An Coimisiún Pleanála

64 Marlborough Street

Rotunda

Dublin 1

D01V902

AN COIMISIÚN PLEANÁLA
LDG- 087976-26
ACP-
19 MAY 2026
Fee: € 50 Type: cash
Time: 15:32 By: Hand

Case reference: PAX19.324161

Lemanaghan Wind Farm

Pleanala Ref. PCX19.342161

Re: Proposed wind farm of 15 turbines, a permanent 220 kV on-site substation and associated infrastructure, etc.

Applicant : Lemanaghan Wind Farm DAC

Dear Sir/Madam

This is a third-party submission/observation on the above SID application, which is accompanied by attachments and the third-party observation fee of €50

The observer : Breda Kenny

New Road

Ballylin

Ferbane

Co. Offaly

R42P296

ecadcollege@outlook.com - 087-1378054

Yours, Breda Kenny

MARTIN LAVELLE, BE. MBA, FIEI, C.ENG.
ROAD SAFETY AUDITOR, DIPLOMA IN BIODIVERSITY & LANDSCAPE MANAGEMENT
Knockaleanore, Partry, Ballinrobe, County Mayo. F12TV08
mlavelle00@gmail.com

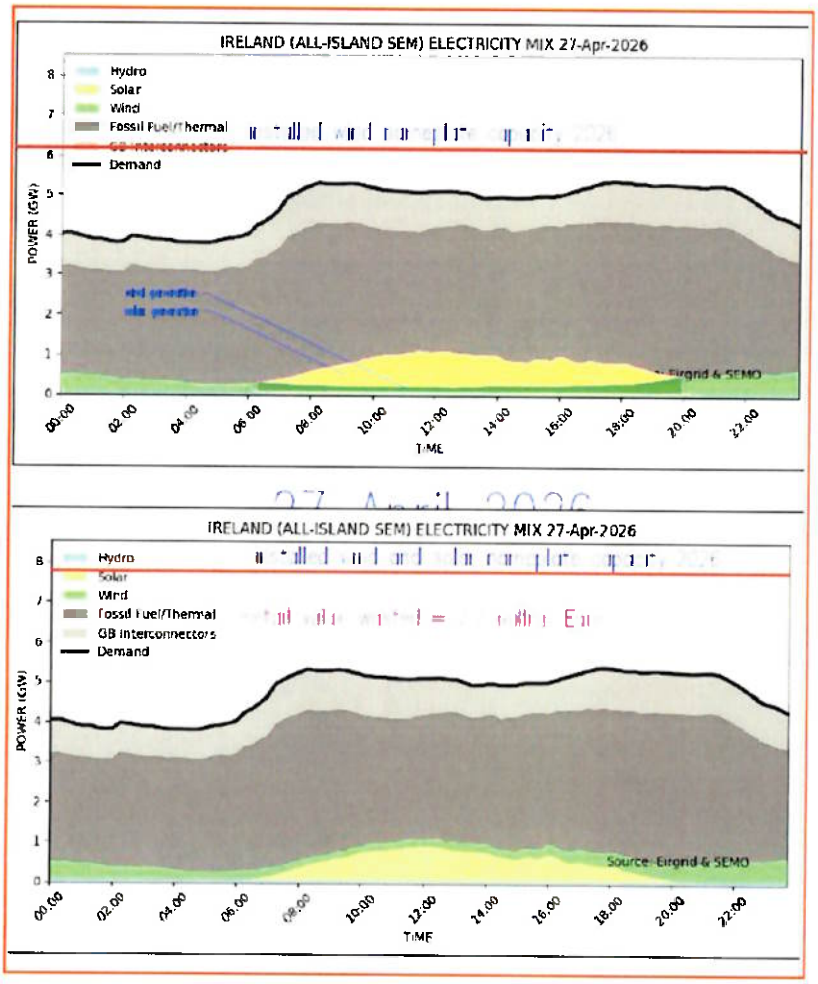
SUBMISSION ON LEMANAGHAN WINDFARM
Planning References: 324161
Submitted: 27th March 2026
Lemanaghan Wind Farm, Offaly Assessment of Non-Technical Summary

Preamble

The Author of this Submission believes in Proper Planning & Sustainable Development. For every Mw of renewable energy, a Mw from fossil fuel or nuclear fuel will be needed as a back-up when the wind doesn't blow or the sun doesn't shine & on top of this duplication, we also have to invest in Grid upgrades costing €billions.
We don't need duplication. We just need one system with capacity. Imposing excessive costs on the Citizen is a long way away from Proper Planning & Sustainable Development. The charging & curtailment charges being paid to developers remind one of the Cash for Ash scam in nIrl. Curtailment payments for energy in August 2025 would have supplied 700,000 houses, September 750,000 houses & October 750,000 houses. The squeezing of wind turbines into a restricted site to avail of such curtailment payments does not comply with the 2006 or 2019 Guidelines.

If we take the 2006 & 2019 WEG separation distance of 7 times rotor diameter of 150m, we will need $\pi 1050^2$ area for each turbine or 3,461,850m^2 per turbine. If we look at a 1Gw area requirement for 6.2Mw turbine at 30% efficiency, then we need 1000/6.2=161, and 538 turbines at 30% efficiency. 3,461,850x538=1,862,475,300m^2 = 186,247ha per Gw. or a square of land measuring 43.156km x 43.156km. If we need 4Gw, we will need 86.312km x 86.312km. This 1Gw area of 1862.4km^2 is larger than many Counties. The 4Gw area requirement is almost the size of Cork, and far in excess of the area of every other county.

County	Area km^2
Cork	7,508
Galway	6,151
Mayo	5,588
Donegal	4,860
Kerry	4,807
Tipperary	4,305
Clare	3,450
Limerick	2,756
Roscommon	2,548
Wexford	2,367
Meath	2,342
Kilkenny	2,073
Wicklow	2,027
Offaly	2,001
Cavan	1,932
Waterford	1,858
Westmeath	1,840
Sligo	1,838
Laois	1,720
Kildare	1,695
Leitrim	1,589
Monaghan	1,295
Longford	1,091
Dublin	922
Carlow	897
Louth	826


IRELAND (ALL-ISLAND SEM) ELECTRICITY MIX 27-Apr-2026
Hydro
Solar
Wind
Fossil Fuel/Thermal
GB Interconnectors
Demand
POWER (GW)
TIME
Source: Eirgrid & SEMO
IRELAND (ALL-ISLAND SEM) ELECTRICITY MIX 27-Apr-2026
Hydro
Solar
Wind
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GB Interconnectors
Demand
POWER (GW)
TIME
Source: Eirgrid & SEMO

[2026] IEHC 65 [H.JR.2025.0001283] JUDGMENT of Humphreys J. delivered on Tuesday the 10th day of February 2026

SHEILA HOCTOR, PATRICK CARNEY, JOHN DOOLEY, MICHAEL MAHON AND REGINA HOCTOR APPLICANTS AND AN COIMISIÚN PLEANÁLA RESPONDENT AND CARRIG RENEWABLE ENERGY LIMITED

"The assessment of public safety is a matter for the statutory decision - takers."

SAFETY, HEALTH AND WELFARE AT WORK ACT 2005 Number 10 of 2005

Liability of directors and officers of undertakings.

80.—*(1) Where an offence under any of the relevant statutory provisions has been committed by an undertaking and the doing of the acts that constituted the offence has been authorised, or consented to by, or is attributable to connivance or neglect on the part of, a person, being a director, manager or other similar officer of the undertaking, or a person who purports to act in any such capacity, that person as well as the undertaking shall be guilty of an offence and shall be liable to be proceeded against and punished as if he or she were guilty of the first-mentioned offence.*

Response from MLavelle: The Carrig Hill HC Decision determines that Public Safety is the responsibility of the decision-taker. The HSE, the competent Authority on health in Ireland determines that there are health issues in relation to windfarms. Thus, any decision is subject to the Precautionary Principle & should be refused. The alternative places the ACP Inspector at risk of prosecution for negligence. Such a prosecution is under the criminal code & ACP insurance doesn't cover such a conviction. A criminal conviction has repercussions for future travel to many countries.

C3S/ECMWF and WMO, 2026: C3S-WMO European State of the Climate 2025, climate.copernicus.eu/ESOTC/2025, doi.org/10.24381/zy93-sb27

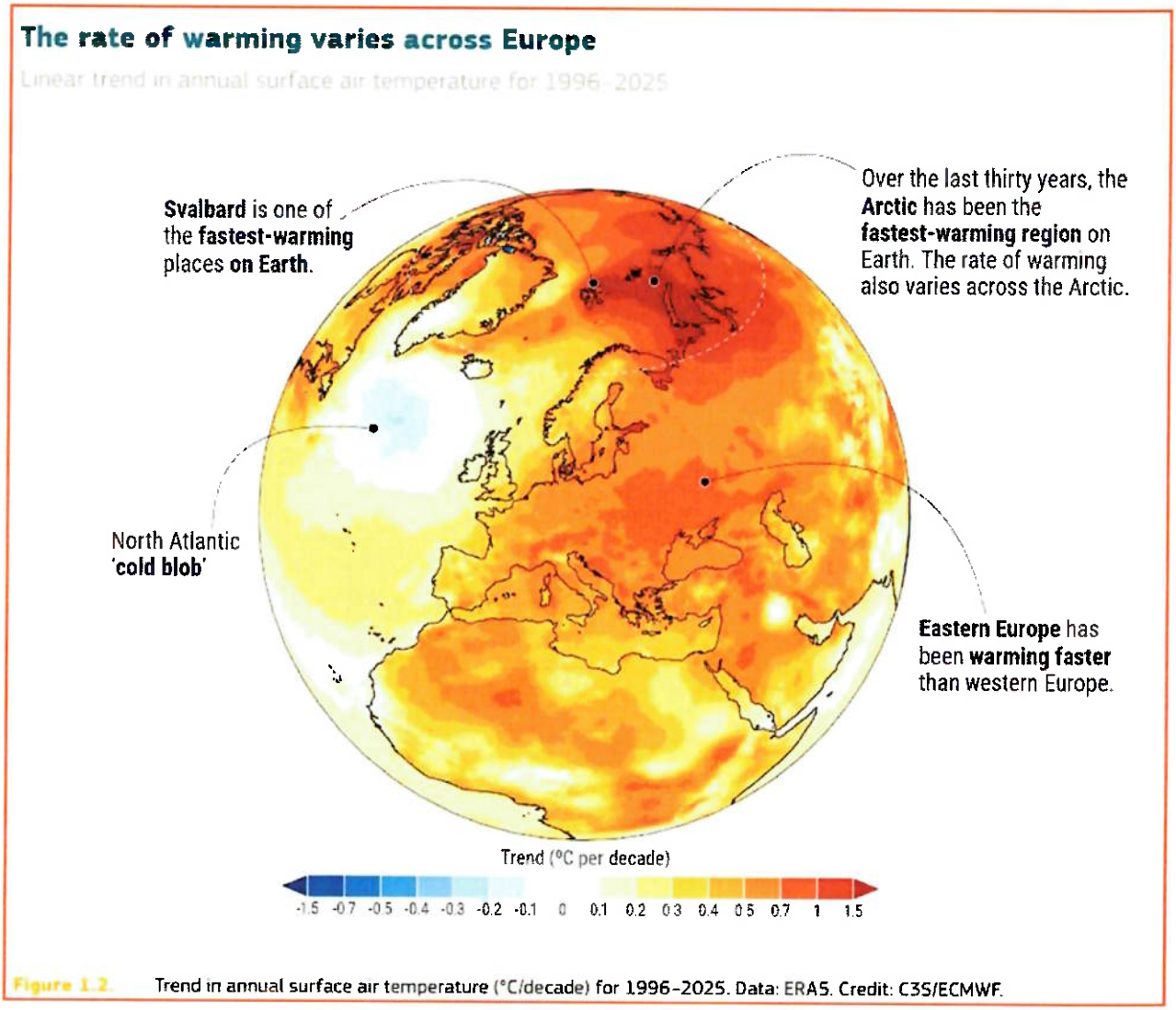
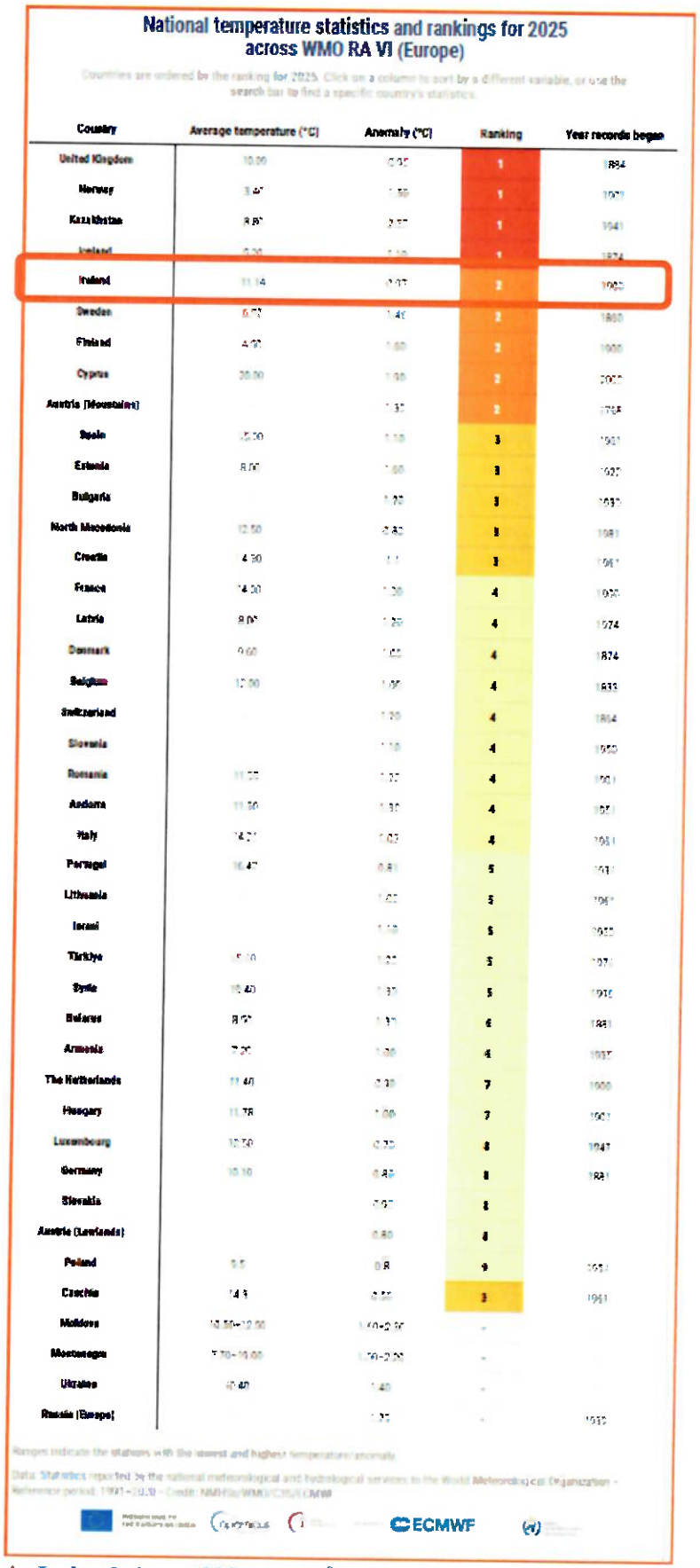


Figure 1.2. Trend in annual surface air temperature (°C/decade) for 1996–2025. Data: ERA5. Credit: C3S/ECMWF.

