, scored using expert judgement – Section 5.3-5.6) and adverse consequences assessment (Section 5.7), to calculate an overall risk score at each location (Section 5.8).

This methodology considered the available ground investigation data, including 2no. boreholes, and 27no. trial pits, with ERT and seismic geophysical surveys conducted in the area of highest identified risk. Following the calculation of risk scores, the KRA applied mitigation measures where considered appropriate, with a full geotechnical risk register (GRR) developed and presented in Appendix I of the KRA. Section 8 concludes that: *“The assessment findings showed that the majority of the proposed infrastructure locations are located in areas of low to medium karst hazard, with localised areas of high and very high hazard identified. One turbine (T4) was identified as being located in an area of high karst hazard, with a section of access track immediately north of T4 also identified as having a high karst hazard. The karst risk assessment shows that the risk at each infrastructure location ranges from medium to very high (at T4) prior to the application of mitigation measures. Following the implementation of mitigation measures, the residual risk at each infrastructure location ranges from low to medium, indicating that development can proceed as long as mitigation measures are implemented and that the risk assessment is further refined following further confirmatory ground investigation.”*

A robust geotechnical karst risk assessment has been carried out, identifying areas of high karst risk, proposing and implementing mitigation measures to reduce to low or medium risk in all infrastructure locations, and proposing confirmatory GI to further refine the risk assessment and allow for further reduction of risk and detailed design of infrastructure foundations and appropriate mitigation measures if required.

APPENDIX 2 Hydro-Environmental Services (HES) Submissions Response MKO, Tuam Road, Galway, Ireland, H91 VW84

F.A.O. Mr Brandon Taylor

Dear Mr Taylor,

Re: An Coimisiún Pleanála Third Party Submissions Response regarding Cooloo Wind Farm, Co. Galway
ABP Ref: PAX07.323761

1 INTRODUCTION

Hydro-Environmental Services (HES) were requested by MKO to respond to third party submissions made to An Coimisiún Pleanála (ACP) regarding the proposed Cooloo Wind Farm, Co. Galway (ACP Case Ref: PAX07.323761).

The Proposed Project (Proposed Wind Farm site and Proposed Grid Connection) is described in full in Chapter 4 of the submitted EIAR.

2 STATEMENT OF EXPERIENCE

Hydro-Environmental Services (“HES”) are a specialist geological, hydrological, hydrogeological and environmental practice that delivers a range of water and environmental management consultancy services to the private and public sectors across Ireland and Northern Ireland. HES was established in 2005, and our office is located in Dungarvan, County Waterford.

Our core areas of expertise and experience include hydrology, hydrogeology and karst hydrogeology and wind farm drainage design and management.

HES has extensive wind farm drainage and hydrogeological experience relevant to this project.

Wind farm environmental impact assessment in respect of geology, hydrology, and hydrogeology has and is a core business area for HES presently and also over the past 20 years.

Wind farm drainage design/management requires experience both as a civil/drainage engineer, a hydrologist, and as a hydrogeological specialist. HES has these combined experiences and expertise. HES has worked on over 100 wind farm projects in Ireland and Northern Ireland. Many of these required assessments of geological conditions, existing drainage features, and streams and water quality data. HES work at all stages of wind farm developments including feasibility stage, layout design & preliminary drainage design/planning stage, FRAs, and also at construction management stage.

HES also specialises in wetland and peatland eco-hydrology. We are very familiar with all type of peatland sites (i.e. blanket, fen, raised bogs, and other types of wetlands).

Relevant to the Cooloo Wind Farm project, HES has completed over 40 Source Protection Assessments for the GSI/NFGWSs, and for Irish Water, and for private developments across the country in a wide variety of hydrogeological settings.

HES has also been involved in over 80 Uisce Éireann water supplies to date in Counties Tipperary, Wicklow Waterford, Kilkenny, Wexford, Cork, Limerick, and Carlow. HES have prepared hydrogeological audit reports for these sites, with follow-on works including water level monitoring, water quality monitoring, camera surveys, and borehole maintenance and remediation works. HES has also completed specification and tendering, and follow-on supervision and management of trial well and production well drilling works and pumping tests works.

All these experiences are particularly relevant to this project, and they have been applied through the project development phase, the constraints mapping phase, and EIAR preparation work, including the cumulative impact assessment.

This response submission has been prepared by David Broderick (P.Geo) and Michael Gill (P.Geo). David and Michael prepared the Land Soil and Geology and Water Chapters of the submitted EIAR, and their qualifications, competencies, and experience are already presented in the EIAR (refer to Section 9.1.2 of Chapter 9).

3 RESPONSE LAYOUT

Firstly, direct responses are presented relating to concerns/or commentary raised in the following submissions:

- Galway County Council
- Uisce Éireann
- Inland Fisheries Ireland (IFI)
- National Office for Environmental Health Services (HSE)
- Hydro-G
- North-East Galway Environmental Protection (NEGEPC)

Following the direct responses, we then present responses to recurring topics raised in the other third-party submissions. These recurring topics include the following:

- Effects on local group scheme and public water supplies;
- General surface water and groundwater quality effects;
- Potential effects on local private wells;
- Potential impacts on Lough Corrib SAC; and,
- Increased flood risk.

Please note regarding the response approach below. Where bold italics are used it indicates text directly referenced from the third-party submission response itself. Regular italics indicates text referenced from the previously submitted EIAR or associated documents.

4 GALWAY COUNTY COUNCIL

Overall, the Galway County Council submission was positive with regard the proposed project:

“Having particular regard to the National Planning Framework – Project Ireland 2040, Climate Action Plan 2024, The Regional Spatial and Economic Strategy 2020 – 2032 (RSES) for the Northern and Western Region and the Galway County Development Plan 2022-2028, it is considered that the proposed development is acceptable”.

“Having reviewed the documents as submitted and having regard to the content of the consultation response received from the Environment Department, Galway County Council are of the opinion that the proposal would not result in adverse impacts on Population, Human Health and Residential Amenity”.

28 no. Conditions were recommended by Galway County Council and apart from the requirement for appropriate management of surface water runoff generated by the development, no other matters were raised with regard the water or soil/geology environment.

The surface water drainage plan is proposed for the wind farm site which is described in Section 9.4.1 of Chapter 9 of the EIAR and with the drainage drawings attached as Appendix 4-3 of the EIAR. The key components of the drainage plan are as follows:

- The first method involves ‘keeping clean water clean’ by avoiding disturbance to natural drainage features, minimising any works in or around artificial drainage features, and diverting clean surface water flow around excavations, construction areas and temporary storage areas;
- The second method involves collecting any drainage waters from works areas within the Site that might carry silt or sediment, and nutrients, to route them towards stilling ponds prior to controlled diffuse release over vegetated surfaces. There will be no direct discharges to surface waters;
- During the construction phase all runoff from works areas (i.e. dirty water) will be attenuated and treated to a high quality prior to being released within the site at Greenfield rates;
- No runoff will be permitted to enter third party lands that neighbour or are downstream of the proposed wind farm site; and,
- The drainage plan will ensure there is no risk of increased downstream flooding as there will be no alteration of the existing hydrology of the local watercourses.

The drainage measures detailed in Chapter 9 of the submitted EIAR are tried and tested, best-practice mitigation measures for the protection of the hydrological (surface water) and hydrogeological (groundwater) environment. These mitigation measures are used at construction sites across the country and have been used in the construction of the countless existing wind farm developments.

All new river/stream crossings will require a Section 50 application (Arterial Drainage Act, 1945).

The river/stream crossings will be designed in accordance with OPW guidelines/requirements on applying for a Section 50 consent (refer to Section 9.5.2.9 for mitigation relating to watercourse crossing proposal).

Also, a site-specific Flood Risk Assessment was also completed for the project (refer to Appendix 9-1 of the EIAR). The Proposed Project has no interaction with OPW mapped fluvial flood zones.

5 UISCE ÉIREANN

Uisce Éireann reviewed the proposed mitigation measures with regard the Mid Galway Public Water Supply (PWS) abstraction and requested the additional measures listed below be conditioned should the development be approved. Please refer Section 9.5.2.1 of the EIAR for mitigation measures relating to the PWS and GWS.

It should be noted that Uisce Éireann did not note any specific shortfall in the proposed mitigation as presented in the EIAR. The list of recommended additional requirements outlined in the table below all relate to mitigation measures already proposed in the Chapter 9 of the EIAR.

In order to compare mitigation outlined in the EIAR to the additional UÉ requirements, we have prepared the following table to allow direct comparison:

UÉ Requirement	Existing mitigation outlined in commitments made in Section 9.5.2.1 of the EIAR
The refuelling for mobile plant and machinery, to be used in construction shall be located outside of the Source Protection Area as 'committed to in the EIAR. Uisce Éireann requires that refuelling take place in a dedicated and designated location. The applicant shall agree the location of the refuelling area with Uisce Éireann prior to commencement.	"Refuelling of mobile plant (i.e. diggers, dumpers etc) will only be permitted outside the SPA".
The EIAR notes that a geotextile liner will be placed below the founding layer (lean mix concrete) where concrete is to be poured to prevent vertical loss of wet concrete at turbine bases. Uisce Éireann requires that details of this geotextile shall be recorded and logged on the risk register.	"A geotextile liner will be placed below the founding layer (lean mix concrete) where concrete is to be poured. These both prevent vertical loss of wet concrete at turbine bases".
The EIAR notes that perimeter shuttering is to be used at turbine bases to prevent lateral loss of wet concrete. Uisce Éireann requires that a consultant hydrogeologist /engineering geologist shall be employed to monitor and supervise foundation works and in particular any grouting works.	"Use of perimeter shuttering at turbine bases to prevent lateral loss of wet concrete".
The EIAR notes that all temporary cement washout lagoons are proposed be located outside the Public Water Supply (PWS) Source Protection Area (SPA). The location of these lagoons, in hardstanding areas outside the PWS SPA, shall be designated and agreed with Uisce Éireann prior to commencement. The washout lagoons shall be lined and a consultant hydrogeologist / engineering geologist shall be employed to monitor and supervise the activities at these lagoons.	"All temporary cement washout lagoons will be located outside the SPA".
The EIAR notes that no wind farm drainage will be released inside the 50m watercourse buffer on the Lecarrow 30 Stream. Any runoff from hardstanding areas shall also be treated for settlement of suspended solids prior to discharge. Turbines T1 and T2 are located within the Source Protection Area for the Mid Galway Public Water Supply.	"No wind farm drainage will be released inside the 50m watercourse buffer on the Lecarrow 30 Stream".
Down-gradient Groundwater quality monitoring of T1 and T2 shall be undertaken prior to construction and during the construction phase of the project. The procedure for groundwater monitoring shall be generated by a consultant hydrogeologist, submitted to, and agreed with Uisce Éireann prior to commencement. A record of groundwater monitoring shall be submitted to Uisce Éireann at agreed intervals during the project	HES can confirm that this groundwater monitoring requirement requested by Uisce Éireann can be implemented during the construction phase.
The applicant/operator shall comply with the Water Framework Directive and River Basin Management Plan objectives to ensure that the development will not negatively impact on the water quality of source/receiving waters during both construction and operational phases.	A WFD Compliance Assessment Report was prepared for the Proposed Project (Appendix 9-4 of EIAR). The assessment shows that with implementation of the proposed mitigation measures, no significant effects on waterbody WFD status will occur.

As can be seen, other than minor additional requirements, the existing mitigation in the EIAR already largely address the UÉ requirements.

HES can confirm that all of the additional requirements requested by Uisce Éireann can be implemented during construction, operational and decommissioning phases of the proposed project (as relevant) should the development be approved.

6 INLAND FISHERIES IRELAND (IFI)

IFI provide a more general submission on the topic of surface water quality protection. The following key topics listed below, all of which are already addressed in the EIAR, are summarised from the IFI submission. No EIAR scoping response was received from the IFI, but many of matters raised in the IFI submission were previously observed in scoping responses from IFI relating to other wind farm developments and are also contained in their guideline document IFI (2016). As such and based on our own experience the matters raised by IFI are

already addressed in the Cooloo Wind Farm EIAR.

The section of the EIAR that addresses each topic is cross-referenced as follows:

- Managing surface water drainage to prevent erosion and soil instability (refer to EIAR Sections 9.4.1, 9.5.2.3, 9.5.2.5 and Appendix 4-3 (drainage plan);
- Ensuring proper drainage and sediment control through settlement ponds and silt traps (Refer to EIAR Sections 9.4.1, 9.5.2.3 and Appendix 4-3 (drainage plan);
- Addressing waste disposal and runoff from stockpiled soils (refer to EIAR Sections 9.5.2.3 & 9.5.2.15);
- Containing pollutants like cement leachate and hydrocarbons (refer to EIAR Sections 9.5.2.6 and 9.5.2.8);
- Management of pumped water from excavations and appropriate use of silt fencing inside 50m hydrological buffer zones (refer to EIAR Section 9.5.2.5);
- Maintenance of natural surface water flowpaths and drainage patterns (refer to EIAR Section 9.5.2.3, 9.5.2.9 and 9.5.2.16);
- Tree felling and surface water quality effects (refer to EIAR Section 9.5.2.2);
- Avoiding sedimentary rocks like shale in road construction to prevent water pollution (refer to EIAR Section 9.5.3.2);
- Consulting IFI for watercourse crossings and minimizing their impact (refer to EIAR Section 9.5.2.9); and,
- Scheduling instream works for the period July 1–September 30) which is outside salmonid spawning seasons (refer to EIAR Section 9.5.2.9).

All of the IFI recommendations are already addressed in the EIAR and appropriate mitigation measures are proposed.

7 NATIONAL OFFICE FOR ENVIRONMENTAL HEALTH SERVICES (HSE)

Overall, the HSE submission was positive with regard the proposed project and determined the proposed mitigation measures would provide adequate protection of surface water and groundwater:

“The NEHS has considered Chapter 9 of the EIAR and the sections referenced based on the information provided in chapter 9 and particularly the surface water management plan detailed in appendix 4.5 Construction and Environmental Management Plan”.

“The NEHS would concur with the conclusions that there is adequate protection of surface and groundwater during construction and operation of the proposed development if all the mitigation identified is implemented in full. This would include drinking water sources identified in the EIAR”.

No response to HSE is required.

[Response from MLavelle: As the surface water & groundwater submission is wrong, proposed mitigation measures cannot be assessed. The Mid-Galway PWS is not a surface water system.](#)

Drinking Water Audit Report

County:	Co. Galway	Date of Audit:	31 st July 2015
Plant(s) visited:	Mid Galway Water Treatment Plant, Scheme Code 1200PUB1038	Date of issue of Audit Report:	18 th August 2015
		File Reference:	DW2009/400
		Auditors:	Mr Darragh Page Ms Ruth Barrington
Audit Criteria:	• The European Union (Drinking Water) Regulations 2014 (S.I. 122 of 2014). • The EPA Handbook on the Implementation of the Regulations for Water Services Authorities for Public Water Supplies (ISBN: 978-1-84095-349-7) • The recommendations specified in the EPA Drinking Water Report. • The recommendations in the previous EPA audit report dated 23/05/2014.		

MAIN FINDINGS

- The supply was removed from the Remedial Action List on the basis of the current audit, following the work on carried out on source protection and the resultant improvements in raw water quality.
- Irish Water shall cover the spring source as planned to maintain levels of source protection.

1. INTRODUCTION

Under the *European Union (Drinking Water) Regulations 2014* the Environmental Protection Agency is the supervisory authority in relation to Irish Water and its role in the provision of public water supplies. This audit was carried out to verify the information provided by Irish Water to request the removal of the supply from the Remedial Action List (RAL).

The Mid Galway PWS is supplied by water abstracted from springs and a recently constructed borehole. Approximately 2,000 people are supplied and the plant produces over 3,000 m³/day. The supply is on the RAL due to *E. coli* detected during 2009 and EPA concerns in relation to the disinfection system and treatment provided. Recent works by Irish Water have included the connection of a borehole for abstraction of a proportion of raw water, intake facilities at the spring source with a piped connection to the plant and servicing of the UV system.

Photographs taken by the audit team during the audit are attached to this report and are referred to in the text where relevant.

The opening meeting commenced at 14.50 hours at the Mid Galway Water Treatment Plant. The scope and purpose of the audit were outlined at the opening meeting. The audit process consisted of interviews with staff, review of records and observations made during an inspection of the treatment plant. The audit observations and recommendations are listed in Section 2 and 4 of this report.

The following were in attendance during the audit.

Representing Irish Water: (* indicates that person was also present for the closing meeting)

Mr Adrian Raftery – Area Engineer, Galway County Council*

Mr Diarmuid Croghan – Divisional Engineer, Galway County Council*

Ms Tara Meehan – Division Technician, Galway County Council*

Mr Pat O'Sullivan – Compliance, Irish Water*

Mr Shay Walsh – Engineer, Irish Water*

Mr Martin Lavelle- Senior Engineer, Galway County Council*

Representing the Environmental Protection Agency:

Mr Darragh Page – Senior Inspector*

Ms Ruth Barrington – Inspector*

2. AUDIT OBSERVATIONS

The audit process is a random sample on a particular day of a facility's operation. Where an observation or recommendation against a particular issue has not been reported, this should not be construed to mean that this issue is fully addressed.

1.	Source Protection a. Water abstracted from the borehole now forms 10-15% of the raw water abstraction. b. The remaining abstraction is taken from the series of springs at the pond at the head of the Daingeanbeg River, and is piped to the treatment plant. The pond is currently open but there are plans to cover this source. c. Previously water from the spring flowed into the Daingeanbeg River for a distance of 500 m and was abstracted from the river at the Mid Galway plant. Since the previous audit Irish Water has cleared the vegetation around the spring (refer to photograph nos. 1 and 2) and now pumps the water directly via pipework from the spring to the treatment plant. This has eliminated surface water entering the raw water resulting in an improvement in raw water quality (improved UVT, reduced colour and turbidity). d. The immediate surroundings of the abstraction points are within the control of Galway County Council. Adjoining land is Coillte forestry. e. A Water Safety Plan is being developed for the supply by Irish Water, and will cover risk mitigation for catchment hazards such as contamination from pesticide use and siltation potentially arising from the forestry areas.
2.	Ozonation and GAC Filtration a. Improvements in raw water quality as outlined above have led to the operation of the ozonation system as duty/ standby units. Previously it had been necessary to run both units simultaneously. b. The GAC filtration media has not been replaced within the lifetime of the filters. c. The development of the procedure for GAC assessment and maintenance is noted by the audit team.
3.	Chlorination and Disinfection a. Primary disinfection is via a UV system incorporating duty and standby units. An alarm and automatic shutdown of the plant is triggered at a UVT set point of 68%.

Response from MLavelle: The source of the drinking water is from underground spring sources. This is indicated in the attached EPA Audit from 2015 (above), chaired by the author of this report. The assumptions in the HES reports of a surfacewater abstraction are wrong. The gradient to the spring source & the Barnaderg spring source is from Cooloo, which is on higher ground.

8 HYDRO G

We have split our responses to issues raised by Hydro-G into 9 items.

8.1 Hydro-G – Item 1

The following statement from page 9 of the Hydro-G submission is addressed below.

“No defensible assessment of groundwater flow systems has been submitted to An Coimisiún Pleanála regarding the groundwater system beneath the areas proposed for excessively abnormal loads, including all haul roads, crane pads, foundations and turbine masts. A Geotechnical Karst Risk Assessment (GDG, 2025) in “support of the application”. However, that Geotechnical Karst Risk Assessment was completed by geologists and not hydrogeologist”.

“The Geotechnical Karst Risk Assessment (GDG, 2025), in “support of the application”, fails to convey the connection between the widespread evidence of surface expression of karst on the proposed project’s landscape with the known conduit system conveying large volumes of groundwater in the immediate vicinity of the PWS sources and two GWS sources”.

8.1.1 HES Response to Hydro-G Item 1:

As detailed in the Land, Soils and Geology Chapter (Chapter 8) and the Hydrology/Hydrogeology Chapter (Chapter 9) an array of ground investigations as well as drainage surveys, field mapping, karst feature mapping and follow up seasonal groundwater monitoring were carried out between 2022 and 2025 to assess the geological and hydrogeological setting (groundwater flow system) at the Proposed Wind Farm site (‘the Site’). Also, it should be noted that the hydrological/hydrogeological impact assessment and assessment of potential effects on the Mid Galway Public Water Supply (PWS) and Barnaderg Group Water Scheme (GWS) was carried out by HES (Hydrogeologists) and not Gavin and Doherty Geosolutions (GDG) who are overseeing solely the peat stability and geotechnical aspects of the project.

Please note, the Barnaderg GWS source springs and borehole is located in close proximity to the Mid Galway PWS abstraction, and they share the same groundwater zone of contribution (ZoC).

The Geotechnical and Karst Risk Assessment carried out by GDG was only one element of the investigations/assessments that informed the potential hydrological/hydrogeological impact assessment with regard the Mid Galway PWS and Barnaderg GWS.

We provide a summary of the groundwater flow system assessment and highlight the key findings below.

8.1.2 Summary of Investigation Approach

A total of 26 no. trial pits were carried out across the Site. The borehole drilling investigations (2 no. monitoring wells were drilled) were targeted around the area where the Mid Galway PWS/Barnaderg GWS Source Protection Area (SPA) overlaps with the Site. Refer to Section 8.3.2 and Section 8.3.3 of the Land, Soils and Geology Chapter of the EIAR for detailed discussion of site investigation data and site investigation mapping and interpretation.

Investigation boreholes BH1 and BH2 were intentionally drilled in close proximity of proposed turbine locations T1 and T2 respectively in order to assess overburden and bedrock conditions (including aquifer/groundwater flow characteristics) at these Proposed Wind Farm locations.

Only these two turbines (T1 & T2) are located inside the GSI/EPA mapped Mid Galway PWS SPA/Barnaderg GWS SPA. Both boreholes were finished as groundwater monitoring wells to allow long-term seasonal water level monitoring to be completed at the Site. Groundwater level monitoring was carried out between October 2022 and February 2025 to assess seasonal changes and variations in the groundwater levels (refer to Section 9.3.9.4 of the EIAR).

In addition, one rotary core borehole (GSI-17-003) from the GSI borehole database was previously drilled on the north of the Site, which also provides geological and hydrogeological information for the Proposed Wind Farm areas (refer to Section 8.3.3.2 of the EIAR for details on this borehole).

Also, geophysical surveys (2D Resistivity and seismic) were targeted in areas of the Site to assess bedrock conditions, particularly to assess the potential for bedrock karstification and the possible presence of potential dolines/enclosed depressions which are karst features. The total combined length of the 4 no. 2D Resistivity survey lines was 0.5km. (refer to Section 8.3.3.5 of the EIAR for details of the geophysical survey). The geophysical survey report is attached to the Geotechnical Karst Risk Assessment report (EIAR Appendix 8-2).

Therefore, as outlined above an extensive array of site investigations and follow up monitoring and surveys was carried out to assess the hydrogeological setting (groundwater flow system) at the Site.

One of the main aims of the investigations was to assess potential pathways (extent of hydrological/hydrogeological connectivity) between the Site and the Mid Galway PWS and Barnaderg GWS which are both located to the south of the Site.

Response from MLavelle: It would seem that this main aim didn't bother checking the source of the Mid-Galway PWS & as a result didn't assess potential pathways or extent of hydrological/hydrogeological connectivity. This level of incompetence determines that this application should be refused.

8.1.3 Summary of Investigation Findings

LIMESTONE bedrock was encountered in all trial pits which terminated on rock. 10 of the 14 no. trial pits that terminated on bedrock encountered competent, unweathered, grey massive LIMESTONE.

While weathered and/or fractured LIMESTONE was only encountered in 4 of the 14 no. trial pits.

No epikarst¹ weathering was reported in any of the trial pits that encountered bedrock.

Bedrock was also confirmed at 7 no. of the proposed 9 no. turbines (T1, T2, T3, T4, T5, T6 & T8), where the bedrock was typically observed as 'grey massive LIMESTONE' with no evidence of an epikarst layer on the top of bedrock (refer to Table 8-8 of the Land, Soils and Geology Chapter for bedrock conditions at turbine locations from trial pitting).

Both investigation boreholes (BH1 & BH2), located in the proximity of proposed turbine locations T1 and T2 on the south of the Site, encountered strong to very strong, dark grey, argillaceous (clay impurities) LIMESTONE with MUDSTONE layers.

Notably, a dark grey argillaceous LIMESTONE and calcareous MUDSTONE was also reported in the GSI exploration borehole (GSI-17-003) located on the far north of the Site.

What's notable about the known bedrock geology of the Site is that all investigation drilling data available to date (i.e. BH1, BH2 and GSI-17-003) encountered impure, argillaceous LIMESTONE with interbedded MUDSTONE layers. Impure, argillaceous limestone is typically much less prone to karstification. MUDSTONE is not prone to karstification.

The seasonal groundwater level variation/fluctuation at the borehole locations (BH1 & BH2) ranged between 0.91m (BH2) and 1.6m (BH1) which is a relatively small range of fluctuation/variation. The low seasonal groundwater level variation is typical of peatland/bog settings where groundwater flows/recharge is generally impeded, and groundwater levels are relatively consistent across all seasons. Groundwater level monitoring data is discussed in detail in Section 9.3.9.4 of the EIAR.

¹ The epikarst is a heavily weathered layer of rock extending less than 10 m below the base of the soil/subsoil (D. Drew, 2018).

Typically, groundwater levels in karst limestone bedrock are highly variable and flashy due to well-developed networks of conduits and fractures that allow for rapid groundwater flow, making water levels fluctuate significantly in response to rainfall and drought conditions.

This type of groundwater level response is not observed in BH1 or BH2 and is consistent with the bedrock type encountered at the Site (i.e. impure LIMESTONE/MUDSTONE). The presence of MUDSTONE layers in the bedrock is likely to significantly impede groundwater flowpaths through the aquifer. Hence, the overall poor land drainage characteristics of the Site.

The subdued groundwater level responses indicate that there is limited recharge/vertical groundwater flow from the overlying glacial deposits down into the underlying bedrock aquifer at the Site. This is also confirmed by the high stream density, man-made drainage density and indeed presence of raised bog at the Site. The

presence of drainage features implies there is a need to drain surface water, as it cannot recharge/drain readily to the underlying bedrock aquifer underneath.

If there was significant underground drainage occurring because of deeper karstified bedrock (conduit systems), these observed conditions, and indeed the raised bog itself, would likely not even exist at the Site. All site investigation data indicate a poorly developed/localised groundwater flow system below the Site.

[Response from MLavelle: This reply is nonsense. Groundwater springs for the Gortgarrow & Mid-Galway schemes produce c10,000m³/day. This is a huge volume of water. If “all site investigation data indicate a poorly developed/localised groundwater flow system below the site”, the applicant’s agent are incompetent or copy/pasted from a different report.](#)

This hydrogeological setting explains why a large proportion of the Site is covered by raised bog.

No GSI karst features are mapped within the Site, however several karst features (‘enclosed depressions’) are mapped by the GSI approximately 0.5km to the southeast of the Site, with a very high density of karst features mapped approximately 2km further to the southeast of the Site (refer to Figure 9-6 of the EIAR for GSI karst mapping).

As a direct comparison to the Site area, what’s notable about the high density of GSI karst features mapped 2km to the southeast of the Site is that there is an overall lack of surface water drainage (watercourses) in that area. This indicates a well-developed underground karst drainage system (i.e. very high groundwater recharge rates) where all surface drainage goes to ground (rapid recharge). There is also an overall lack of peat bogs in that area due to the area being very well drained (refer to Figure 8-1 of the EIAR for GSI subsoils mapping).

Conversely, in the area of the Site there is extensive raised bog present, several watercourses, two wetland/lake waterbodies and numerous man-made drains draining the area of the Site, thereby strongly suggesting a poorly developed groundwater system which impedes recharge to the underlying aquifer. This is consistent with the geological/hydrogeological regime of the Site based on site walkover surveys and site investigation data (i.e. peat and poorly draining overburden over impure LIMESTONE/MUDSTONE bedrock with high groundwater levels).

During field surveys carried out by HES and GDG, several ‘enclosed depressions’ type features were mapped in the area of proposed turbine location T4 on the southeast of the Site. The features present as shallow, nearly flat depressions and are present within glacial deposits. The base of the depressions is underlain by several metres of glacial till as demonstrated by the trial pitting conducted in that area. A review of aerial photography (www.geohive.ie) as far back as 1995, indicate that none of the potential enclosed depressions/dolines have changed in size or appearance over the 30-year period. Refer to Section 9.3.9.3 for details of the karst surveys. There is also no evidence of a swallow hole/sink hole function or any channelling/funnelling of surface water runoff to ground via the depression. The larger of the depressions were actually noted to hold surface water during wet periods and therefore they appear to not have a significant surface water drainage function at the Site.

A follow up geophysical surveying including 2D Resistivity (4 no. lines) and Seismic (1 no. line) was targeted in this area of proposed turbine location T4 to assess the potential for karstification at a number of observed shallow enclosed depression features (Refer to Figure 8-4 and Figure 8-8 of the EIAR for the geophysical survey locations).

All 4 no. 2D Resistivity survey lines interpreted competent, fresh unweathered LIMESTONE bedrock below the ‘enclosed depressions’. No epikarst layer or deeper karstification was found to be present at the survey locations or underneath the enclosed depressions. The total length combined length of the 4 no. 2D Resistivity survey lines was 0.5km, and no evidence of karstification was identified over this significant distance.

The results of the geophysical survey are also consistent with the findings of trial pits TP01 and TP11 which were carried out at proposed turbine location T4 and access road. Both trial pits encountered grey to dark grey, competent, massive LIMESTONE. Refer to Table 8.8 of the Land, Soils and Geology Chapter for a summary of bedrock conditions at trial pit locations.

The geophysical surveys targeted in the area of turbine T4 and its access road, show that the ground surface depressions present in that area have not formed due to karstification in the underlying bedrock, but are a geomorphological feature of the overburden.

Also, the presence of peat/poorly draining soil along with high drainage density at the Site is further evidence of low recharge and poorly developed groundwater drainage system that would not be expected in highly karstified bedrock with conduit flow.

Therefore, all investigations/assessments and hydrological conditions at the Site do not suggest the presence of bedrock conduit system conveying large volumes of groundwater in the immediate vicinity Site towards the PWS and GWS sources. The hydrology of the Site is dominated by a surface water drainage regime.

What also needs to be considered when assessing the potential effects of the proposed project is that wind farms are typically near surface construction activities, where earthworks is largely limited to overburden removal and cease at competent strata (i.e. top of bedrock).

We noted that competent massive limestone was observed at most trial pit locations that encountered bedrock.

The potential to intercept deep groundwater flow systems might be problematic if tunnelling or deep bedrock quarrying were part of the Proposed Project, however, all turbine base excavation works will typically cease when competent strata is encountered which is likely to be the top of bedrock. There are no borrow pits proposed for the Site.

Therefore, even if deep bedrock conduits were present (albeit there has been no evidence of this to date), they will not be intercepted by the Proposed Project.

8.2 Hydro-G – Item 2

The following statement from page 9 of the submission is addressed below.

“Over 10,000m³/day of groundwater is abstracted for public consumption each day in the vicinity of the proposed development. The Source Protection Report for the Mid Galway PWS scheme (EPA, 2012) is presented as Appendix B to this report [appendix to Hydro-G submission report]. Whilst the karst conduit system is well described in EPA (2012), and each of the GWSs are also documented and evaluated, An Coimisiún Pleanála is advised that the Mid Galway report did not have a focus on the actual application area’s subterranean Karst systems.

Therefore, the level of detail is not available for the applicant’s proposed development area. EPA (2012) is provided as an example only of how much work and risk is involved in this hydrogeological setting. As stated, the applicant’s agents approached the situation from a geotechnical rather than hydrogeological perspective”.

8.2.1 HES Response to Hydro-G Item 2:

HES can confirm to ACP that the assessment presented in the EIAR clearly considers the hydrogeology of the area.

As stated above, the GSI/EPA (2012) SPA mapping for the Mid Galway PWS shows that the southeastern portion of the Site lies inside the SPA. This includes proposed turbine locations T1 and T2. Proposed turbine T4, positioned more northerly to the northeast, is located just outside the boundary of the mapped SPA.

To overcome the limitation of the EPA/GSI (EPA, 2012) reporting/mapping for the Site’s application area, an array of focused site investigations (as summarised above) were carried out to assess the hydrogeological setting at these Proposed Wind Farm locations.

The investigations are summarised above and key points include:

- Bedrock conditions below the location of proposed turbine locations T1 and T2 comprise competent dark grey, impure, argillaceous LIMESTONE with MUDSTONE layers;
- No epi-karst, subterranean karst conduits, significant fractures or groundwater strikes were encountered due to the lithology competent nature of the bedrock;
- Any groundwater inflows recorded were slow, suggesting an overall low permeability LIMESTONE/MUDSTONE formation;
- Consistently high groundwater levels at the borehole locations with little fluctuations suggesting a poorly developed groundwater flow system;
- Similar argillaceous LIMESTONE with MUDSTONE was encountered on the north of the Site at GSI investigation hole GSI-17-003 suggesting similar geology across the Site; and,
- No epikarst layer or deeper subterranean karstification was found to be present at the geophysics survey locations carried out near proposed turbine T4 (surveys spanning a distance of 0.5km).

Therefore, the site-specific investigations carried out provided a sufficient level of information to inform the quantitative and qualitative impact assessment of the PWS and GWS with regard the proposed wind farm (refer to Section 9.5.2.1 of the EIAR). There was no single reliance on EPA or GSI mapping for the proposed wind farm impact assessment. The assessment was completed using the array of available data, including the site-specific investigation data.

8.3 Hydro-G – Item 3

The following statement from page 10 of the submission is addressed below.

“Turloughs are a groundwater feature. Turloughs are surface expressions of groundwater moving from the conduit groundwater flow system upwards, often in vertical shafts, to ground level in ephemeral lakes. The proposed construction area is between Horseleap Lough, Summerville Lough and Levally Lough. An underground conduit groundwater flow system connects these Loughs. This is documented in EPA (2012), which is Appendix B to this report [appendix to Hydro G submission report]. Never have excessive and abnormally excessive loads been applied to the landscape of east Galway and there are no site testing data presented for the applicant in which the shear loading capacity is demonstrated for the lands proposed for haul roads or the 9 crane pads and 9 turbine pads suggested”.

8.3.1 HES Response to Hydro-G Item 3:

Firstly, it needs to be pointed out that Horseleap Lough and Summerville Lough are not mapped as turloughs by the GSI, neither does EPA (2012) refer to them as turloughs in the Mid Galway PWS source protection report. EPA (2012) refers to them as ‘significant surface water features’ on page 5 of the report.

Levally Lough, which is located 6km to the north of the Proposed Wind Farm site (north of the Grange River), is mapped in the GSI karst database as a turlough.

There are no GSI mapped tracer lines connecting these water features.

More to the point of the Hydro-G statement above, nowhere in the EPA (2012) report is it stated that there is an underground conduit system connecting the 3 lakes (Horseleap Lough, Summerville Lough and Levally Lough) and there is also no mention of Levally Lough in the EPA (2012) report.

Therefore, the above statement is completely unfounded, unsupported by fact, and incorrect.

8.4 Hydro-G Item 4:

The following statement from page 10 and 11 of the submission is addressed below.

“Groundwater and Surface Water are connected in this karst system. Hence the concern regarding the applicant’s agent’s presentation that:

The topography of the Proposed Wind Farm site is undulating with gentle slopes typical of a low-lying raised bog setting with surrounding local hills. The elevation of the Proposed Wind Farm site ranges from approximately 65m OD (metres above Ordnance Datum) to 80m OD, with slopes falling to the north and southeast from a high point located centrally with the Proposed Wind Farm site which also coincides with a surface water catchment topographic divide between the Grange River to the north and the Abbert River to the south”. & “The Proposed Wind Farm site is drained by several 1st order watercourses that emerge from the peatland areas. There is also a high density of man-made drainage associated with the peatland and grassland areas. The man-made drainage density is evident on the OSI 6”, 25” mapping and aerial imagery” (Appendix 9-1 Flood Risk Assessment, EIAR 2025 Cooloo Wind Farm).

The potential for organic matter release from the bogs, during all phases of the project, to the drainage system has potential to react with the chlorination systems of the Water Treatment plants (WTPs) and has potential to create Trihalomethanes”.

8.4.1 HES Response to Hydro-G Item 4:

Regarding, the point made that ‘*groundwater and surface water are connected in this karst system*’. Indeed, in well-developed karst areas where swallow holes, dolines and losing streams are prevalent, there is a strong surface water / groundwater connection. However, no such strong groundwater / surface water interaction is evident at the proposed wind farm site. The hydrology of the Site is dominated by surface water flows.

The large coverage of peat bogs, poorly draining soil/subsoil, high drainage density and consistently high groundwater levels (*i.e.* shallow and close to ground level) within the site would indicate a poorly developed underlying groundwater drainage system.

[Response from MLavelle: Two drinking water spring sources for MidGalway & Barnaderg wsss, downstream of the proposed site, generating 10,000m³ per day indicate a highly developed underlying groundwater drainage system. This statement by HES is “completely unfounded, unsupported by fact, and incorrect”.](#)

As pointed out previously in this submission response (last para pg 7, in Section 8.1.3), a very high density of karst features is present approximately 2km further to the southeast of the Site, with the same area displaying an obvious lack of surface water drainage (streams/watercourses) as well as absent peat bog coverage (opposite conditions to those present at the Site). This indicates a well-developed underground karst drainage system (*i.e.* very high groundwater recharge rates and strong surface water / groundwater connection) where all drainage occurs underground. Please note, surface waters leaving the proposed wind farm site does not drain towards the southeast into this high-density karst area. These baseline drainage patterns are explained in Section 9.3.4.1 of the EIAR.

It is important to reiterate that the low groundwater recharge rates and high groundwater levels at the Proposed Wind Farm site are consistent with the expected low permeability and competent nature of the impure, argillaceous LIMESTONE/MUDSTONE encountered during drilling at all 3 no. locations within the Site (BH1, BH2 and GSI-17-003). The Site's hydrology is therefore characterised by high surface water runoff rates and low groundwater recharge rates.

As assessed in Section 9.5.2.1 of the EIAR, the dominant drainage pathway from the Site to the Mid Galway PWS abstraction point is via surface water flows in the Lecarrow Stream. There are 2 no. proposed turbines (T1 and T2) located within that stream catchment. The Mid-Galway PWS abstraction point is from the Lecarrow Stream approximately 2km downstream of Horseleap Lough (3km downstream of the proposed Wind Farm site itself).

[Response from MLavelle: The abstraction for Mid-Galway PWS is not from the Lecarrow Stream. It is from spring sources as evidenced in EPA Audit above.](#)

Most of the Proposed Wind Farm site (including 7 no. of the proposed 9 turbines) drains to the north towards the Grange River and therefore are not upstream of the Mid Galway PWS abstraction point from the Lecarrow Stream. Neither are they upstream of the Barnaderg GWS abstraction location (which is purely a groundwater abstraction). The closest downstream abstraction point in the Grange River is at Lough Corrib, which is ~40km away.

[Response from MLavelle: The abstraction for Mid-Galway PWS is not from the Lecarrow Stream. The Mid-Galway abstraction is purely a groundwater abstraction.](#)

Therefore, the potential for Trihalomethanes effects on Mid Galway PWS/Barnaderg GWS due to organic carbon/matter in surface water drainage from the proposed wind farm is very limited for these reasons.

[Response from MLavelle: This assumption of Trihalomethanes potential from organic carbon/matter is not limited.](#)

As described in Section 9.5.2.1 of the EIAR, another important factor mitigating potential organic carbon/Trihalomethanes water quality effects on the Mid Galway PWS in particular is that on leaving the Site, surface water flow in the Lecarrow stream must pass through Horseleap Lough before reaching the Mid Galway PWS abstraction point further downstream. Horseleap Lough is therefore effectively a large natural wetland which will have significant attenuation/retention capacity, offering natural dilution and also removal of organic carbon/matter from any wind farm drainage prior to flows reaching the Mid Galway PWS abstraction point further downstream.

[Response from MLavelle: The abstraction for Mid-Galway PWS is not from the Lecarrow Stream. The Mid-Galway abstraction is purely a groundwater abstraction.](#)

We note that there is no concern raised by UÉ in their submission with respect to organic carbon / Trihalomethanes.

[Response from MLavelle: As the Senior Engineer in charge of Drinking Water for County Galway, I was responsible for the drinking water infrastructure plus improvements & chaired the EPA Audit \(above\). I changed](#)

the abstraction from the Lecarrow Stream to spring sources in 2014 as the surface water quality in the Lecarrow stream was not compliant with the Drinking Water Directive. The Lecarrow Stream characteristics changed in a shower of rain & the treatment plant shutdown automatically on an ongoing basis.

8.5 Hydro-G Item 5:

The following statement from page 10 of the submission is addressed below.

“Whilst the agents cite a 2012 Source Protection Zone report for the Mid Galway Scheme, the GSI and the EPA (2012) state very clearly that “Source Protection Zones are a land use planning tool which enables a more objective, geoscientific assessment of the risk to groundwater quality to be made”. The emphasis is on quality: A source Protection Zone is defined by a 100-day time of travel to the source and is designed to protect the source from microbial and viral contamination (DELG/EPA/GSI 1999). It is wholly inappropriate for wind farm applications to attempt to portray that their proposed development area does not wholly overlap a Source Protection Zone for a PWS or a GWs. Some of the Turbines proposed do overlap the mapped Source Protection Zone. However, ALL of the turbines proposed overlap the groundwater system feeding the Mid Galway and Barnadegort GWS sources. The connectivity to Brierfield GWS is also an issue”.

8.5.1 HES Response to Hydro-G Item 5:

Firstly, it is important to point out to ACP that the presence of proposed development within mapped SPAs/ZOCs for existing water supplies does not preclude development. Source Protection Area/Zone of Contribution mapping are intended to be a planning tool that “*aims to maintain the quantity and quality of groundwater, and in some cases improve it, by applying a risk assessment-based approach to groundwater protection and sustainable development*”, (DOELG/EPA/GSI, 1999).