Note that Ireland has not experienced an increase in surface air temperature 1996 – 2025. Note that Ireland was classified as "Hibernia" [Always Winter & hibernation refer] by the Romans almost 2,000 years ago. We basically have always been cold as a result of being beside the North Atlantic Cold Blob.



National temperature statistics and rankings for 2025 across WMO RA VI (Europe)

Countries are ordered by the ranking for 2025. Click on a column to sort by a different variable, or use the search bar to find a specific country's statistics.

Country	Average temperature (°C)	Anomaly (°C)	Ranking	Year records began
United Kingdom	10.00	0.95	1	1884
Norway	3.47	1.50	1	1901
Kazakhstan	8.87	2.57	1	1941
Iceland	5.20	1.10	1	1874
Ireland	11.14	0.97	2	1900
Sweden	6.77	1.40	2	1860
Finland	4.97	1.60	2	1900
Cyprus	20.00	1.90	2	2001
Austria (Mountains)		1.37	2	1768
Spain	15.30	1.10	3	1901
Estonia	6.07	1.60	3	1927
Bulgaria		1.27	3	1931
North Macedonia	12.50	0.80	3	1981
Croatia	4.50	1.1	3	1961
France	14.00	1.20	4	1900
Latvia	8.07	1.30	4	1924
Denmark	9.60	1.03	4	1874
Belgium	12.00	1.06	4	1833
Switzerland		1.20	4	1864
Slovenia		1.10	4	1950
Romania	11.73	1.27	4	1901
Andorra	11.50	1.30	4	1951
Italy	14.27	1.07	4	1961
Portugal	16.47	0.81	5	1931
Lithuania		1.03	5	1961
Israel		1.10	5	1950
Türkiye	9.10	1.27	5	1971
Syria	16.40	1.37	5	1910
Belarus	8.07	1.37	6	1881
Armenia	7.20	1.20	6	1935
The Netherlands	11.40	0.70	7	1906
Hungary	11.78	1.08	7	1901
Luxembourg	10.50	0.70	8	1947
Germany	10.10	0.83	8	1881
Slovakia		0.97	8	
Austria (Lowlands)		0.80	8	
Poland	8.5	0.8	9	1951
Czechia	7.43	0.77	9	1961
Moldova	10.50–12.00	1.40–2.00	-	
Montenegro	9.70–10.00	1.70–2.00	-	
Ukraine	8.40	1.40	-	
Russia (Europe)		1.37	-	1910

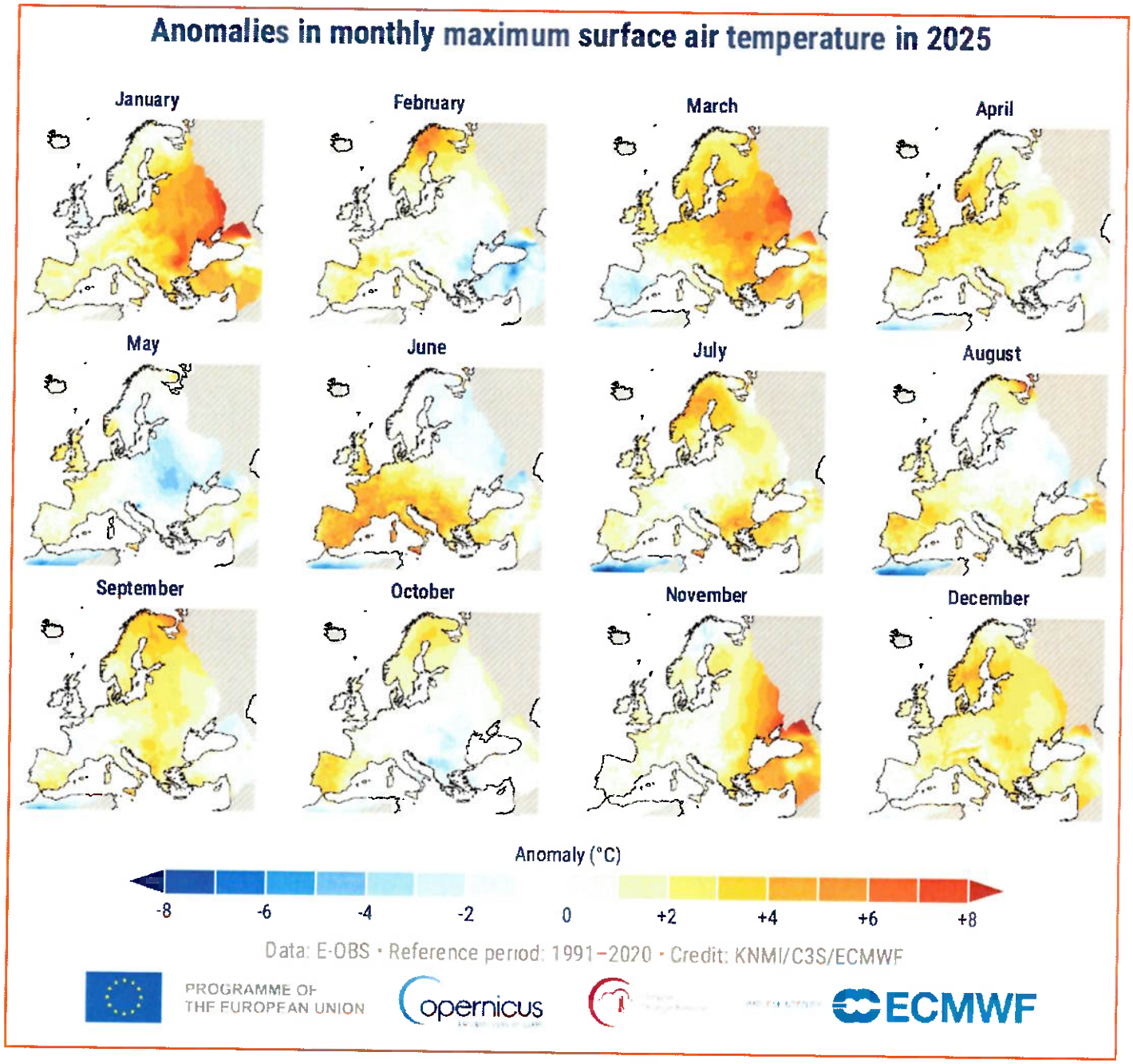
Ranges indicate the stations with the lowest and highest temperature anomaly.

Data: Statistics reported by the national meteorological and hydrological services to the World Meteorological Organization - Reference period: 1991–2020 - Credit: NMHSs/WMO/ECMWF

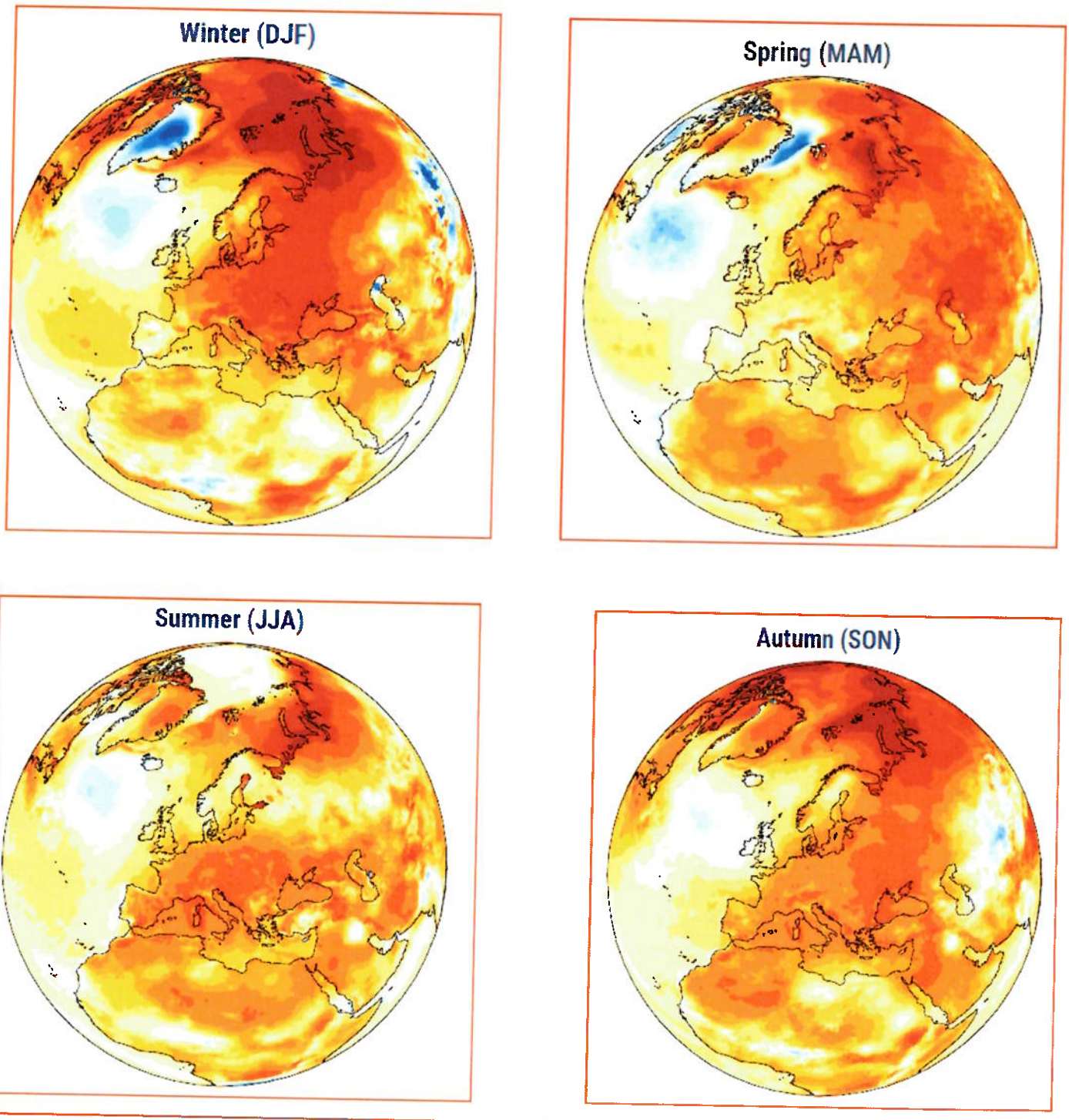
ECMWF

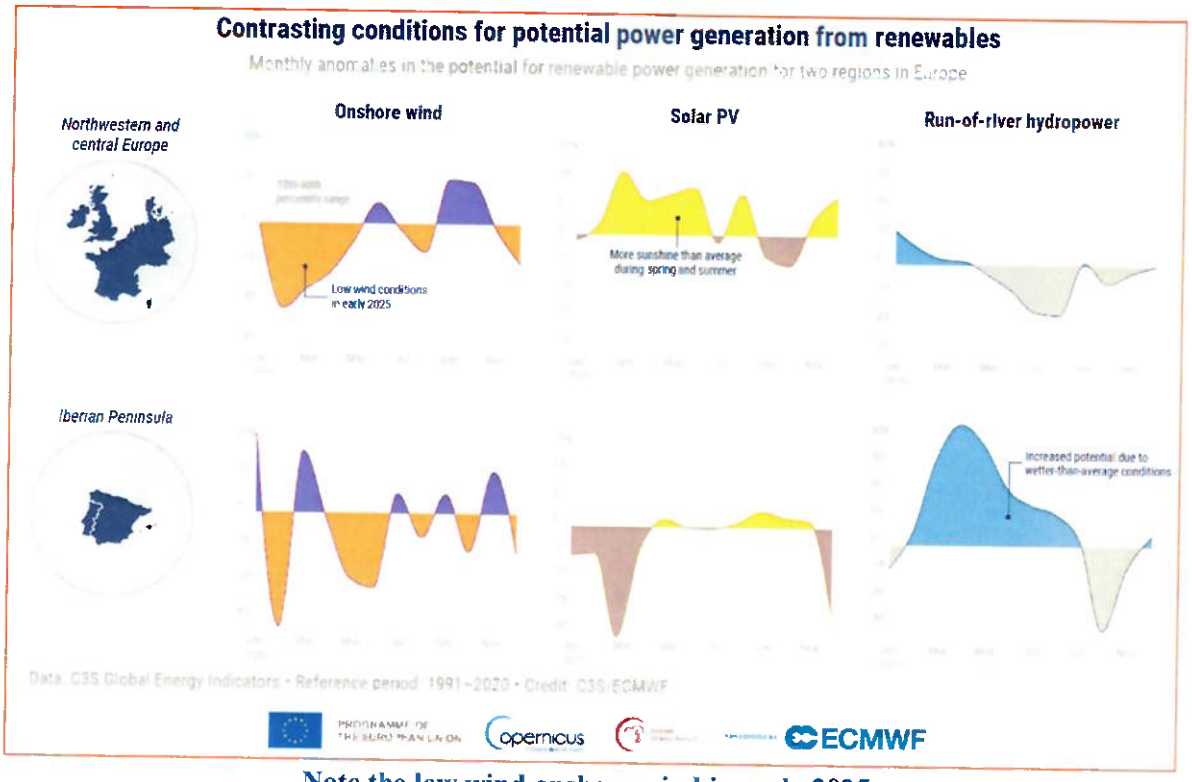
The average temperature in Ireland since 1900 is 11.14^{0}C & we have an anomaly of 0.97^{0}C over that period. We could do with a bit of "Ireland Warming". We don't suffer from Global Warming. Our last ice age finished

about 13,000 years ago. For the period from 27,000 years ago to 13,000 years ago, Ireland was covered by a 1km high ice glacier. The last 13,000 years of "warming" are irrelevant in the context of Global Warming.