As is required by the Groundwater Protection Scheme guideline document (DOELG/EPA/GSI, 1999), we have completed site-specific investigations to further characterise the geological and hydrogeological baseline conditions at T1 and T2, and arising from the site-specific data we have recommended appropriate mitigation for the construction and operational phase of the development to ensure protection of the water supply sources. In other words, we have identified the risks, we have completed further investigations and based on the accumulated knowledge with have mitigated the identified risks.

[Response from MLavelle: HES may have conducted investigations, but those investigations & accumulated knowledge were totally inadequate, where they identified the Lecarrow Stream as the Drinking Water source for Mid-Galway PWS. The Lecarrow Stream abstraction was decommissioned in 2015.](#)

Furthermore, in response to the above paragraph there are several important facts to reiterate here.

- Nowhere in the EPA (2012) Source Protection Zone report for the Mid Galway PWS does it state that the area of the Proposed Wind Farm outside the EPA mapped source protection area (*i.e.* area of the Site including proposed turbine locations T3 to T9 (refer to Figure 9-12 of the EIAR) is also potentially within the groundwater zone of contribution to the Mid Galway PWS source.

- In a karst environment the 100-day time of travel distance is normally applied to the entire groundwater catchment / zone of contribution to the source, which is what was done for the Mid Galway PWS. Typically, in non karst areas, the 100-day time of travel defines the inner protection zone (SI) only and not the outer protection zone (SO). In karst areas the entire zone of contribution is mapped as the inner protection zone.

[Response from MLavelle: It is obvious that the area is karst & should be mapped as the inner protection zone.](#)

- If the authors of the EPA (2012) report thought that the area where the entirety of the wind farm is located is inside the groundwater catchment to the PWS source, the zone of contribution mapping would reflect that (*i.e.* it would be bigger).

[Response from MLavelle: The authors of the EPA\(2012\) report were not aware of the spring sources, which were connected in 2015. If they were aware, the zone of contribution mapping would have been bigger.](#)

- The estimated groundwater zone of contribution for Mid Galway PWS is shown on Figure 18 of the EPA (2012) source protection report as well as Figure 9-12 of the EIAR, and it does not show the entirety of the proposed wind farm site within the zone of contribution, only proposed turbine locations T1 and T2.

- The hydrological boundaries of the Mid Galway GWS source protection area are described in Section 9.2 of the EPA (2012) report. These are the boundary assumptions that are used to delineate the groundwater zone of contribution.

- The hydrological boundary of the source protection area that intercepts the southern portion of the Proposed Wind Farm site (referred to as the northwestern boundary by EPA 2012) is a topographic groundwater divide boundary and not a boundary defined by the 100-day time of travel to the source (i.e. the inner protection zone boundary).
- The boundary is defined by the topographic divide between the Grange River to the north and the Abbert River to the south, which is also assumed to be a groundwater divide, hence the 100-day time of travel does not apply as the boundary is the full mapped extent of the groundwater zone of contribution.
- As the wastewater systems used during the construction phase of the Proposed Wind Farm are enclosed (with no discharge to ground or surface water (wastewater is tankered offsite to a wastewater treatment plant)) such developments do not generate microbial and viral contamination.

Therefore, the statement that **“ALL of the turbines proposed overlap the groundwater system feeding the Mid Galway and Barnaderg Gortbeg GWS sources”** is clearly incorrect.

[Response from MLavelle: Wastewater tankering offsite has no relationship to overlap of the groundwater system feeding the Mid-Galway PWS & Barnaderg-Gortbeg GWS sources.](#)

[Please note, EPA (2012) refers to the Barnaderg GWS, and others refer to it as the Barnaderg Gortbeg GWS, i.e. Barnaderg GWS and Barnaderg Gortbeg GWS are the same scheme].

The Brierfield GWS abstraction point is located centrally within the Mid Galway PWS and Barnaderg GWS SPA and therefore their groundwater zones of contribution overlap. The Brierfield GWS has no EPA/GSI mapped groundwater zone of contribution or source protection area itself. The location of the Brierfield GWS abstraction from Pollifrin Spring can be seen on Figure 6 of EPA (2012).

The Brierfield GWS abstraction (Pollifrin Spring) is located approximately 2km further away from the Proposed Wind Farm site than the Mid Galway and Barnaderg abstractions. Albeit, the Brierfield GWS was not directly assessed in the EIAR, a conservative assumption would be to assume that the Brierfield GWS groundwater zone of contribution is a subset of the Mid Galway PWS and Barnaderg GWS SPA. It is likely to be a much smaller area due to lower abstraction rates. The demand of the Brierfield GWS is relatively small, 90 m³/day. Therefore, the findings of the qualitative and quantitative impact assessment for the Mid Galway PWS and Barnaderg GWS (Section 9.5.2.1 of the EIAR) can be directly applied as an impact assessment for the Brierfield GWS.

A summary of the qualitative and quantitative impact assessment is also provided in Section 8.6.1 below. As such, and similar to the assessment completed for the Mid Galway PWS and Barnaderg GWS (refer to Section 9.5.2.1 of the EIAR), it can be concluded that with the implementation of the proposed mitigation measures no significant effects will occur on the quantity or quality of water available for use at the Brierfield GWS.

8.6 Hydro-G Item 6:

The following statement from page 10 of the submission is addressed below.

“In this conduit karst groundwater setting the potential for collapse of surface karst into subterranean karst is high when the scale of the abnormal and excessively abnormal loads are considered. The issue here is that all groundwater in this GWB has potential to flow to the Mid Galway PWS, Barnaderg Gortberg GWS and Briarfield GWS. Even groundwater outside the 100-day time of travel Source Protection Zone, that was mapped by the EPA and GSI (2012) for microbial and viral contamination, can travel to the sources for the Mid Galway PWS, Barnaderg Gortberg GWS and Briarfield GWS. Therefore, the issue of QUANTITATIVE IMPACT is more relevant, and this has not been adequately assessed in the context of interruption of the PWS in either the Water Chapter or the Geotechnical Risk Assessment”.

8.6.1 HES Response to Hydro-G Item 6:

Firstly, the statement that **“all groundwater in this GWB [Clare-Corrib GWB] has potential to flow to the Mid Galway PWS, Barnaderg, Gortberg GWS and Brierfield GWS”** is incorrect.

[Response from MLavelle: The sentence should have read “all upstream groundwater of the abstraction points in this GWB has potential to flow to the Mid-Galway PWS, Barnaderg/Gortbeg GWS & Brierfield GWS.](#)

The Clare-Corrib Groundwater Body (GWB) is very large, 1,338km² in area, it extends into three counties (namely Galway, Roscommon, and Mayo) and includes major towns such as Tuam, Claregalway and

Ballyhaunis as well as the outskirts of Galway City. The regional groundwater direction in the GWB is towards Lough Corrib which is the focal point of groundwater and surface water collection/drainage.

It is hydraulically impossible (due to topography, main drainage rivers, and the sheer expanse of the GWB) that all the Clare-Corrib Groundwater Body supplies groundwater to the Mid-Galway PWS, Barnaderg GWS or Briarfield GWS.

The statement “**even groundwater outside the 100-day time of travel Source Protection Zone, that was mapped by the EPA and GSI (2012) for microbial and viral contamination, can travel to the sources for the Mid Galway PWS, Barnaderg Gortberg GWS and Briarfield GWS**” is also incorrect and shows a lack of understanding of the correct application of the 100-day time of travel in a karst environment. This statement is addressed in the previous response above with regard its application within the groundwater zone contribution. With regard the adequacy of the impact assessment, both a **qualitative** and **quantitative** impact assessment was carried out in Section 9.5.2.1 of the EIAR Hydrology/hydrogeology chapter with regard potential effects on Mid Galway PWS and Barnaderg GWS. As stated above the impact assessment findings of the Mid Galway PWS and Barnaderg GWS assessment can be applied to the Brierfield GWS.

[Response from MLavelle: The entire area is underlain by karst. This is evidenced by the volumes of water of 10,000m³ per day discharged at the spring sources.](#)

A summary of the **quantitative** impact assessment findings is as follows:

- Boreholes at proposed turbines T1 and T2 both encountered competent dark grey, impure LIMESTONE with MUDSTONE layers;
- No epi-karst, karst conduits, significant fractures or groundwater strikes were encountered due to the lithology competent nature of the bedrock;
- Investigations indicate limited recharge/vertical groundwater flow from the glacial deposits down into the underlying bedrock aquifer at the Proposed Wind Farm site within the source protection area;
- Therefore, due to the nature of the underlying geology (LIMESTONE/MUDSTONE formation) and the prevailing surface water drainage regime within the portion of the Proposed Wind Farm site within the SPA, no effects on groundwater flowpaths towards the Mid Galway PWS or Barnaderg GWS sources are likely to occur due to excavations which will typically terminate at the top of bedrock (*i.e.* there will be no requirement for excavations that extend deep into bedrock).

A summary of the **qualitative** impact assessment findings are as follows:

- Intercepting/unearthing a bedrock conduit/fracture during the construction works would potentially create a direct pathway between the construction work area (*i.e.* turbine base) and the source for potential water quality effects;
- However, the prevailing geology/hydrogeology described above as well as the relatively shallow excavations makes this very unlikely;
- Investigations and groundwater level monitoring data indicates that the majority of the recharge water in the glacial tills actually discharges to drains and the Lecarrow Stream that drains the area of the proposed wind farm site within the Mid Galway PWS source protection area;
- Therefore, the most likely pathway from the proposed wind farm site to the Mid Galway PWS abstraction point is surface water flows in the Lecarrow Stream;

[Response from MLavelle: The source of water at Mid-Galway is from groundwater and not the Lecarrow Stream.](#)

- However, flow in the Lecarrow Stream leaving the Site must pass through Horseleap Lough before reaching the downstream abstraction location;

[Response from MLavelle: The source of water at Mid-Galway is from groundwater and not the Lecarrow Stream.](#)

- Horseleap Lough is effectively a large natural wetland which will have significant attenuation/treatment capacity. Therefore, even in the absence of any wind farm surface water drainage control mitigation (which won't be the case), surface water quality effects downstream of Horseleap Lough in the Lecarrow Stream are not likely.

[Response from MLavelle: The source of water at Mid-Galway is from groundwater and not the Lecarrow Stream.](#)

In addition, a range of mitigation measures are proposed in Section 9.5.2.1 of the EIAR for dealing with potential water quality effects. For ease of reference these measures are listed again below:

- No storage of fuels, oils, cements, or chemicals will be permitted within the SPA
- Refuelling of mobile plant (i.e. diggers, dumpers etc) will only be permitted outside the SPA;
- Refuelling of large immobile plant (i.e. cranes) will only be carried out with a refuelling truck that will be removed from SPA immediately after use;
- Spill kit stations will be present at each turbine location (T1 & T2), temporary construction compound and along the Proposed Grid Connection cable route works areas;
- There are no proposed peat or spoil repositories within the SPA as part of design mitigation;
- A geotextile liner will be placed below the founding layer (lean mix concrete) where concrete is to be poured. These both prevent vertical loss of wet concrete at turbine bases;
- Use of perimeter shuttering at turbine basis to prevent lateral loss of wet concrete;
- All temporary cement washout lagoons will be located outside the SPA;
- Works inside the Lecarrow Stream 50m watercourse buffer limited to 1 no. proposed watercourse crossing culvert which will be clear spanning;
- No wind farm drainage will be released inside the 50m watercourse buffer on the Lecarrow 30 Stream;
- No wind farm drainage will be released inside the 30m buffer for the 1 no. potential enclosed depression/doline mapped inside the SPA at the Proposed Wind Farm site
- Drainage control measures at works areas along the Proposed Grid Connection; and,
- There will be clear signage in place inside the refined SPA to remind construction workers that the area is inside a drinking water protection area.

In summary, the statements outlined above are incorrect. The impact assessment included in the EIAR (at Section 9.5.2.1) includes **qualitative** and **quantitative** assessments with regard potential effects on Mid Galway PWS and Barnaderg GWS. And robust and appropriate mitigation are outlined in the EIAR to protect against potential water quality effects.

Response from MLavelle: The source of water at Mid-Galway is from groundwater and not the Lecarrow Stream. The qualitative & quantitative assessments are not correct & not robust. Relying on a report from 2012 is not appropriate & mitigation is not compliant.

8.7 Hydro-G Item 7:

The following statements from page 10 of the submission is addressed below.

“There are many issues with the Mitigation Measures Proposed. However, most significantly, there is no Mitigation Measure proposed in relation to the potential for Human Health Impact on the people who receive groundwater and ground waterfed Surface Water from the three local PWS and GWS sources in the immediate vicinity of the proposed development area. As previously outlined by Hydro-G and as published by the GSI in their description of the groundwater flow mechanism in the Clare Corrib GWB. Relative to the PWS and GWS abstraction source locations, the proposed haul roads, construction pads, crane pads and turbine erection sites are within the 9km published groundwater flow path length (GSI, 2004). There are no Mitigation Measures proposed for true risks to the source waters for public and GWS supply relating to issues, as follows:

- Increased turbidity in the karst conduit or surface water system. Increased turbidity has the potential to affect the disinfection process in the WTPs and thereby compromises the sterility and safety of the water supplied to the public. There is no information presented by the applicant for baseline turbidity in surface waters or groundwaters of the area.
- Increased Dissolved Organic Carbon in groundwater or surface waters. Construction in peatlands has the potential to exacerbate release of Dissolved Organic Carbon and this constituent is a driver on increased Trihalomethane formation potential in water supplied to the public after the statutory obligation of chlorination prior to discharge to the water mains. No silt buster will remove Dissolved Organic Carbon in waters discharging from the site. There is no information presented by the applicant for baseline Dissolved Organic Carbon in surface waters or groundwaters of the area.

- There is no information presented by the applicant for baseline lubricants and oils that will be in each hub and supplemented in the lifetime of the development, no information on hydrocarbon baseline, no details for the baseline surface water and groundwater constituents relatable to the proposed surface finishes of the coated turbines or those constituents that will be used in the cleaning of the turbine infrastructure”.

8.7.1 HES Response to Hydro-G Item 7:

A Human Health assessment and associated mitigation (cross references) is included at Section 9.5.6 of the EIA. It concludes:

“Potential health effects arise mainly through the potential for surface and groundwater contamination which can have negative effects on public and private water supplies. A portion of the Proposed Project site is located inside the Mid Galway PWS and Barnaderg GWS SPA, but investigations have been carried out to assess the risk (see Section 9.5.2.1 [of the EIA]) posed by the Proposed Project. Notwithstanding this, the Proposed Project design and mitigation measures ensures that the potential for effects on the water environment will not be significant.”

Response from MLavelle: Failure to investigate the Mid-Galway spring source of drinking water since 2015 indicates incorrect assumptions & dictates that the design & mitigation measures do not ensure that the significance of potential effects on the water environment have been considered.

Secondly, Uisce Éireann reviewed the proposed mitigation measures (refer to Section 5 of this response) and no short fall in the proposed mitigation as presented in the EIA were raised.

We note that there is no concern raised by UÉ with respect to organic carbon in their, submission.

8.7.2 HES Response to Bullet Point 1:

The findings of investigations with regard groundwater flow system below the Proposed Wind Farm site have been discussed in Section 8.1.3 above in this submission report. The key finding is that the bedrock lithology below the Site is a combination of impure LIMESTONE with MUDSTONE which will reduce the overall permeability of the aquifer and its recharge capacity.

The site investigations carried out to date at the Site (i.e. trial pits, borehole drilling and geophysical surveys) did not reveal any evidence of significant underlying karstification.

Therefore, all investigations/assessments and hydrological conditions at the Site do not suggest the presence of bedrock conduit system conveying large volumes of groundwater in the immediate vicinity of the PWS sources and two GWS sources. The hydrology of the Site is dominated by a surface water drainage regime. Therefore, no significant groundwater quality effects are expected, with surface water potential being the primary receptor due to the high runoff rates.

Response from MLavelle: The source of water at Mid-Galway is from groundwater and not the Lecarrow Stream.

With regard potential surface water quality effects, the mitigation measures detailed in Chapter 9 of the submitted EIA are tried and tested, best-practice mitigation measures for the protection of the hydrological (surface water) and hydrogeological (groundwater) environment.

8.7.3 HES Response Bullet Point 2:

Organic carbon causing Trihalomethane contamination is dealt with above in this submission response (Section 8.4.1 above). Due to poor groundwater recharge coefficients at the proposed wind farm site, the likely potential pathway for organic carbon reaching the Mid Galway PWS abstraction point is surface water flows in the Lecarrow Stream from where the water is abstracted from.

Response from MLavelle: The source of water at Mid-Galway is from groundwater and not the Lecarrow Stream.

Barnaderg GWS is solely and groundwater abstraction and therefore cannot be affected by organic matter in surface water.

We have already discussed above the presence of Horseleap Lough as a large natural wetland which will have significant attenuation/retention capacity, offering natural dilution and treatment (organic carbon removal) of wind farm drainage prior to flows reaching the Mid Galway PWS abstraction point further downstream on the Lecarrow Stream.

Response from MLavelle: The source of water at Mid-Galway is from groundwater and not the Lecarrow Stream.

8.7.4 HES Response to Bullet Point 3:

Oils and lubricants are common potential hazards at all construction sites (such as road works and industrial sites). These potential contamination sources will be carefully managed at the Site during the construction; operational and decommissioning phases of the Proposed Wind Farm and mitigation measures are proposed below to deal with these common hazards.

Please note that total hydrocarbons were part of the baseline groundwater quality monitoring suite carried out for the EIAR (refer to Appendix 9-2 of the EIAR for groundwater quality monitoring data).

Response from MLavelle: The source of water at Mid-Galway is from groundwater and not the Lecarrow Stream. As HES were not aware that the Mid-Galway PWS abstraction was from groundwater, they could not have monitored the spring sources. So, hydrocarbons were not monitored for Mid-Galway PWS.

8.8 Hydro-G Item 8:

The following statements from page 10 of the submission is addressed below.

“As is shown in the DWGS [drainage drawings] for the application, there will be extensive areas of Spoil Management and water management treatment systems adjacent to each of the proposed 9 turbines, the proposed substation construction site and along all trench excavation routes. All water management will be by infiltration into the epikarst of the underlying Clare Corrib Groundwater Body and the Regionally Important Karst aquifer feeding Lough Corrib and multiple GWS BHs: refer to Drainage Drawings and BH Logs”.

8.8.1 HES Response to Hydro-G Item 8:

Firstly, we refer back to previous responses above, the hydrology of the Site is dominated by a surface water drainage regime with low groundwater recharge rates. Secondly, no epikarst system was observed at the Site. The excess peat/spoil proposed for permanent storage will be placed on virgin ground and therefore storage areas will be underlain by several metres of poorly draining soils/subsoils with low infiltration capacity/rates. Attenuated discharge/runoff from proposed peat/spoil areas will be released onto the naturally vegetated ground surface via buffered outfalls. The water management treatment system design does not include infiltration drains, french drains or soakaways and therefore water management will not be by infiltration into groundwater.

It also should be noted that all proposed peat/spoil storage areas are located outside the Mid Galway PWS/Barnaderg source protection area. There are also no proposed peat/spoil storage areas located inside the Lecarrow Stream catchment from where the Mid Galway PWS abstraction occurs (3km downstream of the wind farm site).

Response from MLavelle: The source of water at Mid-Galway is from groundwater and not the Lecarrow Stream.

8.9 Hydro-G Item 9:

The following statements from page 10 of the submission is addressed below.

*“Moreover, streams are the headwaters of the Clare River and hence supply sources for the Corrib SAC. All tributary streams to the Corrib are salmonid. Hence a windfarm in the headwaters of the catchment represents a risk to that water supply and ecology, especially in quality, notwithstanding the same tributaries are ancillary to an arterial drainage scheme. However, under Nature Restoration, such arterial drainage is itself under review for rehabilitation to more natural conditions (OPW) – building turbines should not be allowed to impede this restoration. The generic drainage system depicted in the report for draining roads and hardstands is unlikely to work since the low permeability soils will accelerate this drainage into the existing network – soil infiltration is likely to be poor, but no field assessment was made. Moreover, the proposed system with ‘silt traps’ is unlikely to work in detaining colloidal solids which, themselves carry Dissolved Organic Carbon (DOC) arising from the extensive excavations/roads on site, as well as from windfarm enhanced **drainage from the peatbogs. Such losses conflict with the role of wind farms as climate mitigation devices”***

8.9.1 HES Response to Hydro-G Item 9:

The proposed drainage measures for the Proposed Wind Farm are used at construction sites across the country and have been used in the construction of the countless existing wind farm developments. It is noted that similar mitigation measures for the protection of the receiving water environment were proposed in the EIARs for the recently permitted Glenard Wind Farm (ABP Case No: 312659) and the permitted Seven Hills Wind Farm (ABP Case No. 313750).

The drainage design, which is site specific, is based on recommendations from Inland Fisheries Ireland (IFI) relating to other recent wind farm projects (i.e. Cahermurphy Wind Farm, Co. Clare - Planning Ref P20/658). The site-specific drainage design was created by dividing the footprint has been into drainage catchments (based on topography, outfall locations, and catchment size) and stormwater runoff rates based on the 10-year return period rainfall event were calculated for various catchment areas in order to size the settlement ponds to achieve Greenfield discharge rates.

Lidar DTM data is used to tailor the design with regard catchment areas and drainage flow paths. Therefore, to call the design **'generic'** shows a lack of understanding of the design (Refer Appendix 4-3 of the EIAR for the drainage layout).