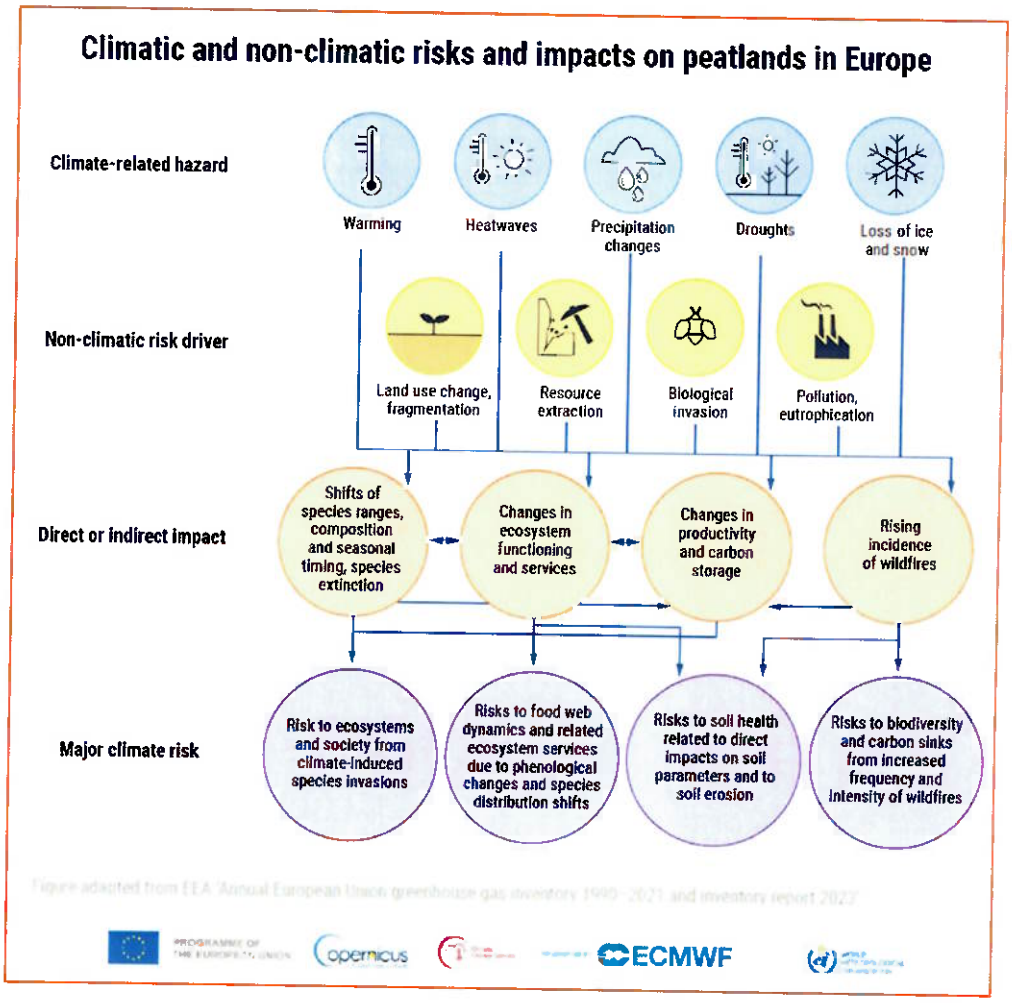


Linear trend in surface air temperature during 1996–2025.





Note the low wind onshore wind in early 2025.



Identified climate risks for key biodiversity systems

Climate risks for ecosystems	Urgency to act	Risk severity			Policies	
		Current	*Mid-century*	*Late century (low/high warming scenario)*	*Horizon*	*Readiness*
Coastal ecosystems	Urgent action needed	Critical •••	Critical •••	Critical/Catastrophic •••	Medium	Medium
Marine ecosystems	Urgent action needed	Critical •••	Critical •••	Critical/Catastrophic ••	Medium	Medium
Biodiversity/carbon sinks due to wildfires (hotspot region: southern Europe)	Urgent action needed	Critical •••	Critical ••	Critical/Catastrophic ••	Medium	Medium
Biodiversity/carbon sinks due to wildfires	More action needed	Substantial •••	Critical ••	Critical/Catastrophic ••	Medium	Medium
Biodiversity/carbon sinks due to droughts and pests	More action needed	Substantial •••	Critical ••	Critical/Catastrophic ••	Long	Medium
Species distribution shifts	More action needed	Substantial •••	Critical ••	Critical/Catastrophic ••	Medium	Medium
Ecosystems/society due to invasive species	More action needed	Substantial •••	Critical ••	Critical/Catastrophic ••	Medium	Medium
Aquatic and wetland ecosystems	More action needed	Substantial •••	Critical ••	Critical ••	Medium	Medium
Soil health	More action needed	Substantial •••	Substantial ••	Substantial/Critical ••	Medium	Medium
Cascading impacts from forest disturbances	Further investigation	Substantial •	Critical •	Critical •	Long	Medium

Low confidence (•) Medium confidence (••) High confidence (•••)

Data: EUCRA • Credit: EEA/C3S/ECMWF

PROGRAMME OF THE EUROPEAN UNION · Copernicus · ECMWF

Summary of issues including Roads: Reasons for invalidation/Refusal in blue font. (not exhaustive):

Issue 1: The Planning Application & the Site Notice are different. The Site Notice excludes structures, etc. as included in the Planning Application.

ISSUE 2: For 8m/s windspeed & for Vestas V150 or Nordex, we get a power output of c3Mw per turbine.(see below) Thus, the total output for 15 turbines is 45Mw and not greater than 50Mw as required for SID. This Application is invalid. ACP is deciding SID cases on applicants suggested brochure capacity & not on output as required by the Legislation. (See below for more data)

Issue 3: The Separation distances between turbines do not comply with 2006 or 2019 Guidelines in order to squeeze extra turbines into the site. Providing 6 figure Northing & Easting Grid references for Wind Turbine locations does not allow the normal Citizen to assess separation distances. Failure to provide turbine setback distances to achieve noise levels below 30dbA in low noise areas +5dBa.

Issue 4 : Various Drawings show the proposed route line & coloured in red. These lands are not in the ownership or control of the applicant & he is not allowed to identify lands not under his control in red or apply for permission.

Any condition in relation to the proposed access over private lands is limited under Section 34(4) to lands which are under the control of & are owned by the Applicant, & the lands are not so owned, and where the imposition of conditions/mitigation measures over the full extent of the route cannot be the subject matter of condition where mitigation measures relate to these lands as the said lands do not fall within the jurisdiction conferred by Section 34(4).
Article 221(2)(g) provides that where the Applicant is not the legal owner of the land or structure concerned the written consent of the owner to make the application is required. The application proposes works across lands where no consent of the owners of these lands has been submitted notwithstanding the requirements of Article 22(2)(g) of the Planning and Development Regulations. The only exception to this obligation is where the Applicant is a Statutory Undertaker which on the face of the documentation submitted does not fall within this exception and where therefore it is necessary where the development is not being carried out by a Statutory Undertaker that the written consent of the landowner be submitted and accordingly, the application does not comply with the requirements of Article 22(2)(g) of the Planning and Development Regulations.

There is no evidence or no basis to disapply the default provision in respect of works being located in lands where the written consent of the said owner of the lands is required, and where there is no evidence of a type that complies with the obligations under Article 22(2)(g)(ii) on the face of the documentation and specifically, there is no statutory undertaker that has been identified nor could be identified which complies with the requirements such as to disapply the obligation to furnish the said written consent which is required as a mandatory obligation under the said regulations.

A citizen cannot be unilaterally deprived of his property rights having regard to Constitutional Provisions in Article 43 & Article 40.3 unless through due course of law.

Issue 5 : The area of the site is indicated as 1.111ha in the application, while it is identified as 1.258ha in Table 11.6 Assessment of potential loss pf carbon Sequestration due to proposed project. The carbon savings are questionable on this basis. The equations used ignore the Carbon losses from Flooding, leaking of dissolved & particulate organic carbon, loss from peat slide & forestry clearance

Calculating potential carbon losses and savings from wind farms on Scottish peatlands: Note – Version 2.10.0. The Applicant quotes this reference in the Planning Application & then ignores the equations for calculations that it provides. Capacity factors for Scotland range between 22.7% and 29.2% . However, this application uses 35% in order to bump up carbon savings. (DECC,2015;https://www.gov.uk/government/statistics/regional-renewable-statistics). Site specific capacity factors may be determined at the site planning stage, and should be used preferentially in these calculations. If these are not available, calculations for Scotland should be repeated with capacity factors 20% and 30% to give estimates of the lowest and highest carbon emission savings. For calculations in other countries, the appropriate published range of capacity factors should be used.

Issue 6 : Maps submitted without Townland boundaries or Townland names & without North point with this application identify various sites coloured red & blue and fail to identify the ownership/control areas. This indicates an intention to trespass on private property without Landowner consent or agreement.

ISSUE 7: The attachments of consent are not linked & identified on any map in red or blue.

ISSUE 8 : PROPOSED SITE LAYOUT : The layout reflects the outcome of the iterative design process. No details of the "iterative design process" & constraints have been provided

ISSUE 9 : LANDOWNERSHIP: No private landowners along the TDR have signed easements to allow the necessary works to enable turbine and oversize loads (e.g. substation components) delivery. This is especially true for areas where hedge cutting, oversail/overhang of 3rd Party lands are identified in the sweptpath pinch points & have not been provided with this application. No details of landowner consents/agreements to hedgerow trimming/clearing to facilitate oversail or passing areas have been provided.

ISSUE 10: Note no mention of abnormal heavy loads in Traffic & Transport Chapter or Appendix, where Nacelle weight could be 350 -750tonnes as evidenced in the size of crane proposed as required by TII Scoping Report. No structural assessment provided for substandard roads, Shannon Bridge, bridges, canal, culverts, watermains or gas mains. If we consider a standard axle carrying 11tonnes, we see that such a crane or truck carrying the nacelle will require around 70axles with bogies for steering purposed. If each wheel is 1m in diameter with a separation of 0.5m, we are looking at a length of 105m. Local Roads are just legacy horse/cattle tracks with a surface seal course. They have no structural strength to carry such weights.

The weight of the nacelle is c400tonnes with crane up to 750tonnes & no assessments or knife edge load assessments are provided for the structural capacities of River Shannon, Stream, Canal or Culvert crossings plus watermain & gas pipeline crushing. The Applicant does not include the weight of the nacelle in his application. Bridge damage might not be immediate. This is similar to the ESB Generators locked in Dublin Port in 2025 as the M50 Westlink bridge couldn't carry the weight.
The abutments to the Shannon Bridge in Athlone are constructed on aeroboard as the underlying material slipped into the Shannon during bridge construction.

ISSUE 11 : Failure to provide turbine separation distances to achieve noise levels below 30dbA in low noise areas as required by the County Development Plan.

ISSUE 12 : The Noise & Wake Windpro model or similar is not provided in addition to the indicated separation assessment from existing Roads. Lacunae must be provided when used to generate data.
Use of the Windpro modelling software & other software requires production of the screenshots of constraints entered. Noise curves for iterations have to be produced. Similarly, for assessments of wind turbines close to public roads. The Noise & Wake model may be a wind tunnel calculation for one turbine & ignores turbulence & noise downwind with short separation distances & rain/ice effects.

ISSUE 13: The Existing negative effects of Infrasound/Seismic & future effects is not addressed.

ISSUE 14: The issue from noise nuisance as determined in the Webster/Rollo v Meenacloghspar Windfarm High Court Case at separation distance of 369m is ignored.
Ignoring the HSE Noise Response in relation to Clonberne Windfarm SID 319307 FI. [Included below]

ISSUE 15 : Omitting seismic effect on existing drinking water wells/boreholes across the catchment.

ISSUE 16 : The seismic effects on frogs, worms & herbivores, such as badgers are not addressed.

ISSUE 17 : No up to date population health data effects is provided. Quoting from reports from 2015 & before fails to recognise that turbines have increased greatly in height in the intervening period.

ISSUE 18 : Population And Human Health as outlined by HSE, the Irish Competent Authority for Human Health

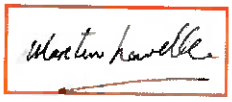
ISSUE 19: Property depreciation of 14% .

ISSUE 20: The health & property value reports submitted are pre-2016 & have no relevance. Turbines were much smaller in that period. References to reports from central America with sparse houses is not relevant. These American windfarms indicate short-term annual usage.
Health effects. Adverse impact on human & animal health including horses. No plans or designs or noise readings related to distances or wake effects provided.

The failure of the Applicant & the Agent to provide up-to-date information is a serious issue.

ISSUE 21: The application should have provided up-to-date studies plus the model used for Biodiversity, Hydrology, Noise & Vibration, Social impacts, Traffic, Birds,Cultural & Historic Heritage & Landscape effects to name a few.
The use of Bird counts from a different site as shown on maps submitted is not acceptable.
The provision of only one 24hour count for a major development with 5 site access points is not acceptable & is not compliant with TII Guidelines/Standards.

ISSUE 22: The lands at the entrance to the site are not in the ownership or control of the Applicant.

Signed: 

Martin Lavelle, BE.
20th May 2026

NON-TECHNICAL SUMMARY [ML CONVERTED INTO WORD AS TEMPLATE FOR COMMENTS]

1 Introduction

This Environmental Impact Assessment Report (EIAR) has been prepared by MKO on behalf of Lemanaghan Wind Farm DAC (the Applicant), which intends to apply to An Coimisiún Pleanála (ACP) for planning permission for the construction of a wind energy development and all associated infrastructure within the Lemanaghan Bog and adjacent townlands, near Ferbane, Co. Offaly.

The proposed project will be known as the Lemanaghan Wind Farm and for the purposes of this EIAR:

- Where the 'Proposed Project' is referred to, this 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 this EIAR.
- Where the 'Proposed Wind Farm' is referred to, this refers to turbines and associated foundations and hard-standing areas, meteorological mast, internal roads, amenity track, temporary construction compounds, underground cabling, peat and spoil management, borrow pits, site drainage, biodiversity mitigation and enhancement, turbine delivery route and associated junction accommodation works, and all ancillary works and apparatus. The Proposed Wind Farm is described in detail in Chapter 4 of this EIAR.
- Where the 'Proposed Grid Connection' is referred to, this refers to the onsite 220kV substation wind farm control building, associated temporary construction compound, 2 no. gantry structures, 2 no. crane pads, 2 no. tower pads, 4 no. steel masts, telecommunications tower, temporary access track, and overhead line (OHL) connecting to the existing Shannonbridge-Maynooth 220kV OHL, and all ancillary works and apparatus. The Proposed Grid Connection is described in detail in Chapter 4 of this EIAR.
- Where the 'Proposed Project site' or 'site' is referred to, this 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 approximately 1,258 hectares.

The application meets the threshold for wind energy set out in the Seventh Schedule of the Planning and Development Acts 2000 to 2024, on foot of a notice issued by ACP on 3rd of March 2026 and is therefore being submitted directly to ACP as a Strategic Infrastructure Development (SID) in accordance with Section 37E of the Planning and Development Act 2000, as amended. Please note, the planning application will encompass all elements of the Proposed Project, including the 220kV grid connection infrastructure and associated works.

This EIAR, along with a Natura Impact Statement ('NIS'), will accompany the planning application for the Proposed Project which will be made to ACP. Both the EIAR and NIS contain the information necessary for ACP to complete the Environmental Impact Assessment and Appropriate Assessment as required for this planning application.

Both the EIAR and NIS take into account the combined impacts identified across the various EIAR disciplines of the Proposed Project. For clarity, in this EIAR all elements of the Proposed Project will be assessed cumulatively and in combination with other projects to aid the competent authority in carrying out an EIA.

Description of the Proposed Project

The Proposed Project will comprise the construction of 15 No. wind turbines and all associated works, including an onsite 220kV substation and all associated works and apparatus. The full description of the Proposed Project is detailed in Chapter 4 of this EIAR.

The development description for the current planning application as it appears in the public notices is as follows:

15 no. wind turbines with the following dimensions: A total tip height of 220m;

Rotor diameter of 150m;

Hub height of 145m.

Permanent turbine foundations, hard-standing and assembly areas;

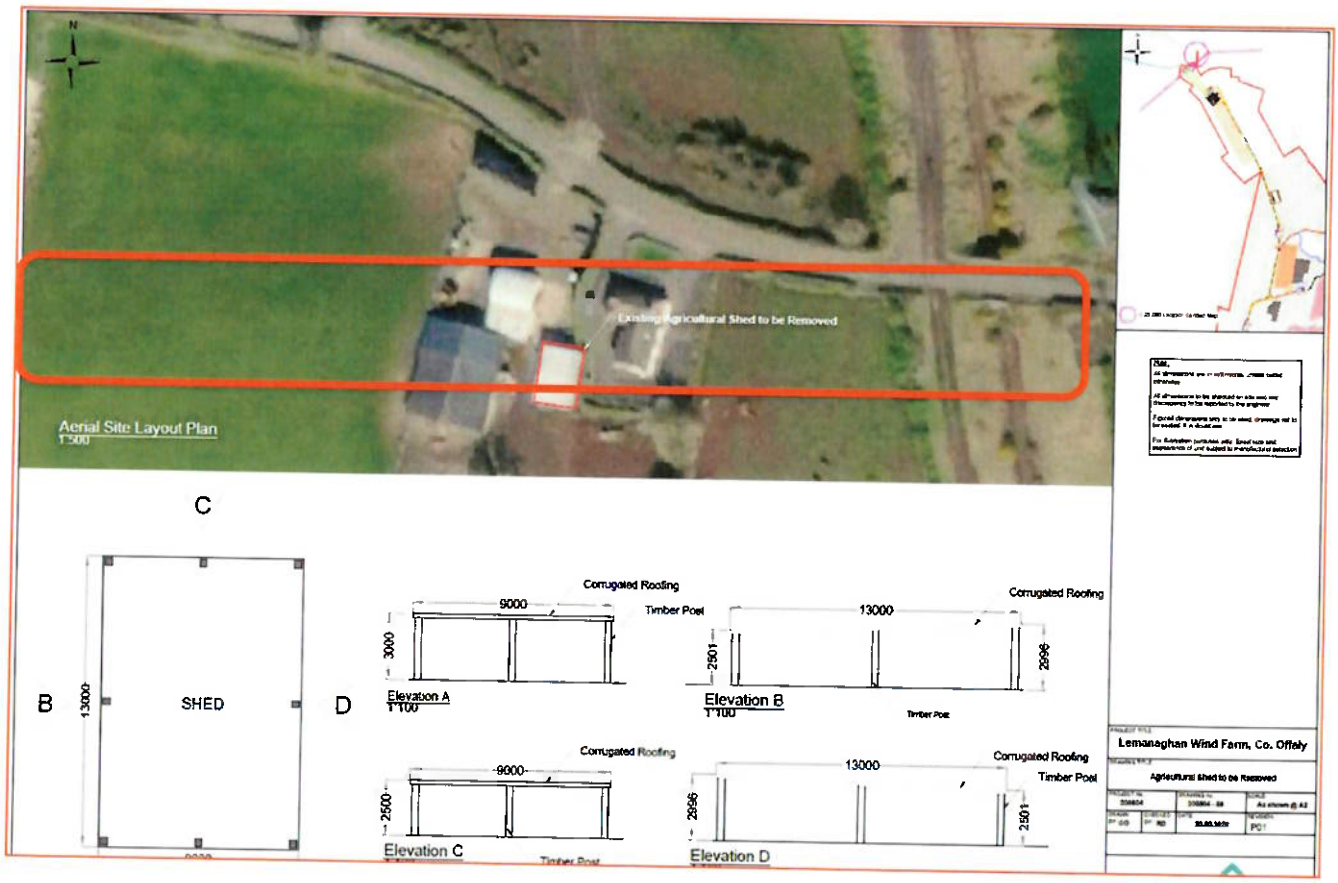
Underground electrical and communications cabling connecting the 15 no. wind turbines to the proposed 220kV onsite electrical substation;

A new permanent 220kV electrical substation compound (c. 9611m²) in the townland of Cooldorragh consisting of 1 no. Gas Insulated Substation (GIS) building, 1 no. Independent Power Producer (IPP) control building, 2 no. gantry structures, all associated electrical and communications plant and equipment, welfare facilities, 2 no. foul water holding tank, 2 no. bored wells, access roads, security fencing and gates, lightning masts, signage, landscaping, drainage infrastructure and all other ancillary works;

A permanent telecommunications tower with a height of 36m and associated foundation and hard-standing area;
The permanent installation of c. 800m of 220kV overhead line, 4 no. new steel masts, temporary tower build areas, temporary tower crane pads and associated hard-standing areas to facilitate the new 'loop-in/loop-out' connection into the existing 220kV Shannonbridge to Maynooth line;
The new permanent overhead line grid connection will require the decommissioning / removal of 1 no. existing steel mast and c. 75m of existing 220 kV line;
A meteorological mast with a height of 145 metres and associated foundation and hard-standing area;
The permanent upgrade of c.1.14km of existing internal site roads/tracks and the provision of c.17.1 km of new permanent internal site access roads, passing bays and a layby area;
The permanent upgrade of c.1.8km of existing tracks and the provision of c.3.9km of new permanent tracks for the purposes of amenity, seating areas, and amenity signage;
The provision of temporary access track off the L7001 local road during the construction phase;
Removal of an existing agricultural shed to accommodate the new temporary access track off the L7001 local road;
2 no. new gated site entrances off the L7002 local road;
Upgrade of 3 no. existing site entrances off the N62 national road, R436 regional road and L7001 local road;
A temporary access track from the N52 national road to the N62 national road at Kennedy's Cross in the townland of Ballindown to facilitate the delivery of turbine components and other abnormal loads;
5 no. temporary construction compounds with temporary offices, containers and staff facilities;
3 no. permanent amenity car parks each including 15 no. spaces for private vehicles, 3 no. spaces for accessible parking, parking for buses and bicycle rack facilities;
4 no. temporary borrow pits;
5 no. temporary security cabins;
2 no. clear span watercourse crossings;
Peat and Spoil Management;
Site Drainage;
Removal of c.1.02ha of immature woodland and c.0.64 hectares of scrub;
Biodiversity management and enhancement measures;
i Operational stage site signage; and
ii All ancillary apparatus and site development works above and below ground, including hard and soft landscaping and drainage infrastructure .
This application is seeking a 10-year permission and 35-year operational life from the date of commissioning of the wind energy development.
Current and future wind turbine generator technology will ensure that the wind turbine model, chosen for the Proposed Project, will have an operational lifespan greater than the 35-year operational life that is being sought as part of the planning application.
Modern wind turbine generators currently have a potential generating capacity in the 4 to 7 MW range, with the generating capacity continuing to evolve upwards as technology improvements are achieved by the turbine manufacturers. For the purposes of this EIAR it is assumed that the wind turbine model installed as part of the Proposed Project will have a generating capacity of 6MW. Therefore, on this basis, the proposed 15 no. wind turbines would have a combined generating capacity of 90MW.

The Application for Planning does not agree with this detail or for Site Notice & as such this application is invalid.

I compared the Planning Application with the Site Notice/Non Executive Summary & they are not similar.



Removal of shed not in site notice

The following are included in the Planning Application form, but not included in the Site Notice. As part of your check system, this application is invalid.

11. Where the application relates to a building or buildings:

Gross floor space of any existing buildings(s) in m2	177 sq.m
Gross floor space of proposed works in m2	Substation compound: 2 no. buildings 1. GIS building: 2.990.23 sq.m 2. IPP building: 202.95 sq.m
Gross floor space of work to be retained in m2 (if appropriate)	N/A
Gross floor space of any demolition in m2 (if appropriate)	177 sq.m

Number of car-parking spaces to be provided	Existing: N/A	Proposed: 45 no. standard spaces and 9 no. spaces for accessible parking across 3 amenity car parks.	Total: 54 no. car-parking spaces

2 no. bored wells are proposed for the proposed electrical substation. Further details are provided in Chapter 4 of the EIAR.

A sealed wastewater storage tank will be used for effluent from the staff welfare facilities in the substation IPP and GIS buildings. Effluent will be removed from site by a permitted waste collector to a licenced waste facility. Further details are provided in Chapter 4 of the EIAR.

Applicant

From August 2020 to March 2024, BnM was the sole applicant. In March 2024 BnM and SSE Renewables entered into a joint venture. Therefore, the applicant for the Proposed Project is Lemanaghan Wind Farm DAC representing the joint venture between SSE Renewables and BnM.

SSE Renewables

SSE Renewables is a leading developer and operator of renewable energy generation, focusing on onshore and offshore wind farms, hydro-electric power and flexible storage technologies. It is part of electricity infrastructure company SSE plc, a FTSE-100 company with operations across the UK and Ireland, and a presence in carefully selected international markets. SSE Renewables delivers clean power assets to increase SSE's operational renewable generation capacity as part of the company's five-year investment plan to 2030. This includes delivery of the world's largest offshore wind farm in construction, the 3.6GW Dogger Bank Wind Farm. SSE Renewables operates some of the leading onshore wind farms in Ireland including the 174MW Galway Wind Park in Connemara and the 73MW Slieve Kirk Wind Park outside Derry City.

Bord na Móna

Bord na Móna plc trading as BnM is a publicly owned company, originally established in 1946 to develop and manage some of Ireland's extensive peat resources on an industrial scale, in accordance with government policy at the time. BnM's lands extend to approximately 80,000 hectares in total and are located mainly in the Irish midlands. BnM currently manages and operates a portfolio of thermal and renewable assets, namely Edenderry Power Plant, a peat/biomass co-fired electricity generating unit, Cushaling peaking plant, Cloncreen, Bellacorick, Mountlucas, Bruckana and Oweninny wind farms, Derrinlough wind farm (under construction), Timahoe North solar farm and the Drehid landfill gas facility.

In 2015, BnM published its 'Sustainability Statement 2030', which sets out the company's commitment to transition to peat-free electricity generation by 2030. Renewable energy generation, including solar power, biomass and wind power, is a key component of this transition. In October 2018, BnM announced its strategy to decarbonise, accelerating moves away from its traditional peat business into renewables, resource recovery and new sustainable businesses. BnM's target is for an 80% reduction in carbon emissions by 2030 based on 2015 levels and to accelerate the development of renewable energy by providing up to 2GW of renewable energy generating assets by 2030 in support of national climate and energy policy targets.

BnM has a long track record of developing energy projects, dating back to the development of the first generation of peat-fired power stations. In recent times, the business has gone through radical change, announcing the new "Brown to Green" strategy, committing to the cessation of peat harvesting, and focusing on developing climate solutions in renewable energy, sustainable waste management, carbon storage and biodiversity conservation. A key objective of this strategy involves using the land to continue to underpin Ireland's energy independence by developing green, sustainable energy sources to assist with Ireland's commitment to achieve 70% renewable electricity by 2030.

Need for the Proposed Project

Ireland faces significant challenges to its efforts to meet EU targets for renewable energy by 2030 and its commitment to transition to a low-carbon economy by 2050.

The Proposed Project provides the opportunity to capture an additional part of County Offaly's valuable renewable energy resource. If the Proposed Project were not to proceed, this opportunity to harness the wind energy resource of County Offaly's valuable renewable energy resource would be lost, as would the opportunity to further contribute to meeting Government and EU targets for the production and consumption of electricity from renewable resources and the reduction of greenhouse gas emissions. The opportunity to generate local employment and investment and to diversify the local economy would also be lost.

Economic Benefits

The Proposed Project will have both long-term and short-term benefits for the local economy including additional income to local landowners, job creation, work opportunities for local businesses and service providers, local authority commercial rate payments and a Community Benefit Scheme.

Additional commercial rate payments from the Proposed Project will be provided to Offaly County Council each year, which will be redirected to the provision of public services within Co. Offaly. 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.