The statement **'soil infiltration is likely to be poor but no field assessment was made'** is a direct contraction to the statement referenced on page 16 above where it states, **'all water management will be by infiltration into the epikarst'**.

The criticism **'but no field assessment was made'** on filtration rates has no relevance as the Proposed Wind Farm drainage design does not propose infiltration as a water disposal solution. Nonetheless, the observed drainage conditions at the Site would indeed indicate low infiltration rates.

The next statement above **'draining roads and hardstands is unlikely to work since the low permeability soils will accelerate this drainage into the existing network'** is perplexing coming from Hydro-G which is a company with a water engineering background. The purpose of the drainage design is to slow down runoff from low permeability hardstand surface and release at Greenfield runoff rates.

Finally, the proposed system does not have just **'silt traps'** but a treatment train of water quality improvement/control systems (i.e. source controls → check dams → silt traps → settlement ponds → level spreaders → silt fences → vegetation filters → watercourse buffer zones) which will all contribute to the reduction of suspended and colloidal solids.

8.10 Summary statement on the Hydro-G submission

- As outlined the Hydro-G submission includes several statements that are misleading and factually incorrect;
- The incorrect statements create uncertainty, may lead to confusion, and undermine the factual and science-based assessment presented in the EIAR; and,
- This section of the submission respectfully seeks to clarify or address statements made in this 3rd party submission that could be misleading, and/or where they are factually and/or scientifically incorrect.

9 NORTH-EAST GALWAY ENVIRONMENTAL PROTECTION (NEGEPC)

We have split our responses to issues raised in the NEGEPC submission into 3 items.

9.1 NEGEPC Item 1:

The following statement from page 3 of the submission is addressed below.

"The location of two proposed wind turbine foundations within the Source Protection Area (SPA) of the Mid-Galway Public Water Supply (PWS) poses an extreme contamination risk due to the underlying karst limestone hydrogeology, which facilitates the rapid, unfiltered transport of pollutants such and hydrocarbons directly to the abstraction point. The construction activity, particularly excavation and dewatering, directly impacts a primary groundwater recharge zone, requiring stringent protective measures to adhere to the Water Supplies Act, 1942. This zone is also legally protected by the Water Framework Directive (WFD), which mandates a commitment of no deterioration to water body status"

9.1.1 HES Response to NEGEPC Item 1:

The investigations and impact assessment with regard the Mid-Galway Public Water Supply (PWS) have been addressed in the Hydro-G response above. In particular refer to Section 8.2.1 above, which summaries the investigation findings in the area of the two proposed turbine (T1 & T2) within the SPA (source protection area).

9.2 NEGEPC Item 2:

The following statement from page 3 of the submission is addressed below.

“The Karst Risk Assessment limited its scope to only geotechnical risk and the Hydrology chapter must address the hydrogeological risks to water. While the Hydrology chapter concludes that with mitigation, there will be no significant effect, the KRA's findings of "High Karst Hazard" at T4 (within) inherently increase the risk of contamination entering the groundwater system, making the Hydrology Chapter's "no significant effect" conclusion more difficult to substantiate beyond reasonable doubt”.

9.2.1 HES Response to NEGEPC Item 2:

The assessment of no significant effects and in particular relating to hydrogeological effects, does not rely on mitigation alone to come to this conclusion, but in fact the geological and hydrogeological setting of the proposed wind farm site as determined by an array of site investigations which are described above in this submission. This also applies to the assessment of effects relating to Mid Galway PWS and Barnaderg GWS. What's notable about the known bedrock geology of the Site is that all investigation drilling data available to date (i.e. BH1, BH2 and GSI-17-003) encountered impure argillaceous LIMESTONE (i.e. clay impurities) with MUDSTONE layers. Impure limestone is typically less prone to karstification. MUDSTONE is not prone to karstification.

The majority of the trial pits that met bedrock encountered competent, unweathered, grey, massive LIMESTONE. No epi-karst weathering was encountered in any of the trial pits that encountered limestone. Also, targeted geophysical surveys in the area of proposed turbine T4 did not reveal any evidence of underlying karstification.

The large coverage of peat bogs, poorly draining soil/subsoil and high drainage density within the Proposed Wind Farm site would also suggest a poorly developed groundwater drainage network. Hence the presence of several surface watercourse at the Proposed Wind Farm site due to low groundwater recharge rates.

The presence of drainage features implies there is a need to drain surface water, as it cannot recharge/drain readily to the underlying bedrock aquifer underneath.

9.3 NEGEPC Item 3:

The following statement from page 6 and 7 of the submission is addressed below.

“Hydrology and Hydrogeology (e.g., Chapter 9): Accurate precipitation data is essential for determining existing flood risk, calculating runoff volumes for drainage design, and modelling potential impacts on local watercourses. Inaccurate or distant rainfall measurements directly lead to questionable hydrological models and potentially inadequate mitigation measures for construction-phase runoff”.

In summary, the use of remote meteorological data violates the principle of site specificity required for a robust EIA. The conclusions drawn in any chapter dependent on weather including, but not limited to, Ecology, Hydrology, and Noise—must therefore be treated with caution, as the underlying environmental parameters are based on surrogate data that is too distant to be scientifically representative of the Proposed Development site”

9.3.1 HES Response to NEGEPC Item 3:

Accurate and relevant climate data was used in the EIAR. Met Eireann do not record data at every location and therefore point data (such as that from Dunmore Garda Station or Claremorris Synoptic Station are what is available (refer to Section 9.3.2 of the EIAR)).

In addition to point data, average long-term data are also used. This is also explained in Section 9.3.2 of the EIAR. Climate change implications for rainfall data are also detailed in Section 9.3.2 of the EIAR.

The application of long-term average rainfall data for general baseline assessment and extreme weather event data for drainage design purposes is explained in Section 9.3.5 of the EIAR.

“The rainfall depths used in this water balance [Section 9.3.5 of the EIAR], which are long term averages, are not used in the design of the sustainable drainage system for the Proposed Wind Farm site. The Proposed Wind Farm Site drainage design is based on the 10-year return period rainfall event as described further in Sections 9.4.1 and 9.5.2.3 below”.

The 10-year return period event is a recommendation from Inland Fisheries Ireland (IFI) relating to other recent wind farm projects (i.e. Cahermurphy Wind Farm, Co. Clare - Planning Ref P20/658).

The application and use of the available climate data as outlined in the EIAR is appropriate, and in line with best practice guidelines and industry standards.

10 3RD PARTY SUBMISSIONS – GENERAL RESPONSES

This section presents our responses to recurring themes included in the various 3rd party submissions relating to the water, land, soils and geological environment. Some of these themes/matters have previously been dealt with in the detailed responses provided above (we cross reference to relevant paragraphs for ease of reading).

- Effects on local group water scheme supplies (Sections 8 & 9);
- Surface water and groundwater quality affects (Section 8);
- Potential effects on local private wells;
- Potential impacts on Lough Corrib SAC; and,
- Potential Increased flood risk (Section 4).

10.1 Effects on local group water scheme supplies

The following statement is recurring in many of the third-party submission letters:

“I use the water from Barnaderg Gortbeg Group Water Scheme as my main source of drinking water for my household. The water is of excellent quality, and I am very concerned that pollution of various types such as silt, sediment and other contaminants will enter the water source, causing me and my family harm. With the location of two Turbines within the Source Protection Area (SPA) I believe the Cooloo Windfarm should not be granted permission whatsoever, especially in such a highly karstified and hydrologically sensitive area”.

The investigations and impact assessment with regard the Mid-Galway Public Water Supply (PWS) have been addressed in the Hydro-G response. In particular refer to page 9 which summaries the investigation findings in the area of the two proposed turbine (T1 & T2) within the SPA.

As stated previously above, the impact assessment included in the EIAR (at Section 9.5.2.1) included **qualitative** and **quantitative** assessments with regard potential effects on the Barnaderg GWS (i.e. no significant effects on Barnaderg GWS).

10.2 Surface Water and Groundwater Quality Effects

The mitigation measures prescribed in the EIAR for the protection of the hydrological/hydrogeological environment are proven, tried and tested, best in class mitigation measures which will ensure that the Proposed Project has no potential for significant effects on the receiving water environment.

The Proposed Project drainage system will ensure that there is no discharge of untreated or unattenuated waters. The EIAR also prescribes best practice mitigation measures in relation to hydrocarbons, cement-based products and wastewater. With the implementation of the prescribed mitigation measures, there will be no potential for significant effects on the hydrological/hydrogeological environment.

10.3 Effects on Local Private Wells

Potential effects on local private wells are assessed in Section 9.5.2.4 of the EIAR.

For the reasons provided in Section 9.5.2.4 (repeated below for ease of reference), we are satisfied that the Proposed Project site will not impact in any significant way on any potential down-gradient private wells.

[Response from MLavelle: What does “will not impact in any significant way on potential down-gradient private wells mean? What happens with the down-gradient Mid-Galway & Barnaderg schemes supplying c10,000m³ of drinking water per day? What happens if they & other wells are impacted? Will the windfarm be obliged to provide potable water/bottled water at their cost until the issue is resolved?](#)

Also, similar to the assessment of groundwater level effects, the assessment on private wells is supported by extensive site investigations and follow-up groundwater level monitoring:

- The large set back distances between turbine locations and downstream potential well locations (720m);
- The proposed project will involve relatively shallow excavations (3 – 3.5mbgl) as no borrow pit is proposed;
- The moderate - low permeability of the glacial deposits in which the turbine gravity base foundations will be constructed;
- The low recharge characteristics of the underlying LIMESTONE/MUDSTONE aquifer that underlies the Proposed Wind Farm site;

- Localised groundwater flow patterns in the glacial deposits which is towards local streams that flow through the Site;
- Groundwater flow patterns are expected towards the watercourses that drain the Wind Farm site; and,
- The shallow excavation depths required for Grid Connection cable, Substation and BESS.

10.4 Effects on Lough Corrib SAC

Lough Corrib SAC is ~40km downstream of the Site (note the distance quoted here relates to the drainage pathway and is not a straight-line distance).

A comprehensive impact assessment was completed for the Lough Corrib in Section 9.5.2.10 of the EIAR. All other designated sites were screened out of the impact assessment due to the lack of hydrological and/or hydrogeological connectivity.

Drainage mitigation measures for surface water quality protection during the construction phase are summarised again below: (Please refer to Sections 9.5.2.2, 9.5.2.3 & 9.5.2.5 of the EIAR for the full description of these measures and how they will be applied)

- The proposed mitigation measures which will include 50m buffer zones for avoidance of sensitive hydrological features (streams and rivers);
- Pre-construction drainage control measures;
- Robust drainage control measures (i.e. interceptor drains, swales, settlement ponds and treatment trains such as Siltbuster) will ensure that the quality of runoff from Proposed Project areas will be very high; and,
- Best practice measures with regard use of oils, fuels (Section 9.5.2.6) and cement-based compounds (Section 9.5.2.8).

Tried and tested, best-practice mitigation measures (as detailed in the EIAR and clarified further in this response) for the protection of surface and groundwater water quality will be implemented during the construction phase of the proposed project to ensure that there is no deterioration in local or downstream water quality at Lough Corrib SAC.

10.5 Potential Increased Flood Risk

Submissions raise concerns for water quality and flood risk affecting neighbouring lands and lands downstream.

A site-specific Flood Risk Assessment (FRA) undertaken for the Site. The full FRA report is attached Appendix 9-1 of the EIAR.

The proposed site, including all 9 no. turbines, battery storage facility, 110kV substation and peat/spoil repositories, are at an elevation above the 1000-year flood level (i.e. are in Flood Zone C) where there is a low risk of fluvial flooding.

The Proposed Wind Farm drainage will not significantly alter the existing drainage regime at the Proposed Wind Farm site. Moreover, the proposed drainage system will be fully integrated into the existing bog, forestry and agricultural drainage systems.

Existing drains will be routed under/around the Proposed Wind Farm site access tracks using culverts as required.

Runoff from access tracks, turbine bases, and developed areas (construction compounds, substation, met masts etc) will be collected and treated in local (proposed) silt traps and settlement ponds and then discharged to existing local drains.

All new proposed watercourse crossings at the Proposed Wind Farm site will be designed to accommodate a 100-year fluvial flood with allowance for climate change (20 - 30%).

The Proposed Project will not result in increased downstream flood risk.

11 SUBMISSION RESPONSE SUMMARY

In summary and in response to ACP's submission response request:

- Overall, the Galway County Council submission was positive with regard the proposed project as well responses from the Prescribed Bodies (refer to Section 5, 6 & 7);
- Uisce Éireann did not note any short fall in the proposed mitigation as presented in the EIAR but did suggest some additional complementary requirements which will be implemented by the developer;

- A comprehensive site investigation dataset, comprising of trial pits, boreholes, geophysics and long-term groundwater level monitoring and water sampling was accrued as part of the baseline assessment of the Proposed Wind Farm site in the EIAR;
- The hydrological/hydrogeological impact assessment and assessment of potential effects on the Mid Galway PWS and Barnaderg (Gortbeg) GWS was carried out by HES (Hydrogeologists) and not Gavin and Doherty Geosolutions (GDG) who are overseeing solely the peat stability and geotechnical aspects of the project;
- Robust scientific reasoning has been provided in the EIAR to support the lack of potential effects on Mid-Galway PWS and Barnaderg (Gortbeg) GWS;
- The Brierfield GWS was not directly assessed in the EIAR. A qualitative and quantitative impact assessment is included in this response which is effectively the same as that completed for the Mid Galway PWS and Barnaderg GWS (Section 9.5.2.1 of the EIAR).

The conclusion of the assessment is that with the implementation of the proposed mitigation measures there will be no significant effects on the Brierfield GWS from the Proposed Project;

- All investigations/assessments and hydrological conditions at the site indicate the lack of karst bedrock conduit system conveying large volumes of groundwater in the immediate vicinity Site towards the PWS and GWS sources;
- Robust scientific reasoning has been also provided in the EIAR to support the lack of potential effects on Lough Corrib SAC and local wells;
- Any potential significant issues with regard flood risk were dealt with at the early design stage of the project in order to ensure all the proposed wind farm infrastructure is placed outside of mapped fluvial flood zones; and,
- With the implementation of the tried and tested, best practice mitigation measures there will be no potential for significant effects on surface or groundwater quality/quantity.

HES has responded to all matters raised in the ACP 3rd party submissions.

We respectfully submit to An Coimisiún Pleanála that this letter response reiterates the conclusions of the robust and comprehensive impact assessments presented in EIAR Chapter 8 (Land, Soils and Geology), EIAR Chapter 9 (Hydrology and Hydrogeology), the associated Flood Risk Assessment (Appendix 9-1), WFD Compliance Assessment Report (Appendix 9-3) and drainage design plan (Appendix 4-3).

The impact assessments presented in the EIAR are informed by a comprehensive site investigation dataset and rely upon the tried and tested, best practice mitigation measures which ensure the protection of the receiving environment. Similar mitigation measures have been successfully applied during the construction of countless wind farm developments across the country and were also presented in the EIARs for several recently permitted wind farm developments.

12 CLOSURE

We trust the above response meets your requirements. Please contact the undersigned if you have any questions regarding the above.

Yours sincerely,

David Broderick Hydrogeologist B.Sc., H. Dip Env Eng. MSc, P. Geo

Michael Gill Civil Engineer / Hydrogeologist BA, BAI, Dip Geol, MSc, MIEI, P.Geo

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APPENDIX 3 TNEI Submissions Response Cooloo Wind Farm: Response to Submissions (Noise)

1 Introduction

This report has been produced in response to the invitation to respond to submissions from An Coimisiún Pleanála (ACP) in respect of Construction of wind energy development and all associated works located within Cloondahamper, Cloonascragh, Elmhill, Cooloo, Lecarrow, Dangan Eighter, Lissavally and Slievegorm, Co.Galway (letter from ACP of 19th December 2025 to MKO) for case number ACP-323761-25. The report provides responses to submissions received (the Submissions) in respect of the potential for operational and construction noise and vibration associated with the Proposed Project.

The report addresses the submissions received in respect of noise and vibration only.

1.1 Overview of Submissions

1.1.1 Submissions from Prescribed Bodies.

Eight submissions were received from Prescribed Bodies in respect of the Proposed Project. Of these, only one refers to noise, which is from the National Office for Environmental Health Services (NEHS). No submissions refer to vibration.

[Response from MLavelle: My previous submission did refer to vibration](#)

TNEI's response to the submission from HSE is included as Section 2.1.

1.1.2 Submissions from Other Stakeholders

213 submissions were received from other stakeholders in respect of the Proposed Project. Many of these submissions referred to noise and/or vibration. TNEI's response to these submissions are included as Section 3.1 to Section 3.9

Most of the submissions are from individuals or families living in proximity to the Proposed Project, although some submissions have also been made from groups and organisations. Those that included observations related to noise and vibration include Barnaderg Cooloo Windfarm Action Collective CLG, one early years educational facility, Killereerin Development Company and Killereerin Community Council. Many of the submissions express concern in respect of noise, primarily from the operation of the wind turbines, though there are also some concerns raised in respect of construction noise and noise from the operation of the BESS.

It should be noted that only two of the submissions have commented on any of the technical elements of the Noise and Vibration EIAR Chapter or the associated Technical Appendices. Specifically, one submission discusses the measured baseline noise levels and the associated limits, and one submission refers to the findings of the Battery Energy Storage System (BESS) noise assessment. These are addressed in Section 3.9.1 and Section 3.9.2.

The general concerns raised relate to the potential for adverse health impacts, in particular from low frequency noise and/or infrasound, however, other issues have also been raised, and the following list seeks to summarise those concerns;

- The use of noise assessment standards, guidelines and legislation
- Health impacts from noise pollution
- Low Frequency Noise (LFN) and infrasound
- Amplitude Modulation (AM)

- Potential impacts on animals (livestock)
- BESS noise
- Construction noise
- Vibration

Each of the above areas of concerns is addressed in Section 3.

1.2 Overview of the EIAR Noise Assessment

This section provides an overview of the noise assessment methodology that was adopted within Chapter 12 of the EIAR. It is useful to detail this here, as reference is made to these standards and guidance throughout this report.

- The assessment of operational noise from the proposed wind turbines is made against noise level limits derived from the noise limit criteria defined in the Wind Energy Development Guidelines (WEDG2006) [1].
- The operational noise assessment methodology is supplemented with the guidance set out in ETSUR-97 The Assessment and Rating of Noise From Wind Farms (ETSU-R-97) [2] and the Institute of Acoustics' A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise (the IOA GPG) [3].
- The prediction of noise from the operation of the wind turbines is undertaken in accordance with ISO 9613-2:1996 Acoustics — Attenuation of sound during propagation outdoors [4], with additional modifying factors as detailed within the IOA GPG.
- The prediction of noise from construction activities and from the operation of the BESS is undertaken in accordance with ISO 9613-2:2024 Acoustics — Attenuation of sound during propagation outdoors [5].
- The construction noise assessment methodology follows the guidance in BS 5228-1 Code of practice for noise and vibration control on construction and open sites - Noise [6] and noise is assessed against the threshold levels presented in that document.
- The noise assessment methodology for the operation of the BESS follows the guidance in BS 4142:2014+A1:2019 (BS 4242) Methods for rating and assessing industrial and commercial sound [7] and noise is also assessed against the noise limits set out in NG4 Guidance Note for Noise: Licence Applications, Surveys and Assessments in Relation to Scheduled Activities [8].

Chapter 12 of the EIAR presents an EIA assessment of the likely significant effects. This includes an assessment of construction and operational noise. Separately, a construction noise impact assessment and two operational noise impact assessments are provided as Technical Appendix 12-1 Construction Noise Report, Technical Appendix 12-2 Operational Noise Report and Technical Appendix 12-3 Battery Energy Storage System (BESS) Noise Report. The technical appendices (TAs) are used to inform the assessment presented in Chapter 12 and contain much more technical detail in respect of data collection and analysis, noise level predictions and assessment methodology.

2 Response to Statutory Bodies

2.1 Response to National Environmental Health Service Submission

The NEHS Submission (in respect of noise) can be split into two parts.

The first part, titled Project Specific Guidance for Wind Energy Development, is generic in nature i.e. it does not refer specifically to the Proposed Project. Rather, it could be applied to all wind turbine developments. The text provides some commentary regarding guidance that can be referred to when assessing the potential for health effects from operational wind turbine noise.

The second part of the NEHS Submission, titled Likely Significant Effects from Noise and Vibration (Chapter 12 of EIAR), provides specific commentary in respect of the Proposed Project and the Environmental Impact Assessment Report (EIAR) noise and vibration chapter.

2.1.1 NEHS Submission – ‘Project Specific Guidance for Wind Energy Development’

The NEHS Submission states that the current guidelines for wind energy development are the 2006 Wind

Energy Development Guidelines (WEDG 2006) but goes on to note that since the publication of those guidelines the nature of wind turbine development has changed e.g. larger turbines, cumulative effects etc. It also states that there have been “substantial increases in the body of knowledge around the likely significant effects of the operation of wind farm development on Population Health, in particular around the characteristics of the noise emissions and health effects of shadow flicker”, however, no specific reference is made to this additional knowledge and how it should be considered - though it is noted that World Health Organisation (WHO) publications are referred to in Part 2 of the Submission (this is addressed in 2.1.2). The Submission then refers to the 2019 Draft Wind Energy Development Guidelines (Draft WEDG 2019) [9], which were published for consultation in 2019 but are yet to be adopted, however, it is not clear whether NEHS is supportive or not of the use of Draft WEDG 2019.

Finally, the Submission refers to the High Court decision in *Webster/Rollo v Meenaclogher (Wind) limited* (2014 IEHC 136) 8th March 2024 [10] and suggests that this should be considered; “... if the Planning Authority are now considering that they are under a duty to incorporate the likelihood of a Private Nuisance into their decision making”. This was a private nuisance case in respect of noise received at a dwelling from the operation of a nearby wind turbine development i.e. not a planning matter. NEHS note that the judge stated that she could consider nuisance irrespective of any compliance with consent conditions, and whilst this is true, it is nothing new and is true of all noise generating developments, not just wind turbines.

TNEI recognise that compliance with a set of conditioned noise limits is not normally sufficient on its own to demonstrate that no nuisance is present. We have not, however, identified anything new in this particular decision that should influence how a noise impact assessment for a wind turbine development should be undertaken or how it should be considered differently in a planning context.

Care needs to be taken not to confuse nuisance with the planning regime, which is what is of concern here. Nuisance and planning operate under completely different legal frameworks and what is relevant here is the planning system, not nuisance. The planning process needs to consider each proposed development on its own merit. It would be incorrect to assume that just because one development caused a nuisance that all future, similar developments would also cause a nuisance.

2.1.2 NEHS Submission – ‘Likely Significant Effects from Noise and Vibration’ (Chapter 12 of the EIAR) Part 2 of the Submission in relation to noise is split out into ten paragraphs denoted as a-j. These are replicated below (blue text in italics) followed by a TNEI response, where necessary.

a) The 2006 guidelines include guidance on how to derive noise limits for daytime and night-time periods, which can be summarised as: daytime limits take account of existing background noise levels and include a fixed limit of 45 dB, or background +5dB, whichever is the greater, except in low background noise environments where a fixed minimum limit in the range of 35-40 dB should be considered.

Response from MLavelle: These 2006 guidelines on noise limits are based on turbine separation distances, which have been ignored.

b) This criteria is therefore that turbine noise at noise sensitive locations should not exceed for daytime periods: 40 dB(A) where background noise levels are below 30 dB; and 45 dB(A) or background noise plus 5 dB, whichever is the greater, where background noise levels are greater than 30.

TNEI Response: The principal of WEDG 2006 is to start from a position of setting a fixed noise limit (generally 45 dB(A)), however, a limit of background noise level + 5 dB can be used in higher noise environments. In this regard the WEDG 2006 states; “In general, a lower fixed limit of 45 dB(A)10min 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.”

As detailed above, when the existing noise environment is very quiet then a lower fixed level limit can be used, to be set between 35 dB (A) and 40 dB (A).

Response from MLavelle: . Low background noise measurement at NML3 of 19.1dBa for nighttime is at the threshold of noise monitoring equipment. To suggest that an increase to 63.5dBa and of over 40dBa plus is a low impact is gross incompetence & an attempt to fool the ACP Inspector. A factor of 16 times the background

noise will have a detrimental impact on citizens. [10dBa = factor 2: 20dBa = factor 4: 30dBa = factor 8: 40dBa = factor 16]. It is somewhat amazing that no academic studies of existing Irish windfarms have been presented in relation to noise

c) This criteria can potentially see a predicted increase of up to 15 dB(A) change in the noise environment as compliant with the criteria. Any change in the noise environment of this magnitude is highly likely to cause complaints and/or nuisance. BS 4142:2014+A1:2019 Methods for Rating and Assessing Industrial and Commercial Sound identifies an increase of 10 dB above the existing rated noise levels will have a significant adverse impact and is highly likely to cause complaints.

TNEI Response: This is an incorrect assumption and an oversimplification of BS 4142 [7], which employs a two-stage assessment process. Initially, an estimate of the impact is made by subtracting the measured Background Sound Level from the calculated or measured Rating Level. The second part of the assessment is to then consider the context in which the sound occurs, which can modify the findings of the initial estimate. The reference to “an increase of 10 dB ...,” is in respect of the Stage 1 initial estimate i.e. the NEHS Submission only considers the first stage of the assessment process, and completely disregards the second stage of the assessment, which considers, amongst other things, the absolute level of sound. It should also be noted that BS 4142 does not state anywhere within the standard that an increase in 10 dB is highly likely to cause complaints. In fact, the only real quote in reference to complaints in BS 4142, is; “Adverse impacts may include but not be limited to annoyance and sleep disturbance. Not all adverse impacts will lead to complaints and not every complaint is proof of an adverse impact”.

In respect of the absolute level of sound, BS 4142 suggests that in instances where the existing sound environment is considered either particularly low (below 30 dBA), or particularly high, then absolute levels may be more relevant, which would modify the initial estimate of impact. The standard states:

“Where background sound levels and rating levels are low, absolute levels might be as, or more, relevant than the margin by which the rating level exceeds the background. This is especially true at night.” This is the approach that both the WEDG 2006 and ETSU-R-97 takes, through the setting a fixed lower-level limit for locations with low background noise levels.

Regardless, BS 4142 is not an appropriate assessment method for evaluating wind turbine noise and a number of pages are given over to this within the ETSU-R-97 document, under the heading; ‘Problems with interpretation and the literal application of BS 4142’.

It is acknowledged that the ETSU document refers to an older version of BS 4142 than the version currently in use, however, with reference to the most recent release, BS 4142:2014+A1:2019, the following should also be noted;

- The Standard is intended for the assessment of noise at low wind speeds, however turbine noise increases proportionately with wind speed and it is at wind speeds above the range of those considered in BS 4142 that a wind farm noise assessment is centred around.
- There is no method to set noise level limits in BS 4142, the standard simply provides a mechanism to determine whether there may be an adverse noise impact for noise generating developments or noise sensitive developments that fit within the scope of the standard; and,
- BS 4142 itself states at 1.3; “The standard is not intended to be applied to the rating and assessment of sound from: a, b, c, ... h) other sources falling within the scopes of other standards and guidance.” In this case wind turbines fall ‘within the scope of other standards and guidance’, namely ETSU-R-97 The Assessment and Rating of Noise from Wind Farms and WEDG 2006. Accordingly, no further consideration of BS 4142 is considered necessary.

d) From the 2006 Guidelines “However, in very quiet areas, the use of a margin of 5dB(A) above background noise at nearby noise sensitive locations 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 30dB(A), it is recommended that the daytime level of the LA90, 10min of the wind energy development be limited to an absolute level within

the range of 35 - 40dB(A). ” There is no evidence base to support the statement that this limit is not necessary to offer a reasonable degree of protection in low noise background areas.

It is a common approach in the assessment of environmental noise to set an absolute lower level limit (also known as fixed ‘minimum limits’, rather than just consider the level above background where background sound levels are particularly low. This is not just confined to WEDG 2006 but is the basis of setting noise limits in ETSU-R-97, and is also discussed in BS 4142 (see quote in response above).

In this regard ETSU-R-97 states; “We are of the opinion that if the noise is limited to an LA90,10min of 35dB(A) up to wind speeds of 10m/s at 10m height then this condition alone would offer sufficient protection of amenity, and background noise surveys would be unnecessary”. To state that there is no evidence base to support this approach is incorrect and significant consideration of the setting of a lower level limit was undertaken at the time of writing ETSU-R-97; the ETSU document itself gives over an entire section (22 pages) considering noise limits and recommended guideline levels from WHO, British Standards and international standards, before coming to this conclusion.

More recently, the WSP report, A Review of Noise Guidance For Onshore Wind Turbines [11] presented a detailed evidence review, which states;

“It is clear from this review that the investigation and evidence on the effects of wind turbine sound has progressed substantially since ETSU-R-97 was published.” But also states;

“The ETSU-R-97 daytime minimum limits appear to be broadly consistent with the approaches taken in overseas national or regional guidelines, and are among the more stringent limits imposed.”

e) The evaluation of significance of an effect is based on the most up to date scientific knowledge and data. The EIA process specifically requires the assessment to be ‘the likely significant effects’ and if the knowledge on an evaluation criteria of significance has developed since the publication of a guidance, then it is reasonable and correct to use the developed knowledge base in assessing the significance of any effect. This is particularly relevant to the protection of public health. Statutory Guidance issued under the Planning Development Act 2000 (as amended) has to be considered by the Planning Authority when making a decision, but it is not a consideration that precludes all other evidence and knowledge. In Webster/Rollo V Meenaclogher (Wind) Limited (2024 IEHC 136) 8th March 2024 the judgement supports this position, in that the judgement makes it clear that compliance with the current Planning guidance does not preclude a private noise nuisance.

TNEI Response: The assessment has been undertaken in accordance with Wind Energy Development Guidelines (WEDG) 2006, which is the current guidance in effect in Ireland. However, whilst the WEDG 2006 sets out the noise level limit criteria, the actual assessment method is based on the application of ETSU-R-97 and the associated IOA GPG, which represents current best science.

ETSU-R-97 is still very much in use today in all countries of the UK, and to inform WEDG 2006 assessments in Ireland, and it is still relevant. The UK Government has been considering the extent to which ETSU-R-97 may require updating and a report produced for the (former) UK Government Department for Business, Energy & Industrial Strategy (BEIS) was published on 10th February 2023 (the WSP BEIS report), which provided some recommendations. The UK government has now acted on these recommendations by commissioning an update to ETSU-R-97, however, it is unclear when any updated guidance would be finalised or how it would be implemented.

An initial consultation period for the update to ETSU-R-97 (referred to as Assessment and Rating of Wind Turbine Noise 2025) has recently ended (August 2025) however, it should be noted that the consultation document states: “This draft guidance update does not represent a final position from government. It should not be used by local planning authorities during or after the consultation period in relation to ongoing planning applications. Following this consultation, we will analyse responses and issue a formal government response. Until this time, the current guidance remains suitable for assessing wind turbine noise. Planning authorities should continue to use existing guidance and are advised not to delay planning decisions on the basis of this consultation.”

In 2013 the Institute of Acoustics (IOA) published ‘A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise’ (IOA GPG), to set out best practice methodology.

This document has been endorsed by all UK governments. For example, the Scottish Government document 'Onshore Wind Turbines: Planning Advice' [12] states that the IOA GPG, "should be used by all IOA members and those undertaking assessments to ETSU-R-97. The Scottish Government accepts that the guide represents current industry good practice."

It is also noted that the Scottish Government 'Onshore Wind Policy Statement 2022' [13] states, "Until such time as new guidance is produced, ETSU-R-97 should continue to be followed by applicants....".

The IOA GPG is a live document that can be updated to reflect best practice, although since publication it has not been updated and the original document still represents best available science.

The use of WEDG 2006, supported by ETSU-R-97 and the IOA GPG, is routinely used for the assessment of wind turbine noise in Ireland and continues to be used for planning applications submitted in 2026.

Whether this assessment methodology is appropriate, how it is incorporated into EIA, and whether it is in keeping with the most up to date knowledge, was challenged during the planning application for the Coom Green Energy Park, a 22 wind turbine development in County Cork, Ireland [14]. The Inspector nonetheless considered the approach appropriate¹ and this was upheld when it was again challenged at a subsequent Judicial Review.

To summarise, TNEI consider the noise impact assessment methodology to represent both current national guidance and best available science.

f) In the opinion of the NEHS, tabulation of the predicted change in the noise environment from the proposed development and the cumulative change in the original baseline noise environment before any wind farm development in the area is the most informative way of reporting the likely effect of operational noise in an EIAR.

Response from MLavelle: . Low background noise measurement at NML3 of 19.1dBa for nighttime is at the threshold of noise monitor equipment assessment. To suggest that an increase to 63.5dBa and of over 40dBa plus is a low impact is gross incompetence & an attempt to fool the ACP Inspector. A factor of 16 times the background noise will have a detrimental impact on citizens. [10dBa = factor 2: 20dBa = factor 4: 30dBa = factor 8: 40dBa = factor 16]. It is somewhat amazing that no academic studies of existing Irish windfarms have been presented in relation to noise.

g) The NEHS would consider the most appropriate criteria for assessing significance of the predicted noise is consideration would be consideration of the ENVIRONMENTAL NOISE GUIDELINES for the European Region, 2018. The 2018 WHO Guidance set health protection levels from environmental noise. <https://iris.who.int/bitstream/handle/10665/279952/9789289053563-eng.pdf?sequence=1> 2
TNEI Response: TNEI do not agree that the Environmental Noise Guidelines for the European Region, WHO 2018 (the WHO Guidelines) [15] are appropriate criteria for the assessment of wind turbine noise. We would also note that the WHO Guidelines only set out guideline noise levels, and do not present any assessment methodology.

Response from MLavelle: The 2018 WHO Guidance are set. The competent Health Authority in Ireland NEHS/HSE accept them. Whether TNEI accept the Guidance is irrelevant & has no relevance in planning decisions.

The main purpose of The WHO Guidelines, as set out on page xiii is: "to provide recommendations for protecting human health from exposure to environmental noise originating from various sources: transportation (road traffic, railway and aircraft) noise, wind turbine noise and leisure noise."

The WHO Guidelines make recommendations in relation to each of the noise sources considered and each recommendation is rated as either 'strong' or 'conditional,' which are defined as follows:

"A strong recommendation can be adopted as policy in most situations. The guideline is based on the confidence that the desirable effects of adherence to the recommendation outweigh the undesirable consequences. The quality of evidence for a net benefit – combined with information about the values, preferences and resources – inform this recommendation, which should be implemented in most circumstances.

A conditional recommendation requires a policy-making process with substantial debate and involvement of various stakeholders. There is less certainty of its efficacy owing to lower quality of evidence of a net benefit, opposing values and preferences of individuals and populations affected or the high resource implications of the recommendation, meaning there may be circumstances or settings in which it will not apply.”

The strength of recommendation was determined following a two-step procedure. Initially the strength of the recommendation was set as strong or conditional based on a qualitative assessment of the quality of the evidence, this was then either adopted or confirmed having due consideration to contextual parameters that might have a contributory role. There were seven additional contextual parameters, which were assessed qualitatively. The WHO Guidelines provided three strong recommendations for each of the transportation noise sources (road traffic, railway and aircraft), one strong and two conditional recommendations for leisure noise, and two conditional recommendations for wind turbine noise.

1 See Inspector’s Report ABP-308885-20 dated 22/23 July 2021 & 6 December 2022

2 Note: The quoted link does not work. The WHO document (as of 4/11/25) can be found here; <https://www.who.int/europe/publicatons/i/item/9789289053563>

Accordingly, the recommendations for Wind Turbine Noise should not be given the same weight as other recommendations detailed within the document.

The recommendations included for wind turbine noise (presented on page xvii of the Guidelines) are reproduced here as Table 2-1. It should be noted that the metrics used for quantifying noise levels throughout the WHO Guidelines are Lden and Lnight, which are different from those used in WEDG 2006 and ETSU-R-97.

Table 2-1: WHO Environmental Noise Guideline Recommendations for Wind Turbine Noise Recommendation Strength

For average noise exposure, the GDG conditionally recommends reducing noise levels produced by wind turbines below 45 dB Lden, as wind turbine noise above this level is associated with adverse health effects.

Conditional

No recommendation is made for average night noise exposure Lnight of wind turbines. The quality of evidence of night-time exposure to wind turbine noise is too low to allow a recommendation.

N/A

To reduce health effects, the GDG conditionally recommends that policymakers implement suitable measures to reduce noise exposure from wind turbines in the population exposed to levels above the guideline values for average noise exposure.

No evidence is available, however, to facilitate the recommendation of one particular type of intervention over another.

Conditional

The Lden metric is an annual (day-evening-night) weighted sound pressure level. The metric, which considers annual exposure to noise, effectively gives additional weight to noise occurring during the evening and further weight to noise occurring at night. The Lden metric is commonly used for assessment of transportation noise and in strategic mapping exercises but there is no guidance in Ireland (or indeed in the WHO Guidelines) to outline how a wind farm noise Lden could be predicted or measured. There are very considerable practical difficulties involved with the use of Lden for wind farm noise and accordingly, it is very rarely used for wind turbine noise assessment.

When considering the recommendations in the WHO Guidelines it is important to consider them in the context of the entire document and there are a number of important points which are set out here;

The recommendations in the Guidelines are based on a 10% absolute risk of High Annoyance in the population. Table 36 of the Guidelines details that this is based on a review of four studies. Table 37 identified that six studies were available that considered sleep disturbance but they did not reveal

consistent results about the effects of wind turbine noise on sleep. Consequently, the Guidelines do not make a recommendation on Lnight. No other studies were identified in the Guidelines that were sufficient to allow for the consideration of any other health effects.

The recommendations are 'conditional,' and such recommendations: "requires a policy-making process with substantial debate and involvement of various stakeholders".

Table 42 of the Guidelines, "provides a comprehensive summary of the different dimensions for the assessment of the strength of the wind turbine recommendations." Within the table it states: "Evidence for a relevant absolute risk of annoyance at 45 dB Lden was rated low quality. No statistically significant evidence was available for sleep disturbance related to exposure from wind turbine noise at night."

Table 42 also sets out additional context in relation to the balance of benefits versus harms and burdens, stating: "Further work is required to assess fully the benefits and harms of exposure to environmental noise from wind turbines and to clarify whether the potential benefits associated with reducing exposure to environmental noise for individuals living in the vicinity of wind turbines outweigh the impact on the development of renewable energy policies in the WHO European Region."

As noted previously, the Lden metric is not currently used in Ireland for the prediction, measurement or assessment of wind turbine noise and this is also highlighted in Table 42 of the Guidelines, which states (in relation to additional considerations or uncertainties) that: "There are serious issues with noise exposure assessment related to wind turbines." This is consistent with earlier text in the Guidelines (on page 84), which notes that: "Based on all these factors, it may be concluded that the acoustical description of wind turbine noise by means of Lden or Lnight may be a poor characterization of wind turbine noise and may limit the ability to observe associations between wind turbine noise and health outcomes."

Whilst the Guidelines provide a useful overview of the information available relating to health effects at the time of the WHO review, the recommendations need to be considered in the context of the entire document and the Guidelines note that the quality of evidence upon which the recommendations are based is low quality. This is reflected in the fact that the recommendation is conditional, and the Guidelines note that the recommendation should be subject to a policy-making process with substantial debate and involvement of various stakeholders.

In relation to wind turbine noise assessment, no formal changes have been made to the 2006 WEDG. Similarly, the UK continues to rely on ETSU-R-97 and the IOA GPG as an appropriate method of assessment. It is also noted that the Institute of Acoustics has not made any changes to the good practice guidance set out in the IOA GPG to incorporate the WHO guidelines.

With due regards to the above, assessment of operational wind turbine noise against the levels presented in the WHO Guidelines is not considered to be appropriate or necessary.

h) The use of the 2006 Guidance with regards to noise exposure, and in particular the 'balance between development and public health' stated are resulting in a significant volume of complaints from communities exposed to noise from wind turbines post development. This position that the absolute noise exposure limits set in the 2006 Guidance do not necessarily protect Public health in specific development situations is now supported by Judgements of the Irish Courts, as referenced previously in this submission.

TNEI Response: NEHS do not provide any evidence in their submission of the 'significant volume of complaints,' nor how these are linked to the use of WEDG 2006. Reference to one or two wind turbine developments that have been ruled to have caused a noise nuisance is not sufficient to determine that the noise limits set by WEDG 2006 are not able to offer appropriate levels of protection. Indeed, it should be noted that the development referred to in the Webster/Rollo V Meenaclogher (Wind) Limited case had noise limits that were not set in accordance with WEDG 2006. If the planning condition and noise limits for that development had been written using the WEDG 2006 guidance, then noise levels from the wind farm development would have been regulated differently.

i) It should be noted that concern with the 2019 draft guidance by acoustic consultants were concerns due to assessment methodology and not the proposed standards set to protect health. In the

response from the institute of Acoustics they specifically state: “The group agreed and stressed in their responses that they believe the setting of suitable noise limits is a matter for government policy. The group was only concerned with aspects of technical accuracy and clarity”

TNEI Response: As lead authors of the acoustic consultants’ response, we would note that significant discussion was presented in that response in respect of the appropriateness of the use of the WHO guideline levels. In particular, we would note that the acoustician’s response covered the same and similar points to those raised above in respect to the WHO ‘conditional’ recommendation, stating; “Table 42 of the WHO document provides a summary of the strength of the recommendation and states: “Evidence for a relevant absolute risk of annoyance at 45 dB Lden was rated low quality.” In addition, the WHO document itself is based on a very limited data set, which only estimated the Lden for the sites studied, rather than assessing it directly from wind statistics (see Appendix 2). This is acknowledged in the WHO document, which states that is “may be concluded that the acoustical description of wind turbine noise by means of Lden or Lnight might be a poor characterization of wind turbine noise”. Additionally, the use of how the WHO guideline levels could be incorporated into an assessment methodology was questioned in respect of both technical accuracy and clarity.

j. Wind Energy Development Guidelines (WEDG) for consultation for Irish Department of Housing, Planning, Community and Local Government (DHPLG) | Institute of Acoustics

This final paragraph presents a link to an article written by Jim Singleton (author of this report) regarding the acoustician’s consultation response to the draft WEDG2019. We would note that the link within that article to the acoustician’s response is broken but it can be found using this link.

https://www.dickbowdler.co.uk/content/publications/wedg_consultation_joint_response_r0.pdf

It is noted that the NEHS submission concludes the ‘noise section’, under the heading Predicted Operational Noise, which states;

“The NEHS notes that the table of predicted noise at NSL in Table 12.15 and 12.173 and that the predicted noise levels are below the adopted standard.”