It is estimated that the Proposed Project has the potential to create 100-120 jobs during the construction phase and **3-4 jobs during operational and maintenance phases.** During construction, additional indirect employment will be created in the region through the supply of services and materials. There will also be income generated by local employment from the purchase of local services, i.e., travel, goods and lodgings. Further details on employment associated with the Proposed Project are presented in Chapter 5 of this EIAR: Population & Human Health. This will provide a long-term benefit to both the local community and visitors to the area.

In addition to the economic and environmental benefits of the Proposed Project, there will be potential social and recreational benefits associated with the Proposed Project. The Proposed Wind Farm creates a unique opportunity to develop an amenity area for use by members of the local and wider community alike, as well as tourists. The peatland habitat within the bogs is attractive to both locals and visitors to the area because of its history and variety of vegetation. The Proposed Wind Farm roads, and dedicated amenity track, will be open to the public for walking and cycling. The Proposed Project will also facilitate linkages to the wider area and to both existing and proposed amenity walkways as part of the Midlands Trail Network. Interpretation and orientation signage will be strategically located throughout the Proposed Wind Farm to guide, inform, and maximise enjoyment of the Proposed Wind Farm for all users.

Purpose and Scope of the EIAR

The purpose of this EIAR is to document the current state of the environment on and in the vicinity of the site and to quantify the likely significant effects of the Proposed Project on the environment. The compilation of this document served to highlight any areas where mitigation measures may be necessary in order to protect the surrounding environment from the possibility of any negative impacts arising from the Proposed Project. This EIAR uses the grouped structure method to describe the existing environment, the potential impacts of the Proposed Project thereon and the proposed mitigation measures. Background information relating to the Proposed Project, scoping and consultation undertaken and a description of the Proposed Project are presented in separate sections.

The EIAR project team comprises a multidisciplinary team of experts with extensive experience in the assessment of wind energy developments and in their relevant area of expertise. Each chapter of this EIAR has been prepared by a competent expert in their subject matter. The chapters of this EIAR are as follows:

1. Introduction
2. Background to the Proposed Project
3. Site Selection and Reasonable Alternatives
4. Description of the Proposed Project
5. Population and Human Health
6. Biodiversity
7. Birds
8. Land, Soils and Geology
9. Water
10. Air Quality
11. Climate
12. Noise and Vibration
13. Cultural Heritage
14. Landscape and Visual
15. Material Assets (including Traffic and Transport & Telecommunications and Aviation)
16. Major Accidents and Natural Disasters
17. Interactions of the Foregoing
18. Schedule of Mitigation and Monitoring Measures

A Natura Impact Statement has also been prepared in line with the requirements of the Habitats Directive and accompanies this planning application.

Reference No 1 : System impacts of wind energy developments: Key research challenges and opportunities. Russell McKenna, Johan Lilliestam, Heidi U. Heinrichs, Jann Weinand, Johannes Schmidt, Iain Staffell, Andrea N. Hahmann, Peter Burgherr, Arne Burdack, Monika Bucha, Ruihong Chen, Michael Klingler, Paul Lehmann, Jens Lowitzsch, Riccardo Novo, James Price, Romain Sacchi, Patrick Scherhaufer, Eva M. Scho¨ Piero Visconti, Paola Velasco-Herrejo´ Marianne Zeyringer, and Luis Ramirez Camargo. Joule 9, January 15, 2025

Onshore wind power deployment primarily affects bird and bat populations, even though wind turbines may also disturb and displace terrestrial mammals. Although there are no global estimates of yearly bird and bat fatalities caused by wind turbines, in the United States, with an installed capacity of 112 GW as of 2021, bird fatalities from turbine collisions number in the several hundreds of thousands annually. Species at higher risk are typically migratory, soaring raptors, or bats; the additional mortality due to collisions can be particularly relevant for populations of long-lived and slow-reproducing species, and collision with rotor blades and wind turbine towers might further endanger species already threatened with extinction.

Although previous research suggested bat fatalities caused by barotrauma, more recent studies identify direct blade and tower collisions as the main cause of fatalities

Despite the growing body of literature on bird strikes in open landscapes, there is a significant lack of research on these impacts in shrub- and woodland environments.

Furthermore, noise pollution from wind turbine operations can negatively affect birds, bats, and non-volant and marine mammals, disrupting their nesting, breeding, and movement patterns, which may result in population decline and displacement. Some species avoid wind turbines due to noise, specifically during construction, whereas others avoid areas with shadow flicker (see section health and annoyance). Although not a bat attractant, low-frequency noise emissions can disorientate bats, which makes hunting difficult. Land transformation related to the construction of wind farms can also affect habitat suitability for wildlife species. Landscape connectivity between habitats can become disrupted if wind farms are built in existing dispersal corridors. Already-isolated populations can face a reduced gene flow if areas in the vicinity of wind farms are avoided and alternative dispersal corridors are rare. In addition, direct mortality due to collisions with wind farms can affect population dynamics on a large scale. Some species might be able to adapt to altered habitat conditions after wind farm construction, whereas others might not become habituated. However, effects on population trends are difficult to assess because effects are highly site and species specific and long-term studies are rare.

Many species' habitat requirements change in the course of a year, it remains a challenging task, especially when considering ecological corridors and stepping stones. Micro-siting to avoid areas with high collision risk can reduce risks for birds, but it is more challenging for bats. A promising solution for on-site impact mitigation is to increase the cut-in wind speed from 3 to 4 m/s to 6 and 8 m/s for bats and soaring birds, respectively, as these animals have the highest flight activities at low wind speeds, while the production losses would remain modest. Temporary shut-downs triggered by visual or radar observations are also effective solutions to minimize collisions.

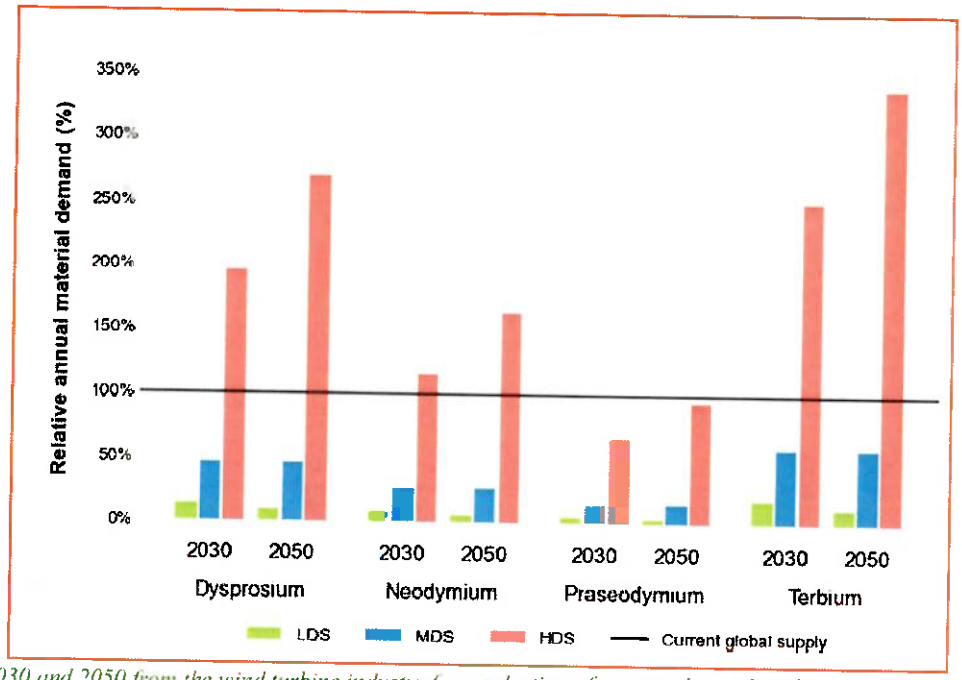
The increasing number and size of wind farms can affect local weather and climate patterns, though the magnitude of these effects is debated. There is broad evidence based on photographs, satellite imagery, measurements, and modeling. Wind turbines extract kinetic energy from the wind flowing through their rotors, replenished downstream of the flow above the wind farm. In large wind farms, the latter process cannot supply enough energy to compensate for lowered wind speeds, especially offshore. Hence, a large wind farm can significantly lower the wind speeds in its vicinity, up to a distance of tens of kilometres, thereby suppressing generation from nearby wind farms.

Wind turbines face several challenges in their end-of-life phase, inevitably resulting in final disposal. By 2030, around 60,000 wind turbines are expected to reach the end of their first life worldwide, two-thirds of which are in Europe Several options exist to delay final disposal, from extending the lifetime and reusing or repurposing components to recovering or recycling different parts of the wind turbine, each bearing its challenges. Recycling components attract the most attention in scientific publications and media. Although the recycling of permanent magnets is widely covered in the media and policies in the context of security of supply for critical raw materials (cf. section policy and regulation), the challenge of rotor blade recycling is intensely debated by the public, questioning the benefits of wind energy in general (cf. section social, economic, and health impacts).

Structural health monitoring and digital twins to extend the lifetime of wind turbines are still not implemented at scale, despite extensive industrial interest in the latter. Although a recent review posits that the reuse and repurposing of old turbines is minimal and not expected to grow in the future, the waste management company Veolia recently signed a contract to repurpose GE wind turbine blades into a raw material for cement in the US. Regarding recycling, suitable processes and related challenges differ for each part of a wind turbine

Although recycling steel towers, gearboxes, and traditional generators is well established, recycling concrete (esp. foundations) in some locations might be environmentally and economically challenging due to the trade-off between soil disruption, transport distances and material circularity. A geopolitical challenge around the recycling of the generator system arises through the trend toward direct drives, with their permanent magnets containing rare earth elements, such as neodymium, praseodymium, and dysprosium, considered critical raw materials by the EU.

Nonetheless, less than 1% of rare earth elements are recycled because of the low technology readiness level (TRL), glued structures and comparably cheaper virgin counterparts. At the same time, global demand for rare earth elements contained in wind turbines could rise from 52 kt/a in 2018 to 236 kt/a by 2030.



Expected demand in 2030 and 2050 from the wind turbine industry for a selection of rare earth metals, relative to the 2018 global supply for all applications

A central end-of-life challenge arises from the turbine blades containing glass fiber reinforcement plastics (GFRPs). Although some major wind turbine manufacturers have announced nearly 100% recyclable wind turbine blades between 2030 and 2040, and the first recyclable blades were launched in 2021, almost all current end-of-life blades are landfilled or temporarily stored, raising much attention in the media. Some regions with high wind energy capacities, like Germany, have already banned their landfilling and incineration, while currently only a negligible fraction is mechanically recycled as filling materials. Thermal and chemical recycling options are evolving but are still at low TRLs and have a high energy demand. For example, pyrolysis (TRL 7), fluidized bed or microwave pyrolysis (TRL 5/4), and solvolysis (TRL 5–6) come with a high upfront investment, low quality of fibers, and potential greenhouse gas emissions by the unavoidable decomposition of products.

Notably, the recycling challenge is not limited to wind turbines but applies to many activities in the building, electronics, and transportation sectors for composites and electric motors, as well as domestic appliances and smartphones for permanent magnets, so considerable sectoral spillovers in solving recycling problems are possible.

The diverse impacts of wind power development on land appropriation and control, which affect the rights of traditional communities to territory and livelihoods, need to be linked to a set of compliance rules. These include procedural aspects such as securing their free, prior, and informed consent, addressing information asymmetries about the project's specific local impacts, and offering fair and legally approved land leasing contracts as well as legal advice on land use. The issue of land ownership and rights is a key challenge to a just energy transition.

Another public concern is that wind turbines negatively impact the perception of landscapes, particularly untouched nature. This visual landscape impact is one of main reasons for local opposition to onshore and offshore wind installations.

Acceptance of wind turbines is higher when they are placed in already unattractive landscapes, far from viewpoints, and with a limited number of turbines, but the cumulative effects may vary by location. Several studies have employed national datasets of landscape aesthetic quality (so-called "scenicness"), based on survey-based ratings of representative landscape photographs, to quantify the costs incurred to power systems when excluding onshore wind potentials in landscapes with high aesthetic quality, showing a large range of impacts between countries.

In addition, viewshed analyses, in which a three-dimensional space (the viewshed) within which one or more hypothetical wind turbines are visible, can aid in understanding the potential visual impact on sensitive receptors: however, these disregard people's visual preference for certain landscapes over others. They may, therefore, be combined with measurements of visual features of landscapes, as a correlation between such metrics and rated landscape qualities has been found. Moreover, RE infrastructure such as wind turbines and power lines strongly influence the rated landscape coherence.

Quantifying the landscape impact of wind turbines to improve placement decisions requires that both visibility and landscape quality are considered. Whereas the latter refer to changes in landscape quality and character, visibility impacts relate to (perceived) changes in views (of the landscape) and how these affect people.

Noise emissions and the "flicker" of the rotating shadow from wind turbines are frequently discussed as negative impacts of wind farms. Although current evidence suggests that noise emissions from wind farms do not have a significant direct impact on nearby populations' health, some studies have noted a correlation between noise-related annoyance and potential indirect effects on quality of life, such as sleep disturbance, increased stress, and related health concerns (e.g., elevated blood pressure and psychological distress). However, the causality and directionality of these effects remain unproven and require further research. The perception of noise seems higher in rural areas and around flat terrains. Although low-frequency noise emissions cannot be heard, they may still lead to annoyance, but the link between wind turbines and low-frequency noise has not yet been established. In addition, many studies show that only a small fraction of the population living near wind farms is disturbed by shadow flicker. Shadow flicker exposure does not necessarily lead to self-reported annoyance but rather subjective factors such as project appearance and general annoyance. However, the disturbance attributed to wind turbine noise emissions should be evaluated compared with other routine noise sources.

In a controlled study, although subjects reported annoyance from the acoustic emissions of nearby wind turbines, health-related effects were specifically attributed to noise pollution from road traffic.

Noise impacts can be mitigated by appropriate wind farm planning and simulations, and it is suggested that a certain noise threshold be respected (e.g., 35–45 dB(a)), as is currently enforced in some countries. Likewise, for cases where high levels of modelled shadow flicker exposure and self-reported annoyance correlate, easy-to-implement solutions exist, such as curtailment after specific exposure thresholds. However, the probability of that correlation occurring is low because detailed shadow flicker simulations are an integral part of planning processes for wind farms and permission might not be granted in case thresholds would be exceeded (see, e.g., the German BImSchg). Nevertheless, the studies leading to that regulation were performed over 20 years ago when turbines were considerably smaller than today and were capable of generating a flickering effect of higher frequency.

Grid strengthening and expansion are essential to address mismatches between supply and demand. But these measures have significant implications for public acceptance, landscape impacts, and potential health impacts. Though, as we discuss in the section social, economic, and health impacts, the direction and magnitude of these health impacts are far from clear.

Table 1. Overview of key systemic wind impacts, potential solutions, and research priorities emerging from this comprehensive review

Category	Impact	Description	Spatial diversity[a]	Potential solutions	Research priorities
Environment and climate	(1) impacts on ecosystems and wildlife	impacts such as direct collision, causing mortality of birds and bats, or noise pollution, causing population decline and displacement of birds, bats, and non-volant and marine mammals by disrupting their nesting, breeding, and movement patterns	high	strategic placement of wind farms, regulating cut-in speeds, temporary curtailment, visual cues, and painting one turbine blade	empirical research and observation: • impacts in shrub- and woodland • multi-annual and multi-site studies (before-after control-impact study design) • net ecological impacts of wind energy compared with alternatives • longitudinal studies in wind energy locations
	(2) impacts on weather and climate	the operation of wind farms can cause a local change in surface temperature and other weather parameters, such as precipitation and evaporation; large wind farms can affect the wind resources for tens of kilometers downstream	medium	wind power siting, integration measures (e.g., storage, grids, etc.), appropriate wind park layouts, consider efficiency losses in wind farm planning	• further measurements and empirical data, especially for large wind farms and local weather effects • net climate effects of wind energy compared with alternatives
	(3) end-of-life treatment of turbine blades	the fiber binding resin challenges the recycling of wind turbine blades; as a result, blades are currently not recycled but instead go to landfills or unofficial "temporary storage sites"	low	prevention, refurbishing or reusing, repurposing, recycling	• address the waste hierarchy through innovative design for recycling and disassembly • improve thermal and chemical recycling processes to higher TRLs and exploit sectoral spillovers • increase coordination and standardization between manufacturers and developers
	(4) rare earth elements	the trend toward direct drives with permanent magnets containing critical rare earth materials for the EU results in a geopolitical challenge, yet less than 1% of the rare earth elements are recycled	low	recycling of permanent magnets, alternatives for permanent magnet wind turbine generators, diversifying supply chains	
Social, economic, health	(5) land governance and tenure (in)security	land requirements for wind power can come at the cost of prior land users due to land tenure insecurity, increasing the vulnerability of traditional rural communities and indigenous groups	high	recognition of common lands and traditional communal land-use rights, improved planning and coordination of spatial energy planning with land tenure issues, participatory planning, legal advice, creating co-benefits	• understand best practice for wind energy planning to reflect community needs • develop collaborative planning, governance, and business models ensure co-benefits
	(6) local monetary costs and benefits	wind turbines can create either positive or negative impacts on neighboring real estate value and tourism, depending on the perception	high	fostering community participation from the projects' planning stages, improving the understanding of wind power as a key technology to achieve the energy transition and monetary compensation	• elaborate models of acceptance and willingness to pay in order to quantify compensation measures • quantify net economic impacts based on improved data bases/availability
	(7) landscape impacts	the local opposition toward wind projects due to the negative visual impact on wild landscape aesthetic value	high	improved planning, participative processes	• enhance concepts of social acceptance to consider frequency of encounters with and quality of landscapes • extend quantitative empirical research on local economic impacts of wind farms
	(8) local health impacts	noise emissions and shadow flicker from wind turbines can cause neighbors' annoyance, which may correlate with deteriorating quality of life, increased stress, and resulting health issues	high	appropriate planning, periodic curtailment and noise threshold and attenuation options (e.g., serrated trailing edge, sinusoidal leading edge, blended winglet)	• build on existing noise models to (i) enhance understanding of wind energy impacts in relation to other local sources of noise and (ii) connect acoustin emissions with annoyance • extend shadow flicker research to consider night-time effects with artificial lighting
Techno-economic	(9) energy system impacts	wind-dominated energy systems may become highly weather dependent and lack inertia due to a prevalence of inverter-based resources (IBRs) forming the grid	medium/ high	grid densification and expansion, use of storage, increasing flexibility and sector coupling, development of smart grids; low carbon provision of key ancillary services, such as inertia, operating reserve, and frequency response	• align modeling with empirical data on energy system transitions to high wind shares • improve techno-economic modeling to reflect social and environmental impacts and constraints
	(10) market and price impacts	integrating wind power into markets creates two key opposing issues: ancillary service costs increase due to increased supply variability, and the "merit order effect" depresses wholesale market prices and increases their volatility	medium	market and regulatory changes that either bring more flexible capacity online or allow the existing system to react more efficiently to wind power volatility, e.g., enhanced frequency response service in Britain	• develop advanced models of market actors, storage, and interactions • derive best practice for wind energy subsidies, depending on energy-political contexts • quantify whole system costs of wind energy integration for diverse systems and contexts

Policy and regulation	(11) financing and controlling the IP	political, economic, and national security concerns, as well as possible resulting shifts in market power due to industry leaders seeking dominance	medium	balance investment opportunities and national security interests	• develop open data and associated research on investments, ownership, and acquisitions through FDI to assess geopolitical and geoeconomic risks • influence political and regulatory processes connected to (wind) energy infrastructure
	(12) supply chain disruptions	energy disruption as a geopolitical weapon has a long history for oil and gas, but it recently shifted to a focus on geopolitics of the energy transition and resurging concerns over the weaponization of energy	medium	increase domestic exploration and production to re-shore and near-shore supply chains	• design robust and resilient supply chains for wind energy • enforce international technology standards and certification schemes • identify the pathways and understand the major implications for developing a domestic (offshore) wind supply chain that can manufacture and deploy the major components needed
	(13) cyber security and hybrid threats	wind farms are exposed to challenges on existing infrastructure security that depends on complex control and monitoring systems, as well as disinformation that can affect news credibility	low	secure technologies and resilient designs	• understand how disinformation can be used to compromise the security of critical infrastructure • understand the potential vulnerability and attack landscape related to control and information systems, including the connected supplier and third-party systems
	(14) planning and permitting	lengthy permitting processes due to increasingly complex formal requirements combined with insufficiently specific legal guidelines and responsibilities for permitting authorities, as well as understaffed authorities and overloaded judicial systems	high	regulatory changes, "go-to areas," financial participation of communities, more resources for authorities	• determine best practice for planning and permitting • observe effects of ongoing/upcoming regulatory changes, including side-effects on acceptance • reflect spatial trade-offs in wind power legislation (centralized vs. decentralized)

Lemanaghan Wind Farm, Co. Offaly; Appendix 2 Decommissioning Plan – F – 2026.03.19 - 200804

It is intended that decommissioning process will remove all the remaining elements i.e., above ground components and underground cabling from the Proposed Wind Farm, and reinstate areas where infrastructure is removed. The following elements will be decommissioned:

- Wind turbines and met mast: dismantling and removal off site;
- Turbine and met mast foundation: turbine and met mast foundation backfilling following dismantling and removal of wind turbines, foundations that protrude above ground level will be backfilled with soil (underground reinforced concrete remaining in-situ);
- Internal underground cabling: removal (ducting remaining).

2.4.2.1.1 ***Wind Turbines and Met Mast***

Prior to any works being undertaken on wind turbines or the met mast, they will be disconnected from the grid by the site operator in conjunction with ESB Networks/EirGrid. The dismantling and removal of wind turbines and met mast of this scale is a specialist operation which will be undertaken by the turbine supplier or competent subcontractor. Turbine dismantling will be undertaken in reverse order to methodology employed during their construction. Cranes will be brought back to the Proposed Wind Farm utilising the hardstand areas adjacent to each turbine. The dismantling of turbines and met mast will be bound by the same safety considerations as will be the case during construction in terms of weather conditions. Works will not be undertaken during adverse weather conditions and in particular not during high winds.

The turbines and met mast will be removed from the Proposed Wind Farm in a similar manner to how they will be transported to the site originally in extended articulated trucks. The details of transport to and from the Proposed Wind Farm are assessed in Section 15.1 of Chapter 15 of the EIAR.

The transport of disassembled turbines from the Proposed Wind Farm will be undertaken in accordance with a Transport Management Plan (TMP). The TMP will be issued to and agreed with the planning authority at that time as part of a permit application for the delivery of abnormal loads using the local roads under the Road Traffic (Special Permits for Particular Vehicles) Regulations 2007. The TMP will provide for all necessary safety measures, including a convoy and Garda escort as required, off-peak turning/reversing movements and any necessary safety controls. A Traffic Management Plan is included as Appendix 15-2 of this EIAR.

Response from MLavelle: What competent subcontractors are there in Ireland to handle this decommissioning? Has this energy usage been factored into the Climate Change calculations? Is there an Insurance Bond provided to pay for Decommissioning?

2 Background to the Proposed Project

Chapter 2: Background to the Proposed Project presents the relevant policies and objectives which have been put in place at the international, national, regional and local level in relation to planning, renewable energy and climate change. It also summarises the scoping, pre-application and community consultations undertaken and sets out the cumulative impact assessment process. This chapter should be read in conjunction with the Planning Report which accompanies the planning application.

The Proposed Project is being brought forward in response to international, national, regional and local policy regarding Ireland's transition to a carbon-neutral and climate-resilient society, a key objective of the Revised National Planning Framework (NPF). The Revised NPF has identified post-industrial peatlands as a key opportunity area for the development of renewable energy. The Eastern and Midlands Region is allocated a target of installing an additional 1,966MW of onshore wind energy by 2030.

The need to decarbonise the economy and reduce emissions has always been imperative, however in recent years the urgency involved has become clearer to all stakeholders. The latest Climate Action Plan 2025 (CAP25) sets out the detail for taking action to deliver the decarbonisation required under the carbon budgets and sectorial emissions ceilings. Central to this are the measures set out to increase the proportion of renewable electricity to up to 80% by 2030 and a target of 9GW from onshore wind.

The Climate Action and Low Carbon Development Act 2015 (as amended) ('the Climate Act') commits Ireland to a legally binding target of net-zero emissions no later than 2050, and a cut of 51% by 2030 (compared to 2018 levels). To ensure that climate targets are met, Section 15 of the Climate Act requires all public bodies to exercise their functions in a manner consistent with, in so far as practicable, the national climate objective and the latest climate policy. Renewable energy projects such as the Proposed Project are key to helping Ireland achieve these legally binding climate targets.

Failure to meet binding EU targets will expose Ireland to financial penalties, increased carbon credit costs, and continued dependence on fossil fuel imports—posing serious risks to energy security and economic stability. Furthermore, Ireland's national interest requires the rapid expansion of renewable energy, making this a matter of strategic economic and social importance. National interest is identified as a matter of regard during planning determination in Section 143(1b) of the Planning and Development Act 2000 (as amended) ('the Planning Act'). Every viable renewable energy project plays a crucial role in meeting Ireland's climate targets. The approval of well-planned, appropriately located renewable energy projects, such as the Proposed Project is not just beneficial—it is imperative. Without decisive action to facilitate renewable energy deployment, Ireland risks missing national and EU commitments, incurring financial penalties, and undermining energy security.

The application for the Proposed Project is covered by the provisions of the Renewable Energy Directive III (Directive 2023/2413) and the planning application is subject to a completeness check under section 37JA of the Planning and Development Act 2000, as amended by the European Union (Planning and Development) (Renewable Energy) Regulations 2025.

Local Planning Policy

date	Curtailment Cost incl UAEC	date	Curtailment Cost incl UAEC	date	Curtailment Cost 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