And;

“The NEHS is of the opinion that there is no requirement for additional noise mitigation measures during the construction phase providing those measures identified in the in the EIAR are implemented in full”.

The response also states that construction should be limited to 08:00 – 19:00 Monday to Friday and Saturday 09:00 – 14:00. Section 1.3 of the Construction Noise Assessment (Appendix 12-1 of the EIAR) notes construction activities are expected to be limited to 07:00 – 19:00 Monday to Saturday and standard 3 Tables 12.15 through to 12.17 of EIAR Chapter 12 present the predicted noise levels from the operation of the wind turbines compared to the Total Noise Limits and the Site Specific Noise Limits.

construction activities are not anticipated outside of these, however some activities outside of the core hours could arise under certain conditions.

The Applicant commits to upholding construction within the limits recommended by NEHS should they be conditioned by the consenting planning authority.

3 Response to Third Party Submissions

The following sections seek to provide an overarching response to the common themes found across the range of submissions. It should be noted that in the majority of cases, the submissions relate to noise from wind turbines generally and do not focus specifically on the Proposed Project or raise questions in respect of the noise impact assessments submitted as part of the planning application.

Table 3-1 signposts the sections for each of the issues addressed. Where project specific questions have been raised, however, we have sought to address these (see Section 3.9).

Table 3-1: Issues Addressed

Issue	Section
Noise assessment standards, guidelines and legislation	3.1
Health impacts from noise pollution	3.2
Low Frequency Noise (LFN) and infrasound	3.3

Amplitude Modulation (AM)	3.4
Potential impacts on animals (livestock)	3.5
BESS noise	3.6
Construction noise	3.7
Vibration	3.8

Whilst it is recognised that the issues detailed in Table 3-1 represent legitimate concerns, it should be noted that many of the submissions refer to articles, technical papers, court hearings and similar, which in most cases are often mis-understood, mis-quoted or misrepresented. For example, multiple responses refer to the paper ‘Importance of Noise Hygiene in Dairy Cattle Farming—A Review’ [16], with one submission stating, “The paper also discusses how exposing animals to noise from an unfamiliar source can cause them stress. Therefore we can conclude that the noise associated with the wind farm will negatively affect animal and milk production”. This completely misrepresents the paper, which primarily focuses on noise inside farm buildings that is generated from the use of machinery, such as may be used for milking. Sound levels from wind turbines in outdoor environments, which are likely to range between 30 to 50 dBA depending on distance and wind conditions, are in no way comparable to the sounds that are occurring inside farm buildings, which are quoted as between 60 to 80 dBA.

Similarly, many submissions misunderstand the nuances of the different assessment standards that are used; for example, it is not possible or correct, to apply guideline noise levels from WHO documentation to ETSU-R-97 style wind turbine assessments, nor is it appropriate to refer to BS 4142 background sound levels for the assessment of operational wind turbine noise. This is understandable, as the topic of environmental noise assessment can be highly complex, and it is not reasonable to assume that the technicalities of such assessments should be understood by all. Conversely, however, it is not reasonable to simply ignore the findings of the technical assessments and instead focus any objections to the Proposed Project (or any development) based on soundbites, news headlines and generalisations. Care needs to be taken when considering the content of many of the submissions, as to the validity of the claims, which are often based on assumptions rather than science.

It is noted that many submissions make reference to the Webster/Rollo v Meenaclogher (Wind) Limited noise nuisance case, discussed previously in Section 2.1.1. This is understandable, as it was a high profile case that gained lots of media coverage. Reference to this case, however, and similar references to media reported noise issues, needs to be considered in context and with a full understanding of the facts. In that particular case, a two-turbine scheme whose nearest turbine was extremely close to the complainants’ property (approximately 380 m), was found to be causing a noise nuisance. The operator did not appear to acknowledge the noise complaints over a long period of time (several years) or attempt to reduce the noise output. Most importantly (in relation to this report), the noise level limits set in the planning conditions were not set in accordance with WEDG2006, ETSU-R-97 or any other recognised guidance. Had the noise limits been set appropriately (and assuming the development complied with those limits), this would have reduced the likelihood of nuisance occurring in the first place.

[Response from MLavelle: The separation distances in this application are not in accordance with WEDG2006 Or Draft WEDG2019. Thus turbulence & noise will be far higher than the manufacturers 63.5dBa figure for 12m/s. Rain & friction from insect detritus on the blades will increase this level further. This noise level does not comply with any standards.](#)

Furthermore, it is not reasonable to assume that because a noise nuisance was found at one wind turbine development that all future turbine developments are liable to cause a nuisance. Similarly, that development cannot be compared directly to the Proposed Project in terms of noise; setback distance and topography are different, turbine technology has advanced; noise mitigation measures can be designed in (mode management), and the noise level limits for the Proposed Project are derived in accordance with recognised, best practice.

[Response from MLavelle: The noise level limits for the application at 63.5dBa \(below\) is not in accordance with any practice, not alone best practice.](#)

There are many instances of references to other turbine developments in the submissions, however, the planning system needs to consider each Proposed Project on its own merit. The inclusion, for example, of the Huson & Associates review of the Noise Impact Assessment report for the Ballynisky Wind Farm in Limerick, which is appended to the Barnaderg Cooloo Windfarm Action Collective CLG submission, is not relevant to the Proposed Project. Similarly, inclusion of a policy document of the Environmental Protection Authority of Tasmania is not relevant here and it is not, as is claimed, ‘best practice’, it is simply a regional policy document.

Response from MLavelle: The applicant quotes reports from many countries in his application. However, he objects to the respondents quoting similarly. Everything is relevant in relation to expert submissions. It seems obvious that the Huson & Associates review is relevant & the applicant cannot deal with the issues raised. Similarly, the Tasmanian policy document is relevant & is best practice. The FI Response should have dealt with the issues of disagreement & not denial.

3.1 Noise assessment standards, guidelines and legislation

Many of the submissions question whether the use of WEDG 2006 and ETSU-R-97 is appropriate for the assessment of operational noise. Similarly, many of the submissions state WHO guideline levels should be used for assessment. This has already been addressed in Section 2.1.1 and Section 2.1.2, so does not need to be discussed further here.

3.2 Health impacts from noise pollution

Many submissions present statements regarding alleged adverse health effects attributable to wind farms but these comments do not specifically address the Proposed Project. Rather, the submissions discuss wind turbines in general and the tone of many of the submissions infer that adverse health effects are likely from all wind farm developments.

Understandably, many residents are anxious and concerned about potential health impacts related to noise from the turbines, however, the fact that high levels of noise (from any noise source) may contribute to adverse health effects is not under debate here; nor is the evidence that lack of sleep as a result of noise disturbance may contribute to adverse health effects. Both of these issues are well documented, for example, in publications such as those published by the WHO. What is important is not whether high levels of noise contribute to adverse health effects but how levels of noise are assessed and controlled, to remove, reduce or mitigate this risk. In this case, the assessment has been undertaken in accordance with recognised best science and the most up to date good practice. As already presented in detail in Section 2.1.2 but worth repeating here, it is not appropriate to assess wind turbine noise against the WHO Guidelines published in 2018.

Particular concern has been raised in respect of low frequency noise and infrasound, and this is addressed separately in Section 3.3, as it features in many of the submissions.

Concerns have been raised regarding the ability for wind turbine noise to affect nearby residents that are neurodivergent. Responses to third-party observations regarding human health are addressed in Section 2.5.4 of the main response document.

Some of the submissions refer to ‘vibroacoustic disease,’ which the WSP BEIS report covers within a literature review of effects of noise from wind turbines, and details the following:

Tonin 2018

“Tonin (2018) presented a narrative literature review focussed on wind turbine infrasound, including hypotheses for potential explanations for reported health symptoms and emerging research evidence. The range of hypotheses discussed included ‘vibroacoustic disease’, a specific ‘wind turbine syndrome’, and suggestions that exposure to infrasound below perception thresholds may impart stimulation of inner ear components not directly associated with auditory sensations, or vestibular activation, which may be linked with ‘motion sickness’ symptoms. Tonin noted that, from those reviewed, the only observational study to examine infrasound was the Health Canada study, which employed year-long measurements to demonstrate that wind turbine infrasound could sometimes be detected up to 10 km, but was often below residual levels;

infrasound levels measured near the turbine base were around a perception threshold corresponding to the most sensitive 1% of people. Tonin reported the results from the author's own experimental study, which used controlled infrasound exposure based on a real wind turbine signal. It was found that exposure to either real or sham infrasound had no influence on the reporting of health symptoms by participants. However, the expectation of effects connected with the participants' attitudes prior to the experiment did have a significant effect, which supports a nocebo explanation for reported health symptoms associated with wind turbine infrasound. Tonin also reviewed an earlier experimental study that used lower levels of infrasound exposure (Tonin asserted these levels were too low, such that the experimental comparison for exposure groups would have been sham/sham rather than real/sham), but arrived at similar conclusions; symptom reporting could be explained by nocebo effects rather than infrasound exposure". [17]

Van Kamp et al (2018)

"The authors identified that the symptoms proposed to be connected with exposure to inaudible infrasound are already described in the manual of health disorders as associated with generalised anxiety disorder, and noted that anxiety could be brought about by negative feelings about new or planned wind farms. It was concluded that there is little scientific evidence to support any new or unique health effects associated with wind turbine infrasound or low frequency sound. Reported symptoms linked with wind turbine infrasound could be explained by stress. Suggestions of wind turbine syndrome and vibroacoustic disease are not supported." [18]

3.3 Low Frequency Noise (LFN) and infrasound

The term infrasound can be defined as the frequency range below 20 Hz, while low frequency noise (LFN) is typically in the frequency range 20 – 200 Hz. An average young healthy adult has an audible range from 20 Hz to 20,000 Hz, although the sensitivity of the ear varies with frequency and is most sensitive to sounds with frequencies between 500 Hz and 4,000 Hz. Accordingly, the average human can hear LFN but cannot hear infrasound.

Wind turbines do produce low frequency sounds, but our threshold of hearing at such low frequencies is relatively high i.e. low frequency sounds need to have a high level of amplitude before they are audible. Therefore, LFN will usually go unnoticed.

Infrasound from wind turbines is often at levels below that of the infrasound generated by other local noise sources, for example, from the wind around buildings and other obstacles.

Many of the submissions express concern with regards to the potential for LFN and / or infrasound generated by the proposed wind turbines and the potential for adverse health impacts attributable to exposure to certain levels of LFN. However, levels of LFN and infrasound have been found to be particularly low from wind turbines and this is backed up by a large body of work, some of which is detailed here:

In 2004, the former UK Department for Trade and Industry (DTI) commissioned The Hayes McKenzie Partnership to report on claims that infrasound or LFN emitted by wind turbine generators (WTGs) were causing health effects. Of the 126 wind farms operating in the UK at that time, five had reported LFN problems, therefore, such complaints are an exception, rather than a general problem that exists for all wind farms. Hayes McKenzie investigated the effects of infrasound and LFN at three of the wind farms for which complaints had been received and the results were reported in May 2006 [19]. The report concluded that:

- infrasound associated with modern wind turbines is not a source which will result in noise levels which may be injurious to the health of a wind farm neighbour;
- low frequency noise was measurable on a few occasions but below the existing permitted [UK] Night Time Noise Criterion. Wind turbine noise may result in internal noise levels within a dwelling that is just above the threshold of audibility, however at all sites it was always lower than that of local road traffic noise;
- that the common cause of complaint was not associated with LFN, but the occasional audible modulation of aerodynamic noise especially at night. Data collected showed that the internal noise levels were insufficient to wake up residents at these three sites. However once awoken, this noise can result in difficulties in returning to sleep.'

The Applied and Environmental Geophysics Research Group at Keele University was commissioned by the

UK Ministry of Defence (MOD), the DTI and the British Wind Energy Association (BWEA) to undertake micro-seismic and infrasound monitoring of LFN and vibrations from wind farms for the purposes of siting wind farms in the vicinity of the Eskdalemuir Seismic Array in Scotland. Whilst the testing showed that vibration can be detected several kilometres away from wind turbines, the levels of vibration from wind turbines were so small that only the most sophisticated instrumentation can reveal their presence and they are almost impossible to detect [20]. Nevertheless, the Renewable Energy Foundation alleged potential adverse health effects and when that story was picked up in the popular press, notably the Scotsman, the report's authors expressed concern over the way in which their work had been misinterpreted and issued a rebuttal statement in August 2005, stating:

'Vibrations at this level and in this frequency range will be available from all kinds of sources such as traffic and background noise – they are not confined to wind turbines. To put the level of vibration into context, they are ground vibrations with amplitudes of about one millionth of a millimetre. There is no possibility of humans sensing the vibration and absolutely no risk to human health.'

In response to concerns that wind turbines emit infrasound and cause associated health problems, Dr Geoff Leventhall, Consultant in Noise Vibration and Acoustics and author of the Defra Report on Low Frequency Noise and its Effects, said in the article in the Scotsman ('Wind Farm Noise Rules 'Dated' - 5 August 2005') [21]:

'I can state quite categorically that there is no significant infrasound from current designs of wind turbines.' An article published in the IOA Bulletin (March/April 2009) concluded that there is no robust evidence that either low frequency noise (including 'infrasound') or ground-borne vibration from wind farms, has an adverse effect on wind farm neighbours.

Further work by Dr Leventhall looked at infrasound levels within the ear, compared to external sources, and concluded:

'The conclusion is that the continuous inner ear infrasound levels due to internal sources, which are in the same frequency range as wind turbine rotational frequencies, are higher than the levels produced in the inner ear by wind turbines, making it unlikely that the wind turbine noise will affect the vestibular systems, contrary to suggestions made following the measurements at Shirley. The masking effect is similar to that in the abdomen (Leventhall 2009). The body, and vestibular systems, appear to be built to avoid disturbance from the high levels of infrasound which are produced internally from the heartbeat and other processes. In fact, the hearing mechanisms and the balance mechanisms, although in close proximity, have developed to minimise interaction (Carey and Amin 2006).'

During a planning Appeal (PPA-310-2028, Clydeport Hunterston Terminal Facility, approximately 2.5 km south-west of Fairlie, 9 Jan 2018), the health impacts related to LFN associated with wind turbines were considered at length by the appointed Reporter (Mr M Croft) [22]. The Reporter considered evidence from Health Protection Scotland and the National Health Service. In addition, he also considered LFN surveys undertaken by the Appellant and the Local Authority, both of which demonstrated compliance with planning conditions and did not identify any problems attributable to the turbine operations; some periods with highest levels of low frequency noise were in fact recorded when the turbines were not operating.

The Reporter concluded that:

- The literature reviews by bodies with very significant responsibilities for the health of local people found insufficient evidence to confirm a causal relationship between wind turbine noise and the type of health complaints cited by some local residents;
- The NHS's assessment is that concerns about health impact are not supported by good quality research; and,
- Although given the opportunity, the Community Council failed to provide evidence that can properly be set against the general tenor of the scientific evidence.

To summarise, it is acknowledged that LFN can be generated from operational wind turbines, however, the levels are below that at which adverse impacts may occur. Levels of infrasound associated with wind turbine operations are particularly low and no higher than is experienced in everyday settings with no wind turbines present. Accordingly, no adverse health effects, including loss of sleep, are anticipated.

3.4 Amplitude Modulation (AM)

In the context of wind turbine noise, amplitude modulation describes a variation in noise level over time; for example, observers may describe a ‘whoosh whoosh’ sound, which can be heard close to a wind turbine as the blades sweep past. Amplitude Modulation (AM) of aerodynamic noise is an inherent characteristic of wind turbine noise and was noted in ETSU-R-97, on page 68:

“The modulation or rhythmic swish emitted by wind turbines has been considered by some to have a characteristic that is irregular enough to attract attention. The level and depth of modulation of the blade noise is, to a degree, turbine-dependent and is dependent upon the position of the observer. Some wind turbines emit a greater level of modulation of the blade noise than others. Therefore, although some wind turbines might be considered to have a character that may attract one's attention, others have noise characteristics which are considerably less intrusive and unlikely to attract one's attention and be subject to any penalty. This modulation of blade noise may result in a variation of the overall A-weighted noise level by as much as 3dBA (peak to trough) when measured close to a wind turbine. As distance from the wind turbine [or] wind farm increases, this depth of modulation would be expected to decrease as atmospheric absorption attenuates the high frequency energy radiated by the blade.”

In recent times the acoustics community has sought to make a distinction between the AM discussed within ETSU-R-97, which is expected at most wind farms and as such may be considered as ‘Normal Amplitude Modulation’ (NAM), compared to the unusual AM that has sometimes been heard at some wind farms, hereinafter referred to as ‘Other Amplitude Modulation’ (OAM). The term OAM is used to describe an unusual feature of aerodynamic noise from wind turbines, where a greater than normal degree of regular fluctuation in sound level occurs at blade passing frequency, typically once per second. In some appeal decisions it may also be referred to as ‘Excess Amplitude Modulation’ (EAM). It should be noted that the noise assessment and rating procedure detailed in ETSU-R-97 fully takes into account the presence of the intrinsic level of NAM when seeing acceptable noise limits for wind farms and as indicated by Association of Acoustic Consultants of Ireland (AACI) in Noise Guidelines for Local Authorities [23], the noise limits in the Wind Energy Development Guidelines (WEDG 2006), although not explicit, “are evidently derived from ETSU-R-97”.

On 16 December 2013, Renewable UK (RUK) released six technical papers on AM, which reflected the outcomes of research commissioned over the previous three years, together with a template planning condition. Whilst this research undoubtedly improved understanding of Other Amplitude Modulation (OAM) and its effects, it should be noted that at the time of writing it has not been endorsed by any relevant body such as the Institute of Acoustics (IOA).

On 22 January 2014, the IOA released a statement regarding the RUK research and the proposed planning condition to deal with the issue of amplitude modulation from a wind turbine and stated:

“This research is a significant step forward in understanding what causes amplitude modulation from a wind turbine, and how people react to it. The proposed planning condition, though, needs a period of testing and validation before it can be considered to be good practice. The IOA understands that Renewable UK will shortly be making the analysis tool publicly available on their website so that all interested parties can test the proposed condition, and the IOA will review the results later in the year. Until that time, the IOA cautions the use of the proposed planning condition. [24]”

Research regarding amplitude modulation continued. In April 2015, the IOA issued a discussion document entitled ‘Methods for Rating Amplitude Modulation in Wind Turbine Noise’ [25]. The document presented three methods that can be used to quantify the level of AM at a given measurement location. After extensive consultation a preferred method of measuring OAM, which provides a framework for practitioners to measure and rate AM, was recommended by the IOA.

On 3 August 2015, the UK’s Department for Energy and Climate Change (DECC), commissioned independent consultants WSP Parsons Brinkerhoff to carry out a literature review on OAM (which they refer to simply as AM). The stated aims were as follows:

- “To review the available evidence on Amplitude Modulation (AM) in relation to wind turbines, including but not limited to the research commissioned and published by Renewable UK in December 2013;

- To work closely with the Institute of Acoustics' AM working group, who are expected to recommend a preferred metric and methodology for quantifying and assessing the level of AM in a sample of wind turbine noise data;
- To review the robustness of relevant dose response relationships, including the one developed by the University of Salford as part of the Renewable UK study, on which the correction (or penalty) for amplitude modulation proposed as part of its template planning condition is based;
- To consider how, in a policy context, the level(s) of AM in a sample of noise data should be interpreted, in particular determining at what point it causes a significant adverse impact;
- To recommend how excessive AM might be controlled through the use of an appropriate planning condition; and
- To consider the engineering/cost trade-offs of possible mitigation measures."

Their report, which was released in October 2016 [26], concluded that there is sufficient robust evidence that excessive AM leads to increased annoyance from wind turbine noise and recommended that excessive AM is controlled through a suitably worded planning condition, which will control it during periods of complaint. Those periods should be identified by measurement using the metric proposed by the work undertaken by the IOA, and enforcement action would rely upon professional judgement by Local Authority Environmental Health Officers based on the duration and frequency of occurrence.

It is not clear within the body of the report, which evidence the authors relied upon to arrive at their conclusions, although the Executive Summary states (page 4);

"It is noted that none of the Category 1 or 2 papers have been designed to answer the main aim of the current review in its entirety. The Category 1 studies have limited representativeness due to sample constraints and the artificiality of laboratory environments, whereas the Category 2 studies generally do not directly address the issue of AM WTN exposure-response. A meta - analysis of the identified studies was not possible due to the incompatibility of the various methodologies employed. Notwithstanding the limitations in the evidence, it was agreed with DECC that the factors to be included in a planning condition should be recommended based on the available evidence, and supplemented with professional experience".

The report states that any planning condition must accord with existing planning guidance and should be subject to legal advice on a case by case basis. Existing guidance would include compliance with the six tests of a planning condition, which are embodied in various UK documents depending on the country e.g. Circular 4/98 in Scotland.