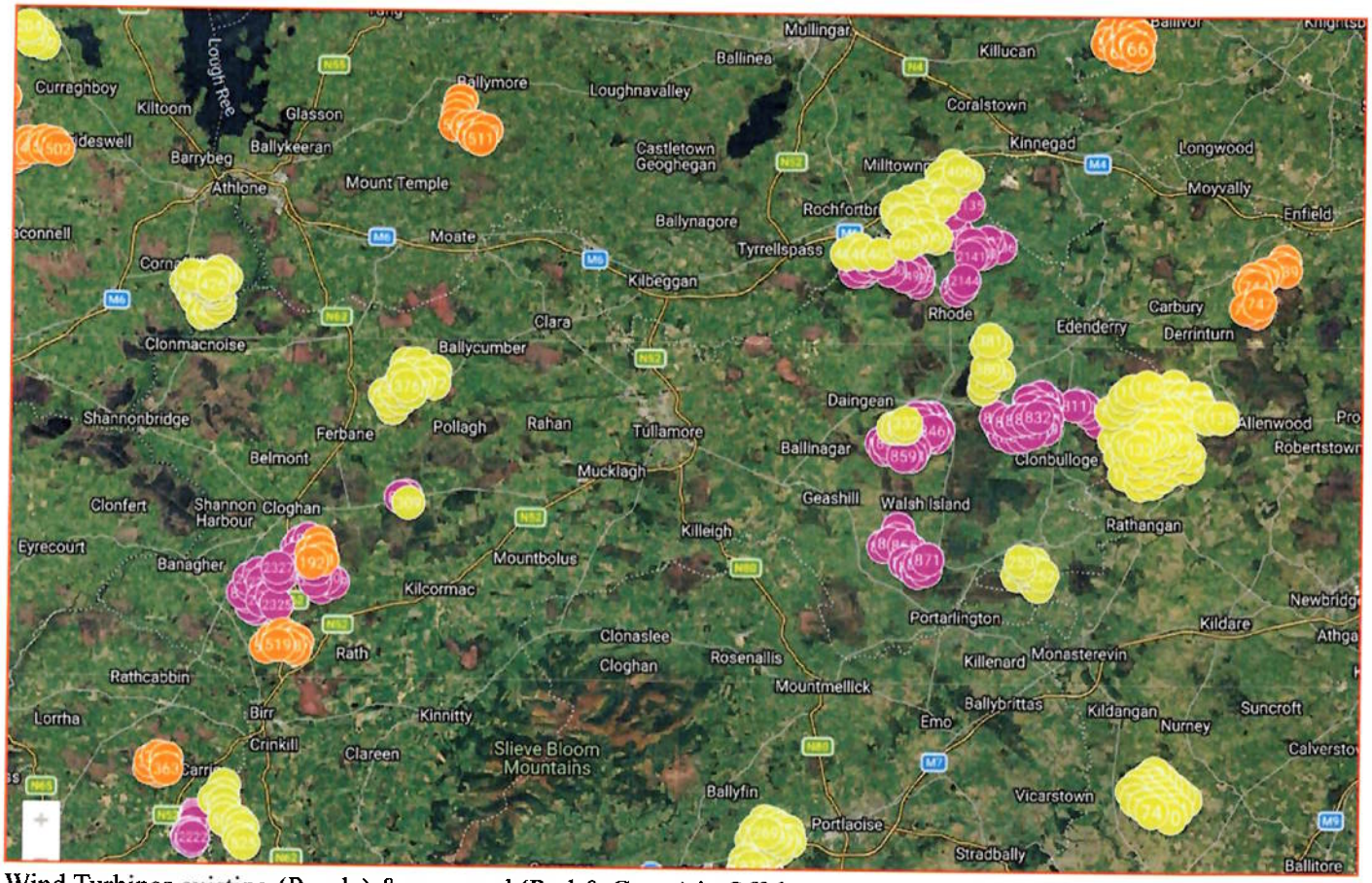
13/01/26	€ 6,696,160	13/02/26	€ 2,400,000	13/03/26	€ 8,400,000
14/01/26	€ 2,100,000	14/02/26	€ 1,900,000	14/03/26	€ 810,000
15/01/26	€ 150,000	15/02/26	€ 3,000,000	15/03/26	€ 8,300,000
16/01/26	€ 552,800	16/02/26	€ 2,900,000	16/03/26	€ 7,200,000
17/01/26	€ 630,000	17/02/26	€ 2,400,000	17/03/26	€ 7,800,000
18/01/26	€ 620,000	18/02/26	€ 4,300,000	18/03/26	€ 1,100,000
19/01/26	€ 480,000	19/02/26	€ 1,900,000	19/03/26	€ 150,000
20/01/26	€ 2,400,000	20/02/26	€ 4,500,000	20/03/26	€ 760,000
21/01/26	€ 2,100,000	21/02/26	€ 4,000,000	21/03/26	€ 710,000
22/01/26	€ 590,000	22/02/26	€ 8,100,000	22/03/26	€ 1,300,000
23/01/26	€ 2,400,000	23/02/26	€ 3,500,000	23/03/26	€ 2,100,000
24/01/26	€ 4,100,000	24/02/26	€ 2,300,000	24/03/26	€ 8,300,000
25/01/26	€ 2,400,000	25/02/26	€ 730,000	25/03/26	€ 13,000,000
26/01/26	€ 2,900,000	26/02/26	€ 1,700,000	26/03/26	€ 1,300,000
27/01/26	€ 7,100,000	27/02/26	€ 150,000	27/03/26	€ 3,300,000
28/01/26	€ 2,600,000	28/02/26	€ 1,400,000	28/03/26	€ 6,900,000
29/01/26	€ 4,900,000			29/03/26	€ 11,000,000
30/01/26	€ 2,500,000			30/03/26	€ 6,900,000
31/01/26	€ 660,000			31/03/26	€ 2,800,000
TOTAL COST	€ 70,379,280		€ 61,210,000		€ 133,570,000

This Table shows the amount of monies paid by the Irish State to Windfarm companies to turn off the wind turbines. Payments approach €1bn per annum are made. This increases costs to householders & businesses. This is not consistent with Proper Planning or Sustainable Development. It represents a confidence trick on Irish citizens, where the Windfarm groups state that wind energy is reducing consumer costs. [Further monthly data is available & can be presented if requested]

It is considered that the Proposed Project is consistent with the policies and objectives of the Offaly County Development Plan 2021-2027 (OCDP). The OCDP outlines the overall strategy for the proper planning and sustainable development of County Offaly. The CDP and accompanying documents (including the Offaly Wind Energy Strategy 2021-2027 (WES)) set out the key policy context for the development of wind energy in County Offaly.

The OCDP and associated WES fully recognises the importance of tackling climate change through the increased supply of renewable energy. Furthermore, there is a range of policies in place which support the development of renewable energy.

The layout of the Proposed Wind Farm has been strategically developed, with the Proposed Wind Farm turbines being located in an area classified as 'Areas Deemed Open for Consideration for Wind Energy Developments' within the WES, with the exception of T05 which is located on the border of an area designated 'Not Deemed Suitable for Wind Energy Developments'. The overlap of T05 with the border of the 'Areas Not Deemed Suitable for Wind Energy Developments' is minor and as demonstrated by this EIAR, will not give rise to any significant effects on the environment. When assessed in accordance with the Development Management Standard 109 within the OCDP, the Proposed Project is found to be in compliance. Accordingly, the Proposed Project is considered to be compliant with the relevant provisions of the OCDP and represents proper planning and sustainable development in the functional area of the Offaly County Council.



Wind Turbines existing (Purple) & proposed (Red & Green) in Offaly

Reference No 2 : Mayo County Council Variation Number 2 County Development Plan. May 2026

Table 4.2 Renewable Energy (RE) Generation by County (GWh) & RE Type for 2024

County	RE Generation (GWh)	% of total National RE generation	Biomass	Hydro	Solar	Wind
Cork	1770.42	14.7%	0	79.57	135.20	1555.66
Kerry	1658.80	13.8%	0	0	0	1658.80
Donegal	1329.02	11.0%	0	252.05	0	1076.97
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Offaly	965.11	8.0%	443.29	0	2.15	519.68
Clare	888.46	7.4%	0	366.04	0	522.42
Mayo	813.09	6.8%	0	0	0.69	812.40
Galway	696.13	5.8%	0	0	0.14	695.99
Wexford	439.92	3.7%	0	0	196.47	243.44
Limerick	370.89	3.1%	0	0	0.09	370.79
Cavan	342.01	2.8%	0	0	0.10	341.90
Roscommon	270.82	2.2%	0	0	0	270.82
Wicklow	234.57	1.9%	0	14.08	11.80	208.70
Leitrim	216.32	1.8%	0	0	0	216.32
Meath	196.29	1.6%	0	0	173.88	22.41
Monaghan	182.05	1.5%	0	0	0	182.05
Dublin	181.63	1.5%	0	0	177.76	3.86
Sligo	141.23	1.2%	0	0	0	141.23
Waterford	130.13	1.1%	0	0	0	130.13
Kilkenny	82.37	0.7%	0	0	4.46	77.90
Laois	46.73	0.4%	0	0	0	46.73
Kildare	25.08	0.2%	0	6.27	18.83	0
Louth	20.05	0.2%	0	0	3.71	16.34
Carlow	15.65	0.1%	0	0	0	15.65
Longford	0.00	0.0%	0	0	0	0
Westmeath	0.00	0.0%	0	0	0	0
Total	**12041.52**	**100.0%**	**443.30**	**718.0**	**725.7**	**10154.6**
% of National RE Generation			3.7%	6.0%	6.0%	84.3%

These figures for wind energy in Offaly do not include recent schemes such as Mount Lucas & don't include schemes with ACP. The Generation (GWh) for Offaly is far higher.

Counties of Ireland by area [Note Offaly 14th largest County by area]

Rank	County	Area km²
1	Cork	7,508
2	Galway	6,151
3	Mayo	5,588
4	Donegal	4,860
5	Kerry	4,807
6	Tipperary	4,305
7	Clare	3,450
8	Limerick	2,756
9	Roscommon	2,548
10	Wexford	2,367
11	Meath	2,342
12	Kilkenny	2,073
13	Wicklow	2,027
14	Offaly	2,001
15	Cavan	1,932
16	Waterford	1,858
17	Westmeath	1,840
18	Sligo	1,838
19	Laois	1,720
20	Kildare	1,695
21	Leitrim	1,589
22	Monaghan	1,295
23	Longford	1,091
24	Dublin	922
25	Carlow	897
26	Louth	826

Table 3A Non-Residential Metered Electricity Consumption by County for 2015-2024 (GWh)

Gigawatt hours

County	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Carlow	140	144	148	154	153	142	157	163	160	148
Cavan	326	340	331	329	333	328	347	344	327	335
Clare	321	328	330	331	323	287	285	302	300	304
Cork	1,808	1,852	1,862	1,917	1,899	1,813	1,891	1,948	1,946	1,973
Donegal	332	338	345	354	352	334	342	358	347	347
Dublin County	694	712	699	711	706	665	667	687	682	688
Dublin Postal Districts	3,393	3,428	3,492	3,580	3,471	3,162	3,299	3,530	3,329	3,378
Galway	637	653	656	676	654	600	605	636	636	643
Kerry	390	393	393	407	349	310	313	337	330	339
Kildare	547	553	555	569	564	535	541	563	548	565
Kilkenny	208	220	219	235	236	211	209	215	214	225
Laois	159	162	163	168	165	160	169	172	167	171
Leitrim	60	60	60	62	60	55	57	61	60	60
Limerick	661	675	697	721	715	686	707	739	755	784
Longford	135	138	142	147	152	151	159	161	160	162
Louth	317	330	334	339	317	288	312	317	305	311
Mayo	344	350	350	365	354	334	336	363	366	366

Meath	303	314	323	332	331	325	342	359	368	348
Monaghan	217	226	229	235	233	220	230	230	230	232
Offaly	156	162	164	173	168	163	168	171	169	170
Roscommon	131	131	131	136	134	132	133	137	135	138
Sligo	184	186	179	178	174	165	166	172	170	174
Tipperary	461	474	477	484	467	456	479	488	476	480
Waterford	450	447	455	469	467	455	483	486	477	474
Westmeath	284	291	298	292	273	278	287	287	280	281
Wexford	325	337	346	355	350	331	335	352	344	348
Wicklow	304	305	293	303	305	292	302	314	307	310
Not Coded	2,941	3,409	3,637	4,037	4,461	4,949	5,879	7,170	8,411	9,198
Total	**16,230**	**16,959**	**17,312**	**18,059**	**18,165**	**17,825**	**19,201**	**21,062**	**22,002**	**22,953**

Table 3B Residential Metered Electricity Consumption by County for 2015-2024 (GWh)

Gigawatt hours

County	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Carlow	107	109	109	113	111	121	124	117	115	120
Cavan	138	138	138	143	137	151	154	145	143	147
Clare	205	202	204	210	201	224	226	212	207	216
Cork	1,001	1,010	1,009	1,047	998	1,108	1,117	1,048	1,028	1,067
Donegal	273	272	273	280	271	297	303	285	280	293
Dublin County	488	487	487	501	485	545	548	516	509	535
Dublin Postal Districts	1,699	1,693	1,682	1,725	1,640	1,808	1,788	1,670	1,617	1,684
Galway	474	474	478	496	478	527	533	501	490	509
Kerry	300	298	300	311	299	325	329	308	302	313
Kildare	372	377	378	390	378	425	433	417	415	440
Kilkenny	163	165	166	172	167	184	188	176	172	180
Laois	132	133	134	140	137	151	152	147	145	152
Leitrim	64	62	63	65	63	69	70	66	64	66
Limerick	362	367	370	377	363	400	401	377	369	381
Longford	76	77	77	80	77	85	86	81	79	83
Louth	230	228	228	234	226	250	250	238	235	247
Mayo	240	238	236	244	235	259	263	245	238	246
Meath	317	323	325	338	331	369	375	361	359	379
Monaghan	113	115	115	118	115	126	129	121	119	123
Offaly	125	127	128	133	127	141	145	136	134	141
Roscommon	100	96	96	100	97	108	109	103	102	106
Sligo	120	118	119	121	116	129	131	122	119	124
Tipperary	316	322	325	336	321	356	360	340	329	342
Waterford	226	230	229	236	229	251	254	237	232	242
Westmeath	179	177	179	186	180	197	201	189	183	191
Wexford	290	293	295	303	295	328	336	317	308	323
Wicklow	261	264	266	272	263	295	297	283	277	292
Not Coded	2	2	3	3	3	4	4	4	5	8
Total	**8,370**	**8,397**	**8,414**	**8,671**	**8,340**	**9,231**	**9,305**	**8,763**	**8,579**	**8,951**

Offaly produced 965.11GW per annum in 2024 & used 311GW. Offaly has delivered on its obligations. It generates the most MW per person Nationally at 11.61MWh

Table 4.3 RE Generation Across the Regional Assembly Regions (MWh per capita)

County	RE Generation (MWh) per capita	County	RE Generation (MWh) per capita	County	RE Generation (MWh) per capita
Eastern & Midland Regional Authority		Southern Regional Authority		North & West Regional Authority	
Offaly	11.61	Kerry	10.60	Donegal	7.95
Wicklow	1.51	Clare	6.94	Leitrim	6.15
Meath	0.89	Tipperary	6.10	Mayo	5.89
Laois	0.51	Cork	3.03	Cavan	4.19
Louth	0.14	Wexford	2.68	Roscommon	3.85
Dublin	0.12	Limerick	1.77	Monaghan	2.79
Kildare	0.10	Waterford	1.02	Galway	2.51
Longford	0.00	Kilkenny	0.79	Sligo	2.01
Westmeath	0.00	Carlow	0.25		7.95
Total	14.88	Total	33.20	Total	35.34

From Table 4.3, one can see that Offaly generates 11.61MWh per capita, which is the highest figure for any County in Ireland. Yet it is only the 14th largest County by area. The Applicant quotes employment numbers in Chapter 5. How many people in Offaly are employed in the wind energy industry?

5.3.6.2.3 ***Employment Potential [3-4 Jobs identified for O/M period above]***

According to a 2021 KPMG report on behalf of Wind Energy Ireland, "Economic impact of onshore wind in Ireland"16, as of 2021, the onshore wind energy sector in Ireland supported 5,130 jobs in 2021 (excluding employment in grid development) through the sector and its supply chain. By 2030, under a scenario of 8,200 MW installed capacity, there is potential for 7,020 jobs. These figures update those estimated in a Siemens and IWEA (2014) report, which predicted that the wind energy sector in Ireland would produce 6,659 direct jobs in a scenario where 4GW capacity is achieved by 2020. It was estimated that 5,596 of these jobs would be associated directly with the construction and installation of windfarms, while the remaining 1,063 jobs would be associated with the national grid. Under this scenario, this translates to 1.66 direct jobs per megawatt (MW) of wind capacity throughout the various stages of installation. Ireland needs to achieve a total of 9GW of onshore wind by 2030 which will further support further employment. According to Wind Energy Ireland, the installed onshore wind capacity in Ireland has exceeded 5,000 MW as of January 202517, which would support employment during the last decade.