In Ireland the same six tests are detailed within Section 28 Development Management Guidelines for Planning Authorities, 2007 [27], and the Office of the Planning Regulator (OPR) Practice Note PN03, 2022 [28]. The six tests are; Necessary; Relevant to planning; Relevant to the development to be permitted; Enforceable; Precise; and Reasonable.

The report's authors did not dictate a particular condition to be used but did suggest that any condition should include the following elements (p5):

- "The AM condition should cover periods of complaints (due to unacceptable AM);
- The IoA-recommended metric should be used to quantify AM (being the most robust available objective metric);
- Analysis should be made using individual 10-minute periods, applying the appropriate decibel 'penalty' to each period, with subsequent analysis;
- The AM decibel penalty should be additional to any decibel penalty for tonality; [tonality means mechanical sound already covered by ETSU noise limits]; and
- An additional decibel penalty is proposed during the night time period to account for the current difference between the night and day limits on many sites to ensure the control method works during the most sensitive period of the day."

At the time of writing there has been no official response to those recommendations from the IOA Noise Working Group and, as yet, no endorsement from any Government.

At present there is no method available to predict AM and, as a result it is not possible to predict what impact the inclusion of an AM condition would have on the operation of the wind farm.

The recommendation to impose a planning condition and the associated penalty scheme is at odds with the advice from the IOA GPG, which currently states (paragraph 7.2.10):

“The evidence in relation to “Excess” or “Other” Amplitude Modulation (AM) is still developing. At the time of writing, current practice is not to assign a planning condition to deal with AM.”

It is noted that OAM, should it occur on a site, can be controlled through statutory nuisance powers and in the absence of robust research this is considered to be the most appropriate way to control OAM where required. In this respect it is worth noting a recent Appeal decision in Scotland. For Clachaig Glen Wind Farm (WIN-130-7), in the report produced for Scottish Ministers, the Reporter, J Alasdair Edwards, stated; “... I also follow the applicants witness evidence that residents would continue to be protected against excessive amplitude modulation as it would be covered under statutory nuisance powers” [29].

The Decision Notice for that development (DOC17) stated;

“In relation to concerns about amplitude modulation, which were also discussed at the public inquiry, it is noted by the Scottish Ministers that the Reporter concluded that if there is excessive amplitude modulation it would be covered under statutory nuisance powers concluding that there was no necessity for a condition to be applied” [30].

3.5 Potential impacts on animals (livestock)

Several submissions have expressed concern in respect of operational noise effects on cattle, including health effects and reduced milk production.

A number of studies have been published considering noise levels in general and their effects on cattle, one of which, Importance of Noise Hygiene in Dairy Cattle Farming—A Review [16], is referred to several of the submissions.

Effects of Noise on Wildlife and Other Animals (1971) [31], written for the US Environmental Protection Agency includes a section looking at the Effects of Noise on Farm Animals, including pigs, cattle and poultry, but found that noise effects had little impact on milk production.

A number of studies have been carried out on the effects of noise on cattle from low-flying aircraft, including jets, helicopters and sonic booms and in response to concerns about noise effects on both milk production and pregnancies in cattle, the U.S. Air Force prepared a handbook for environmental protection summarising these studies. No link was identified between either reduced milk production or disturbance to pregnancies and in a report to congress in 1992 the U.S. Forest Service stated; “there is no proven cause and- effect link between startling cattle from aircraft overflights and abortion rates or lower milk production.” [32]

Whilst noise from low-altitude flights is not directly comparable to continual noise produced by wind turbines, it should be noted that impact or impulsive noise i.e. noise levels that increase and decrease rapidly such as may occur from a low-altitude flypast, is much more likely to cause disturbance to animals than the continual and consistent noise generated by wind turbines. In this regard Head et al states, “Many studies indicate that sudden, novel sounds seem to affect cattle behaviour more than continuous high noise” (1993) [33].

With regards to the ability of cattle to discern LFN it is worth noting the paper ‘Effect Of Noise On Performance, Stress, and Behaviour of Animals’ (J Brouček) [34], which states; “Cattle hear high-frequency sounds much better than humans, their high-frequency hearing limit being 37 kHz, compared with only 18 kHz for humans (Heffner, 1998). Their best audible sound is also at a higher frequency, at about 8 kHz, compared with 4 kHz for humans (Phillips, 2009). However, thresholds for discomfort for cattle was noted at 90-100 dB, with physical damage to the ear occurring at 110 dB. (Phillips, 2009). Indeed, cattle, with an auditory range between 25 Hz and 35 kHz, can detect lower pitched sounds than other farm species (Heffner and Heffner 1993). Dairy breeds are more sensitive to noise than beef breeds (Lanier et al., 2000)”. Therefore, cattle have a similar low frequency threshold to humans (25Hz compared to 20 Hz), but their higher frequency response extends beyond the human range and they are more sensitive to noise at higher frequencies than humans. Accordingly, it is reasonable to assume that cattle will be no more affected by LFN than a human would.

[Response from MLavelle: These historic papers, for the most part over c30-years old have no relevance to current sized windfarms.](#)

The 2023 paper Importance of Noise Hygiene in Dairy Cattle Farming—A Review, is referred to in several of the submissions, however, the findings of this paper are misrepresented and / or misunderstood. Whilst the paper does discuss the potential for adverse noise impacts on cattle, the sound levels quoted, which are predominantly based on measurements inside farm buildings, are many times higher than the noise levels that cattle would be exposed to from the operation of a wind turbine. The paper is primarily concerned with noise from farmyard plant, such as milking machines, mechanical ventilation etc, and routinely refers to measured noise levels in farms in the range of 60 – 80 dB. In fact, the only recommendation in the paper in respect of what would be an appropriate noise level is; “When milking dairy cows, the noise level should not exceed 65–70 dB, or if it exceeds this value, it should be for a short time”. Operational noise levels from the Proposed Project would be much lower than this. The findings in the paper that have been reported in the submissions have been taken out of context and have little relevance to the Proposed Project.

[Response from MLavelle: The noise levels below for 12m/s wind indicates noise at 63dBa. These turbines cut out at 25m/s, which indicates far higher noise levels.](#)

3.6 BESS noise

Operational noise from the BESS has been assessed in accordance with BS 4142 and against the noise level limits presented in NG4. The noise limits used from NG 4 are those that are set for areas that are classified within NG4 as an ‘Area of Low Background Noise’.

BS 4142 is a two stage assessment process. The full BS 4142 assessment i.e. after completion of both stages of assessment, concludes that there would be a low impact at all residential receptors during both the daytime and night-time. It is noted that some submissions only refer to the first stage of the assessment process and ignore the actual assessment outcome. This is discussed further in Section 3.9.2.

The assessment, which is presented in detail in Technical Appendix 12-3 also indicates that operational noise from the BESS would be below the NG4 noise limits at all residential receptors for all time periods.

3.7 Construction noise

Several submissions present concerns in respect of construction levels that are likely to be experienced. The construction noise assessment, which is inherently conservative, has indicated that noise levels from construction activities will remain below the thresholds for potentially significant effects, as defined in BS 5228-1:2009+A1:2014.

3.8 Vibration

Many submissions refer to vibration using language that suggests vibration impacts from the Proposed Project are inevitable. For example, “... and constant turbine noise and vibration could cause pain, anxiety, and loss of concentration, reducing quality of life.”

To clarify, there will be no perceptible ground borne vibration at any residential receptor in the proximity of the Proposed Project from the operation of the wind turbines. Responses to third-party observations regarding human health are addressed in Section 2.5.4 of the main response document.

3.9 Project Specific Observations

The following sections address specific technical points that were raised in the submissions.

3.9.1 Background Noise Level and Limits

One submission provides screenshots from the EIAR document and presents comments. In respect of Chapter 12, the Noise and Vibration Chapter, Tables 12.10 and 12.11 are included and commentary provided that incorrectly states what the allowable operational turbine noise should be. The suggestion is that wind speeds of 7 and 8 m/s should be used to set the noise limits and that the lowest noise level measured at these wind speeds should be applied.

Table 12.10 is provided below for reference. Table 12.11 is identical except that noise levels are presented for night-time background noise levels, rather than quiet daytime. For clarity, Tables 12.10 and 12.11 should be read as follows;

- The first column presents the Noise Monitoring Locations. Seven locations were used for the baseline survey for the Proposed Project.
- The remaining 12 columns present the background noise level at each monitoring location across the range of wind speeds, 1m/s through to 12 m/s.
- The measured levels are used to set noise limits for each wind speed bin. There is a separate limit calculated for each integer wind speed.
- It is not correct to select the lowest measured noise level to set the limits. Rather a set of limits are calculated for every monitoring location and then those limits allocated appropriately to nearby residential receptors e.g. NML01 may be used to set the limits at one cluster of houses, NML02 at the next cluster of houses, and so. In this way, the most appropriate levels of protection are afforded to all residential receptors.

Table 12-10 Summary of Prevailing Background Noise Levels during Quiet Daytime Periods (dB(A))

Noise Monitoring Location	Wind Speed (m/s) as standardised to 10m height											
	1	2	3	4	5	6	7	8	9	10	11	12
NML1	30.1*	30.1*	30.1*	30.1	30.5	31.4	32.9	34.9	37.5	40.6	44.3	48.5
NML2	24.9*	24.9*	24.9	25.4	26.5	28.3	30.6	33.4	36.6	40.2	44.2	48.4
NML3	22.3*	22.3*	22.3	22.6	23.7	25.6	28.1	31.3	35	39.3	44.1	49.3
NML4	34.4*	34.4*	34.4	34.5	34.9	35.5	36.5	37.9	39.8	42.3	45.5	49.4
NML5	26.3*	26.3*	26.3	26.7	27.5	28.7	30.3	32.6	35.5	39.3	43.9	49.6
NML6	28.6*	28.6	29.0	29.5	30.2	31.1	32.4	34.1	36.3	39.2	42.7	47.1
NML7	30.8*	30.8	30.9	31.6	32.8	34.6	37	39.9	43.4	47.4	52	57.2

** Flattened where derived minimum occurs at lower wind speeds, see Section 5.8 of Appendix 12.2: Operational Noise Report.*

3.9.2 BESS Noise Impact Assessment outcomes

The Barnaderg Cooloo Windfarm Action Collective CLG submission states;

“The developer’s own Appendix 12-3 Battery Storage Noise Assessment (Sept 2025) identifies fifteen CATL EnerC+ battery containers – a commercial lithium-ion (LiFePO₄) system manufactured by CATL – with predicted operational noise levels of up to 31 dB LAeq at homes near the compound, representing an increase of +11 to +14 dB above background levels and classed within the report as a ‘significant adverse impact’ on residential amenity”.

This is a misunderstanding of the assessment, which does not conclude that there would be a ‘significant adverse impact’. As previously stated in Section 2.1.2, a BS 4142 assessment is a two-stage process. Initially, an estimate of the impact is made by subtracting the measured Background Sound Level from the Rating Level, and in this regard the standard states:

“Obtain an initial estimate of the impact of the specific sound by subtracting the measured background sound level from the rating level, and consider the following:

- Typically, the greater this difference, the greater the magnitude of the impact.
- A difference of around +10 dB or more is likely to be an indication of a significant adverse impact, depending on the context.
- A difference of around +5 dB is likely to be an indication of an adverse impact, depending on the context.
- The lower the rating level is relative to the measured background sound level, the less likely it is that the specific sound source will have an adverse impact or a significant adverse impact. Where the rating level does not exceed the background sound level, this is an indication of the specific sound source having a low impact, depending on the context.”

The submission quotes from the Stage 1 assessment only, however, the second part of the assessment, which the submission ignores, is to then consider the context in which the sound occurs, and this may modify the findings of the initial estimate. There are many elements of context that can be considered, and the following list, which is not exhaustive, gives some examples that could be relevant to the assessment:

- the absolute level of sound;
- the character and level of the residual sound compared to the character and level of the specific sound;
- whether specific sound insulation and noise control measures have already been incorporated into a receptor (which would lower the sensitivity of the receptor);
- former uses, at or close to the site;
- the legitimacy of the industrial use, e.g. planning permissions or environmental permits;
- implementation of best practicable means for a given process or activity; and,
- whether the Rating Level represents typical levels, realistic worst-case levels, unlikely worst-case levels etc.

In this case the assessment, which is provided in full in Technical Appendix 12-3, considered the following elements of context;

- the absolute level of sound;
- the character and level of the residual sound compared to the character and level of the specific sound;
- the sensitivity of the receptors;
- operational scenarios; and
- the NG4 noise level limits

Following the BS 4142 assessment through to the end, the assessment concluded as follows;

“the full BS 4142 assessment concludes that there would be a low impact at all residential receptors during both the daytime and night-time.”

Response from MLavelle: A 10dBa noise increase is a doubling of the noise. Wake turbulence from Windpro output, which is intentionally omitted as part of the lacunae determines that such increases will exist. Squeezing in turbines with separation distances far lower than the 2006 Guidelines & 2019 Draft Guidelines will increase noise & rainfall plus operations will increase noise levels. Using wind tunnel noise estimates for singular turbines is totally unacceptable. Low background noise measurement at NML3 of 19.1dBa for nighttime is at the threshold of noise monitor equipment assessment. To suggest that an increase to 63.5dBa and of over 40dBa plus is a low impact is gross incompetence & an attempt to fool the ACP Inspector. A factor of 16 times the background noise will have a detrimental impact on citizens. [10dBa = factor 2: 20dBa = factor 4: 30dBa = factor 8: 40dBa = factor 16]. It is somewhat amazing that no academic studies of existing Irish windfarms have been presented in relation to noise.

Table 12-11 Summary of Prevailing Background Noise Levels during Night-time Periods (dB(A))

Noise Monitoring Location	Wind Speed (ms ⁻¹) as standardised to 10m height											
	1	2	3	4	5	6	7	8	9	10	11	12
NML1	28.0*	28.0*	28.0*	28.0	28.3	29.3	30.8	32.9	35.6	38.9	42.8	47.3
NML2	18.5*	18.5*	18.5	18.7	20.2	22.7	26.1	30.1	34.7	39.5	44.4	49.3
NML3	16.7*	16.7*	16.7	16.9	18.3	20.6	23.8	27.9	32.6	38.0	43.8	50.2
NML4	33.3*	33.3	33.1	33.1	33.3	33.9	34.9	36.4	38.4	41.0	44.4	48.4
NML5	19.1*	19.1*	19.1	19.2	20.3	22.1	24.8	28.1	32.1	36.7	41.7	47.2
NML6	20.3*	20.3*	20.3*	20.3	21.2	22.9	25.3	28.3	31.8	35.7	39.9	44.2
NML7	22.1*	22.1	22.6	23.9	25.8	28.4	31.7	35.7	40.3	45.7	51.8	58.5

Table 12-14 Total 2006 Guidelines Noise Limit – Night-time

Noise Assessment Location	Wind Speed (ms ⁻¹) as standardised to 10m height											
	1	2	3	4	5	6	7	8	9	10	11	12
NAL1	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	48.8	55.2
NAL2	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	44.5	49.4	54.3
NAL3	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	44.5	49.4	54.3
NAL4	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.9	47.8	52.3
NAL5	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.3	50.7	56.8	63.5
NAL6	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.3	50.7	56.8	63.5
NAL7	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	44.9	49.2
NAL8	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	44.9	49.2
NAL9	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	46.7	52.2

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Response: Note that the vast majority of these references are historic for periods when wind turbines didn't exist or were far smaller. Note not one peer reviewed windfarm noise study and none for Ireland or West of Ireland. There are scientific reports (included) for Reindeer & Moose that show negative effects.

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 Scherhauser, 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
	(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	● increase coordination and standardization between manufacturers and developers
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 acoustical 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 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”, they 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 Presidential 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 non-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 placebo 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 (L_{max}(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 Chautauqua 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 be 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\\$](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 than 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 markedly 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 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 called "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	*
	Increased average motility when sleeping	$L_{night, outside}$ 42
Well-being	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.

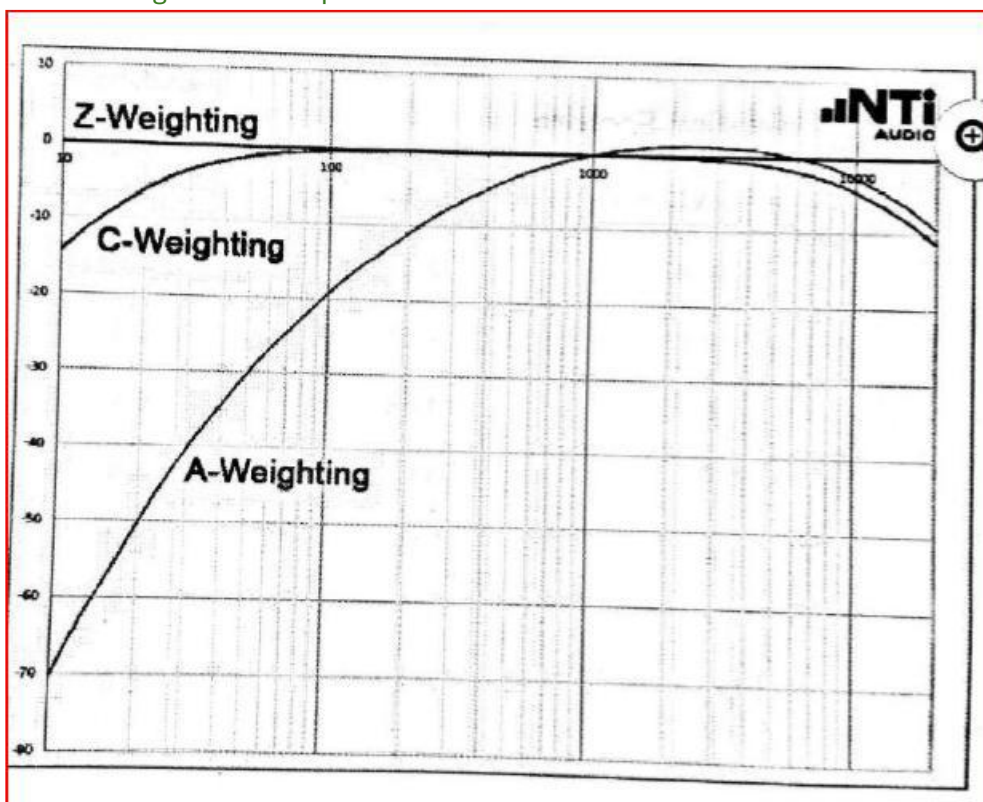
Note: That "loudness" (or sound pressure) is measured in decibels (dB) and is quantified on a logarithmic scale meaning, e.g., that increasing the measured loudness of a sound from 30 dB to 40 dB (at 1000 Hz) is approximately 2 times louder (not 25%). The relationship of dB change to loudness varies 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 than 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 takes 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, sometimes 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 Leventhal'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. Leventhal 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".

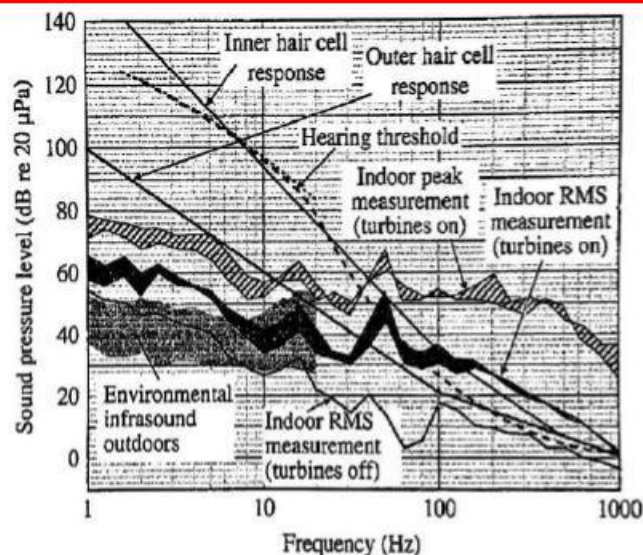


Figure 7.7 Inner and outer hair cell responses, hearing thresholds, environmental infrasound and wind farm infrasound.

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. I. Etter, R. I. 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 Origin 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, Leventhall, 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 Questionnaire
- 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 exemplified 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 L_{max} (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 LA_{eq} of 35 dB. This would equate up to 46 dBA L_{max}. (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 than 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 geared up".

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 considered "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
- **Déjà 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 - "always 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. will 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 be 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://windvictimsonario.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 user 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 window 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 msec (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 on-to-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**

is www.aveablog.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

Director, Policy and Government Relations

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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=Zk11vl-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 "undoubtedly 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.

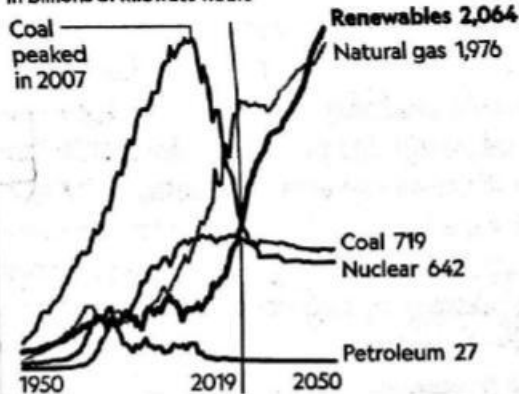
Likely net-zero Carbon state has been reached by 2050.

Taken from **National Geographic**, April 2020

Graphs from Earth Day 50th Anniversary Special Issue

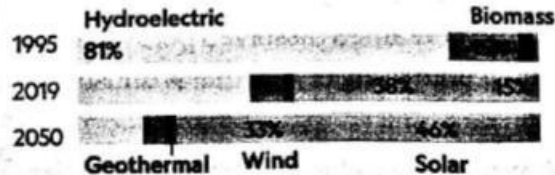
An Optimist's Guide to Life on Earth in 2070

**U.S. ELECTRICITY GENERATION
BY MAJOR ENERGY SOURCE, 1950-2050**
in billions of kilowatt-hours



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.

SHARE OF RENEWABLE ENERGY, BY SOURCE



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)

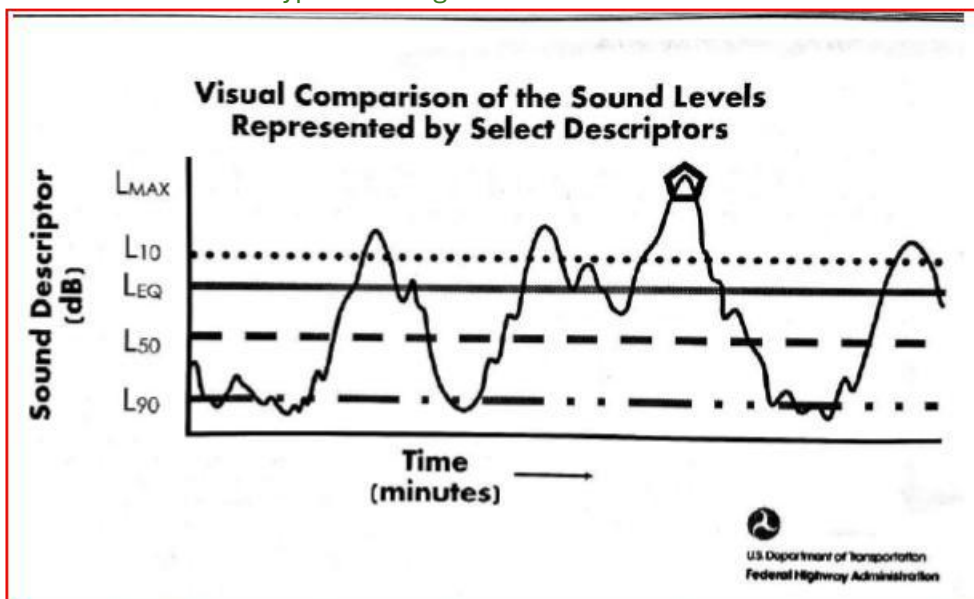
Implication of Leq:

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 in dBs can be 0 to 7 for frequencies of 20-100 Hz. For frequencies below 20 Hz that range becomes 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 (Lnight-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 **Lnight-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

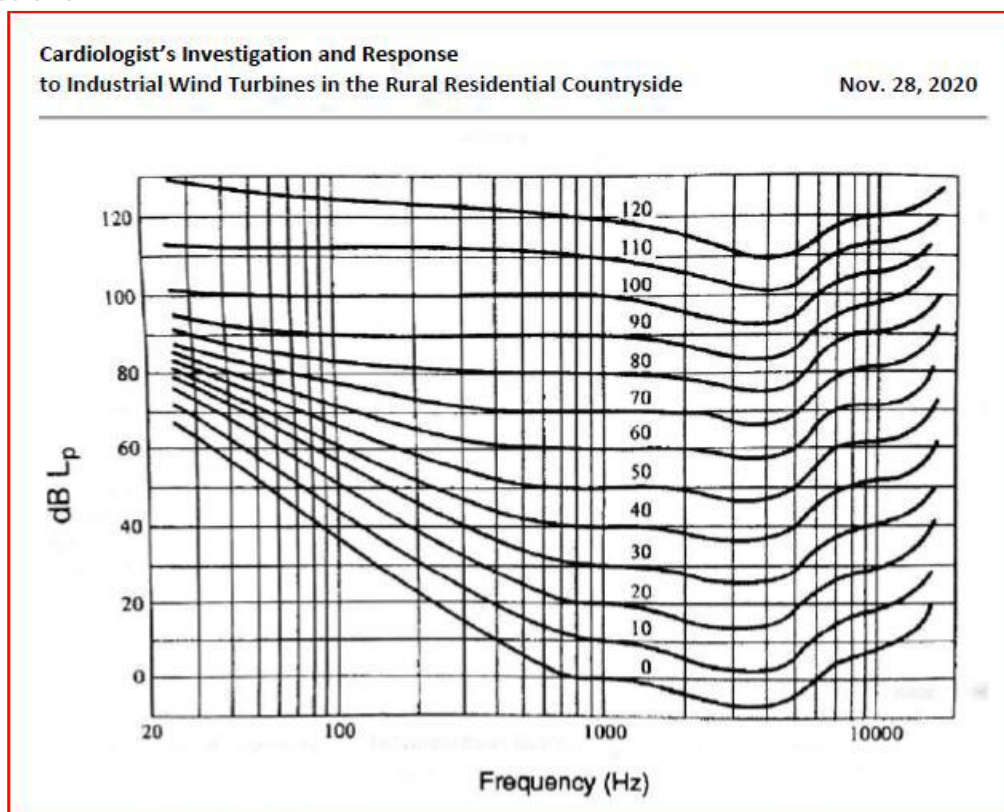
Equating decibel differences (more or less than reference) to a change in loudness varies over the range of the sound spectrum. The "Phon" loudness chart below (40 phon = 40 dB Lp at 1000 Hz) shows how low frequency noise "loudness" at smaller decibel changes.

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 amounts 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 problem is that, by installing huge turbines, the wind industry is 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 LFN 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 dBA 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	45	40	35
Residential			
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 of 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 than 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 dBA_{Lden}. No specific nighttime level was given. With "less annoying sound sources of road traffic, railway noise and aircraft noise, L_{den} 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 sheer 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 from 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) Health 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". Leventhall (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.



Ireland's Draft

Wind Energy Development Guidelines 2019

Review of guidelines by
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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

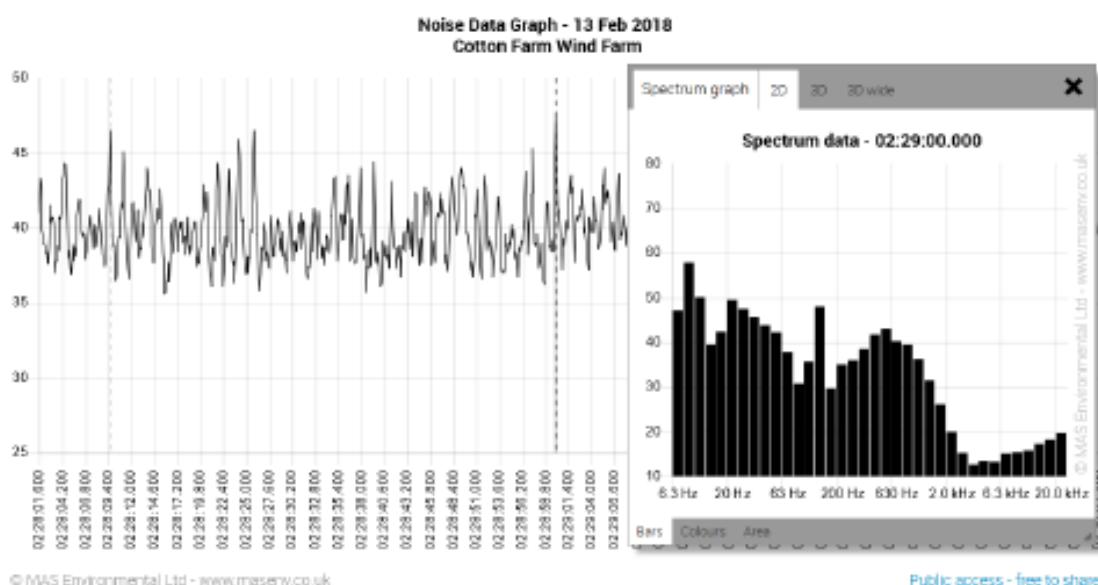
<http://curia.europa.eu/juris/document/document.jsf?jsessionid=CC659AAC994F94CDA0EA7FC24F86309F7?text=&docid=211190&pageIndex=0&doclang=EN&mode=req&dir=&occ=first&part=1&cid=6525478>

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 than 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 shear. 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 situation³. 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. Regrettably 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:

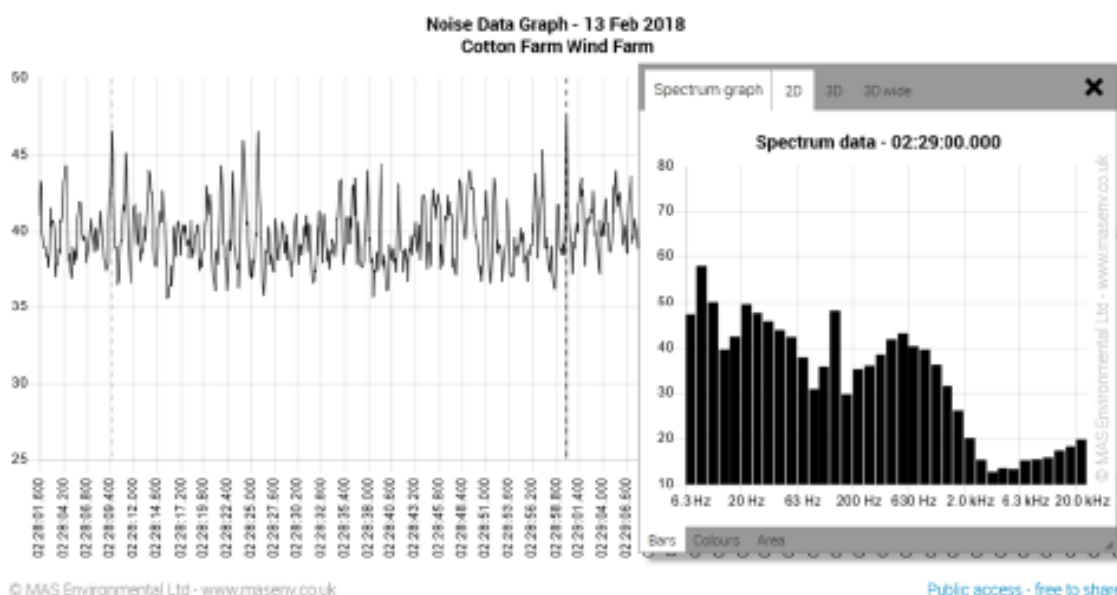
"There is a risk of adverse effects on health wherever the limit values are exceeded. Appropriate measures must be taken there in order to prevent adverse effects. It is only of limited importance to that risk whether an exceedance applies to the entire zone or agglomeration on average. This is clearly 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 criticised⁴.
- 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 periods 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 disappplied 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 noise⁵ 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 shear 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 shear. 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 assessable 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 effects⁷ 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 Güzelde, 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 noise¹⁹

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

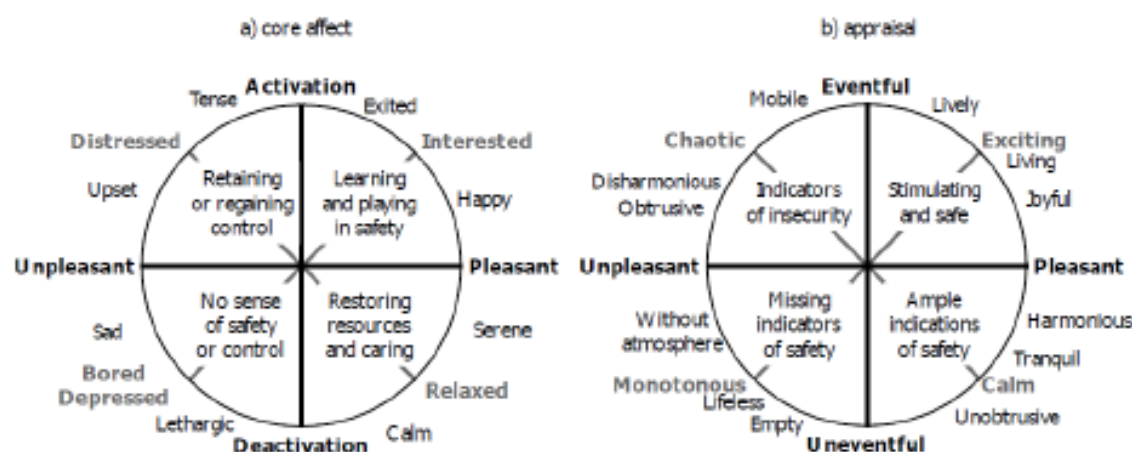


Figure 1: Interaction between appraisal of noise and how this influences emotional experience and arousal

- 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.

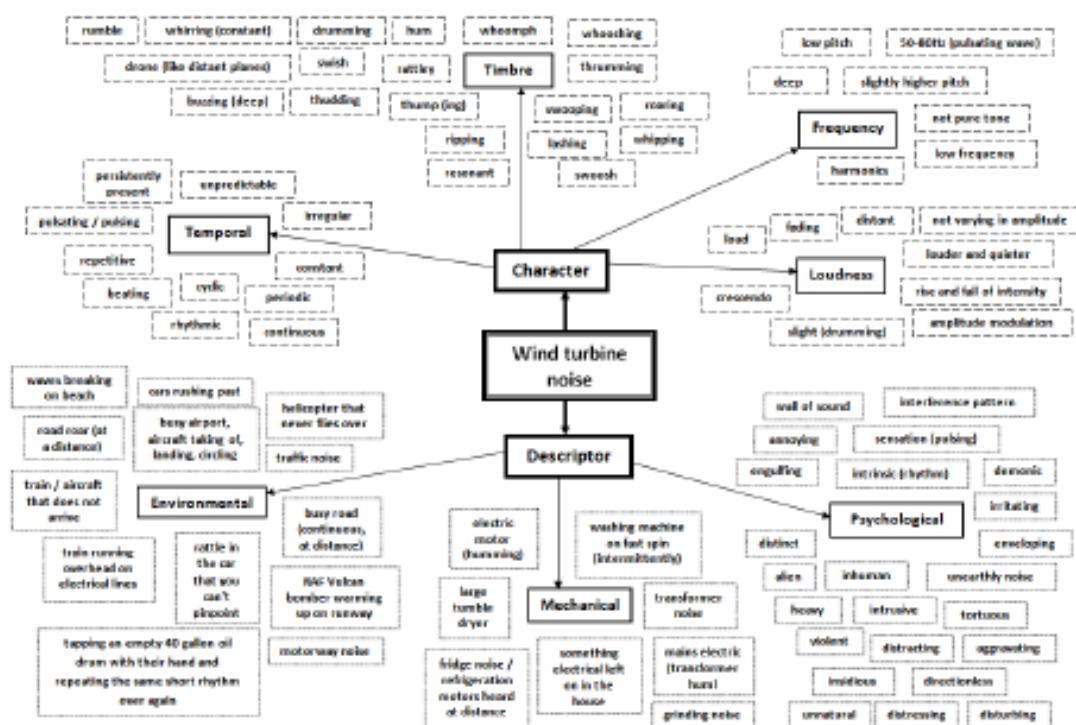


Figure 2: Terms used by affected residents to describe wind farm noise and AM

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.

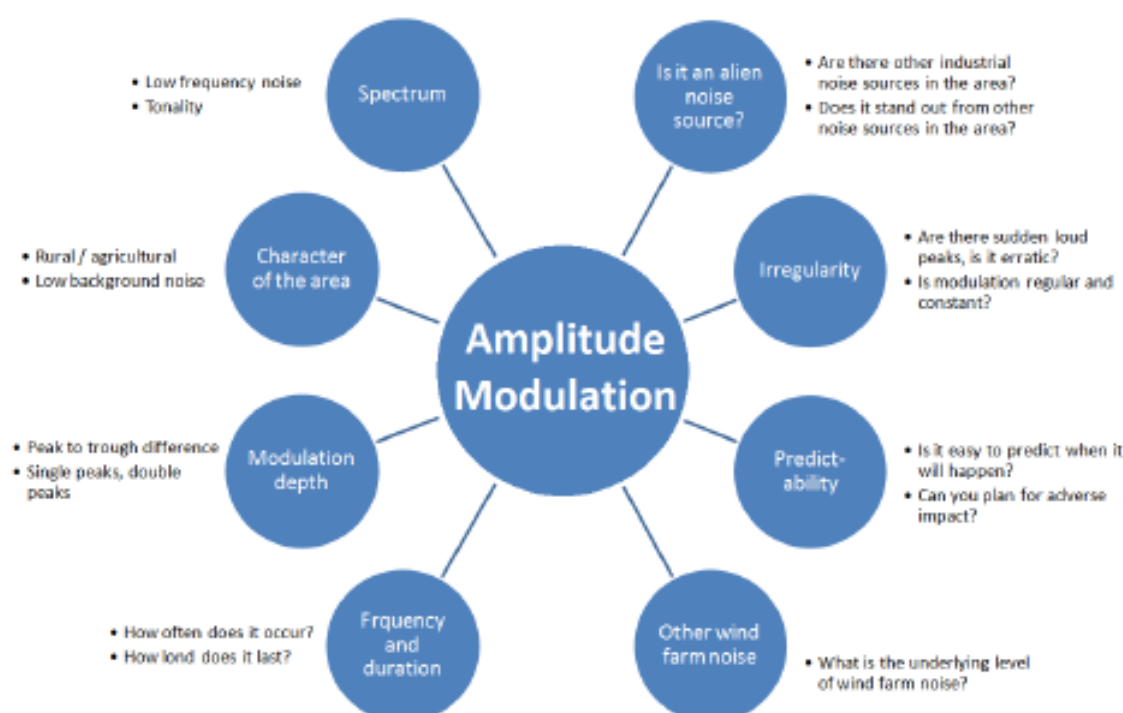


Figure 3: Aspects contributing to AM assessment

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 regularity 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.³⁰ 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.

³⁰ 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.

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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.

When is sound noise?

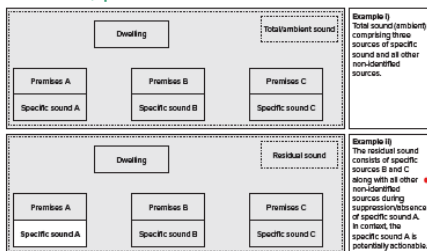
In air, sound is an aural sensation caused by pressure variations. The pressure variations are waves of energy. Sound is the human perception of those pressure waves via the hearing mechanisms located within the ear as interpreted by the brain. The pressure variations are transmitted via the middle ear (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 **PSO**

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

"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



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 (NPS) 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.³

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,

Above: Figure 1

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.⁴ 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.^{4,5}

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 stimuli 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.⁶

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.

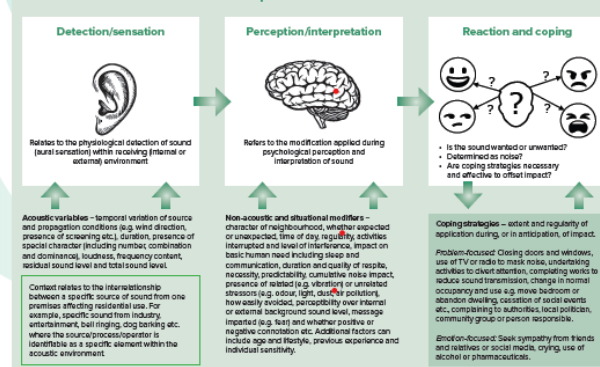
Figure 2 shows the detection/sensation, perception/interpretation and reaction/coping at the individual level.⁶ Sensation relates to the physiological detection of sound and acoustic variables. Perception/interpretation refers to modification due to non-acoustic and situational factors applied during 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.⁶ 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 responses. The specific sound arising from industrial/commercial use is likely considered unwanted 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. [G29](#)

Below: Figure 2

Human response to actionable sound



TECHNICAL CONTRIBUTION

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.¹⁴ 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.¹⁵

Cognition and habituation

Unlike other environmental stressors such as light, noise cannot be 'shut out' physiologically by the body.¹⁶ 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,

Below: Sources of actionable noise most commonly fall into the 'neighbour' and 'neighbourhood noise' category

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.



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.¹⁶

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.^{14,17} 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 of 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.

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 policy¹⁸ impacts 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 (air/road/rail). 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.¹⁹ Health effects including but not limited to annoyance and sleep disturbance are recognised to impact at certain trigger/noise 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 fight 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 characterless 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.²⁰ 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 of 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, duration 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 the 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 noise 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,²¹

Below: Sound can have positive psychological connotations such as a songbird reminding the listener of nature



16. 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 beneficial to the operator. However, it would likely be considered noise when received in a home environment to a resident living close to a crossing and many complaints arise.

17. 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 cacophonous 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 65dB(Aeq) 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,²⁶ 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 characteristic 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. ●

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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 Selectagaze 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 shored 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 Selectagaze 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 extend windows.

The new secondary glazing to this Hatfield landmark will help lower energy

billis 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. Selectagaze 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 Selectagaze 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 Selectagaze on 01727 837771. Email: enquiries@selectagaze.co.uk Visit: www.selectagaze.co.uk

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