In its 2011 report 'Wind Energy Roadmap 2011-2050"18, the SEAI notes that "Onshore and offshore wind could create 20,000 direct installation and O&M jobs by 2040". This Roadmap estimated that onshore and offshore wind could create 20,000 direct installation and operation/maintenance jobs by 2040 and that the wind industry would also have an annual investment potential of approximately €6-12 billion by 2040.

A 2014 report by Pőyry, "The Value of Wind Energy to Ireland" 19, stated that growth of the wind sector in Ireland could support 23,850 jobs (construction and operational phases) by 2030. The report states that if Ireland chooses to not develop any more wind, then by 2030 the country will be reliant on natural gas for the majority of electricity generation, at a cost of €671 million per annum in fuel import costs.

A 2017 report issued by WindEurope, entitled 'Wind energy in Europe: Scenarios for 2030"20 details various scenarios in Europe in respect to the EU target for renewable energy. According to WindEurope's High Scenario, which assumes favourable market and policy conditions including the achievement of a 35% EU renewable energy target (slightly higher than the 32% EU target for renewables), "397 GW of wind energy capacity would be installed in the EU by 2030, 298.5 GW onshore and 99 GW offshore. In this scenario, the wind energy industry would invest €351bn by 2030, and it would create 716,000 jobs".

A March 2021 report by MaREI, the SFI Research Centre for Energy, Climate and Marine, hosted by University College Cork21, estimates that were Ireland to meet the government's target of net-zero carbon emissions by 2050, at least 25,000 jobs would be created in the onshore and offshore wind sectors.

A more recent report issued by WindEurope in February 2022, titled "Wind Energy in Europe: 2021 Statistics and the Outlook for 2022-2026" 22, further details various scenarios in Europe with respect to the EU's targets for renewable energy. According to this report, "Europe installed 17GW (11 GW in the EU-27) of new wind capacity in 2021. This is not even half of what the EU should be building to be on track to deliver its 2030 Climate Energy Goals." The report also states that "The European Commission modelling shows that we need at least 79 GW offshore wind but National Governments have pledged to build at least 92 GW offshore wind capacity by 2030.'"

As of January 2025, the installed capacity of wind energy on the island of Ireland was 6.3GW23. Of this, 4.9GW was installed in the Republic of Ireland. The majority of the Republic of Ireland's installed wind energy capacity is located

in Counties Kerry, Cork, Donegal, Mayo, Galway and Clare, contributing to employment potential on the island of Ireland.

Response from MLavelle: This submission is Wanderly Wagon stuff. It is incorrect & fictional.

5.3.7.1 **Equine Industry**

2 no. stud farms or equestrian facilities was identified within 10 km of the Proposed Project site; Erryvale Stud, located in Clara, Co. Offaly, approximately 6.1 km northeast of the nearest proposed turbine (T15) and Belmont House Stud, approximately 9 km southwest of the nearest proposed turbine (T03).

There have been no known studies carried out in Ireland on the impacts of wind farms on the equine industry. In 2014 Marshall Day Acoustics published a document entitled "Summary of research of noise effects on Animals"27. The Marshall Day study specifically assessed the impacts of varying levels of noise on horses in three differing behavioural settings. The three behavioural settings studied included horses in stables, breeding mares and racing horses.

Horses in Stables

The study by Marshall Day Acoustics found that horses, stabled at the Flemington Racecourse in Australia at the same time as a music concert took place on the site, when exposed to LAeq,15min of 54-70 dB, showed little response to the music noise unless the noise was particularly impulsive. The horses stabled at Flemington Racecourse were thoroughbreds, and stables were located 200 metres from the concert.

Breeding Mares

A study by Le Blanc et al. (1991) and summarised by Marshall Day studied the effects of simulated aircraft noise over 100 dB and visual stimuli on pregnant mares in the United States. Aircraft noise generates infrasound, which is also generated from wind turbine, cars and trains. The study focused on pregnancy success, behaviour, cardiac function, hormonal production, and rate of habitation. Noise levels of 100 dB are similar to that of the Vestas 150 turbine operating at 5m/s wind speed, as indicated in Chapter 12: Noise and Vibration. Le Blanc concluded the following:

" [the] birth success of pregnant mares was not affected by F-14 jet aircraft noise. While the 'fright-flight' reaction was initially observed, the mares did adapt to the noise."

Racehorses

Marshall Day Acoustics concluded the following in relation to their study on the impacts of noise on racehorses:

"Marshall Day Acoustics have observed horses grazing in paddocks directly under the main approach path of the Christchurch International Airport where noise levels are in excess of 90 dB (LAmax) during an aircraft flyover. Although these horses are arguably "used to" the noise, there was generally little recognition by them of an aircraft passing, let alone any sign of disturbance. This tends to support the conclusions by Le Blanc et al. (1991)."

5.3.7.1.2 ***Guidance***

In the absence of national policy or guidance in relation of the development of wind farms near stud farms/equestrian centres, MKO has reviewed the British Horse Society's 'Advice on Wind Turbines and Equestrian Access'. A copy of the guidance document is included in Appendix 5-3 of this EIAR.

The British Horse Society policy statement states the following in relating to the siting of wind turbines in the vicinity of equine businesses:

"The British Horse Society strongly recommends a minimum separation distance of blade tip height plus 10% — 'fallover distance' or 'fallover' — between a commercial turbine, one of multiple on site, and any route used with horses and a separation distance of twice tip height for microgeneration units",

This is an update from the previous guidance of "a minimum separation distance of 200m or three times blade tip height (whichever is greater) will be required between a turbine and any route used by horses or a business with horses.'"

5.3.7.1.3 ***Summary***

On a precautionary basis, i.e., under the assumption that every inhabitable dwelling owns a horse or horses, the closest inhabitable dwelling, not including involved properties, is located approximately 896 metres (over four-times blade tip height) from the nearest proposed turbine location. As mentioned previously, the closest stud farm/equestrian facility is located approximately 9.0 km from the nearest Proposed Wind Farm turbine (T03). In this instance, the proposed turbines are at a distance beyond that of the British Horse Society's recommended minimum separation distance of blade tip height plus 10%. In this instance, the minimum separation distance from proposed turbines exceeds the 370 metres separation distance (based on two times the turbine blade tip height of up to 185 metres) between a turbine and any routes used by horses.

Response from MLavelle: **HORSES & STUDFARMS**

Reference No 3 : Wind turbines and horse husbandry in France. Translated from french by : Karen DUFFY - Agata RZEKĘĆ - Gwenaëlle GRANDCHAMP-RENARD

A wind turbine produces neither infectious nor chemical agents, but does produce physical phenomena. There are four types of physical effects :

- Acoustic vibration phenomena, i.e. audible sound and infrasounds produced by the movements of the blades and the electric generator.
- Ground vibrations.
- Electromagnetic fields resulting from converting the mechanical power of the wind to an electric current, and the transfer of this current.
- Parasitic electrical current, induced by the electromagnetic fields, but also linked to current leakage, to couplings between electrical and mechanical elements, and faulty earthing.

Horses are not as sensitive to infrasounds as humans, or even as cattle (Heffner and Heffner, 1983)

Scale of sound frequencies in several animal species and in humans (according to Heffner (1998))				
Animal species	**Low frequency limit** (Hz)	**High frequency limit** (Hz)	**Ideal sensitivity** (dB)	**Ideal frequency** (Hz)
Cattle	23	37 000	-11	8 000
Human	20	20 000	-10	4 000
Pigs	42	40 500	9	8 000
Horses	**55**	**33 500**	7	**2 000**
Cats	55	79 000	-10	8 000
Dogs	67	44 000	-1	8 000
Laboratory rats	530	70 500	0	8 000
Laboratory mice	900	79 000	5	15 000

The persistence of audible sounds does not appear to affect animal behaviour, unlike some people suffering from hyperacusis.
However, infrasound remains controversial in the equine sector. In an expert study conducted in Portugal, there was a suspicion of consequences on joint tissue in Lusitano horses (Branco *et al*, 2005). The results of this expert study have however not been confirmed by the Lisbon University veterinary thesis (Costa, Pereira e Curto 2012) which analysed the afore mentioned cases

Ground vibrations
Ground vibrations are produced by the wind turbine itself, like any building with foundations and wind.
The transmission of vibrations through the ground depends on the nature and structure of the ground they go through. The mechanical waves through the ground, produced by wind turbines, are essentially surface vibrations (Saccorotti G. *et al*, 2011). There is very little data regarding the level of the vibrations for local residents, produced by wind turbines. The few studies conducted show that when further than 300 metres (Lubw, 2016) to 700 metres away from a wind turbine (internal study by Cerema), the vibrations merge into the backgound noise of the site (vibration speeds below 0,07mm/s).

Electromagnetic fields
The study of electromagnetic fields revolves around three themes:

- Behaviour and neurophysiology
- Zootechnical and sanitary impact
- Cellular and physiological impact

Behaviour and neurobiology

There is little information regarding perception of electromagnetic fields, and our knowledge is mainly related to wildlife. Likewise, there is no data as to whether electromagnetic fields produced by various structures (wind turbines, high voltage power lines…) have an influence on perception. There are no effects noted on the behaviour of farm animals, only on laboratory animals (rats and mice).

Zootechnical and sanitary impact

With regard to cattle, the results of experiments conducted in the field differ from those of experiments in a controlled environment. In an experimental environment, a decrease in the quantity of milk produced and in the percentage of fat was noticeable, as was an increase in the quantity of feed ingested. The field studies showed no changes.
With regard to poultry, electromagnetic fields presented a teratogenic effect (affecting the embryo, and causing malformation) with a window effect (non-linear effect, i.e. the negative effect of electromagnetic fields is lesser for the weaker and the stronger fields).

Cellular and physiological impact

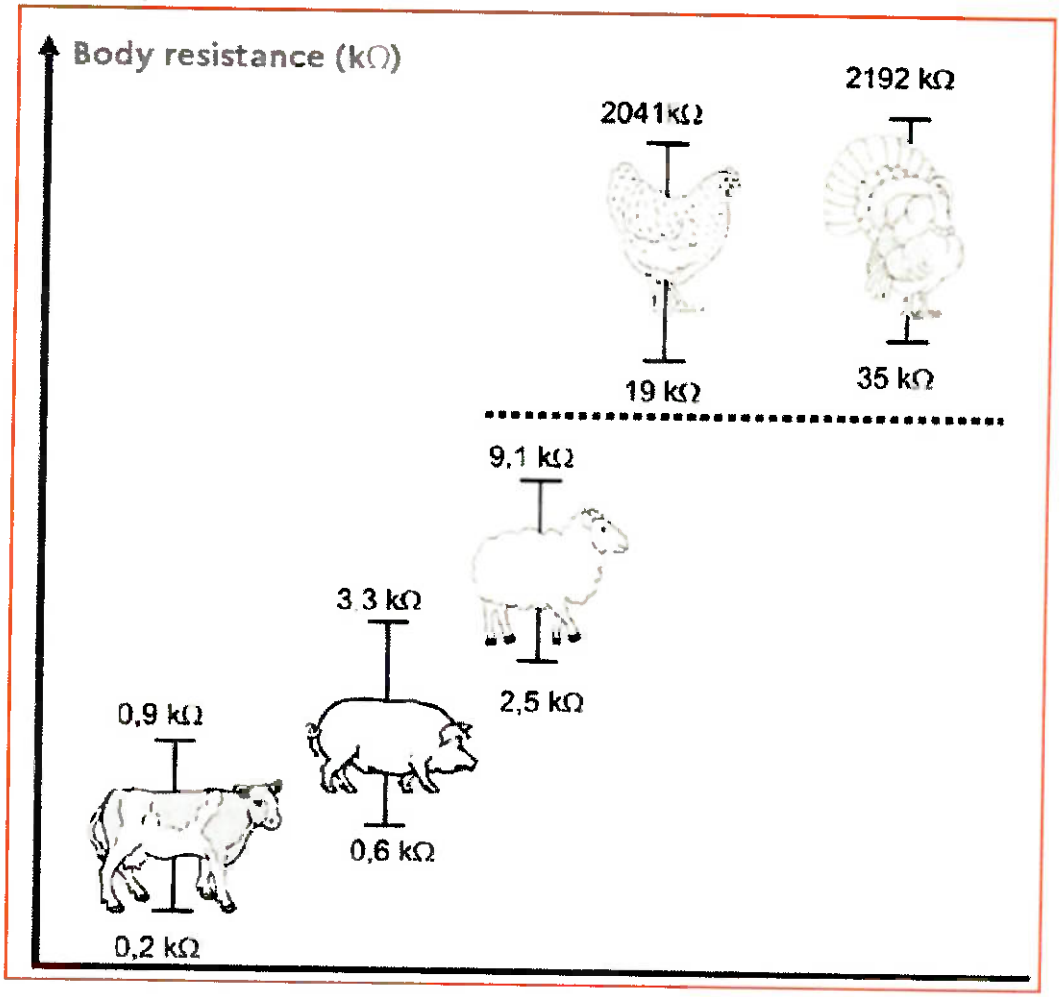
Studies conducted *in vitro* show a genotoxic effect (capacity to compromise the structure or the functioning of the genome) of electromagnetic fields. Moreover, these fields amplify the action of chemical products which have an effect on DNA. Cells submitted to electromagnetic fields are more sensitive to oxidative stress, i.e. there is a higher count of DNA lesions, therefore more frequent cell death. Electromagnetic fields also have an effect on the circadian cycle («the internal clock » of an organism) by modifying the release patterns of melatonin, or through other mechanisms yet to be discovered. However, electromagnetic fields have no effect on immunity and physiological stress (ways in which the organism copes with real or presumed aggression).

Parasitic current

Parasitic current is derived either from electromagnetic fields, or from electrical current (cables…). Parasitic currents can cause different types of voltage :

- **Contact voltage** (contact with a metallic element such as a drinking trough) ⇒ the current goes through the animal and back to earth though the legs.
- **Pace voltage** ⇒ Current goes from the front legs to the rear legs.

The sensitivity of animals depends on the electrical resistance of the species, of the individual and on living conditions.



Animals are more sensitive than humans. Parasitic currents cause pain, leading to physiological stress which can modify behaviour (avoidance, refusing to drink, memory and training issues…) and the state of health (weight loss, decrease in immunity, higher risk of gastric ulcers and colic, genetic alterations in the long term…). An animal's sensitivity to parasitic current can be increased due to its living conditions.

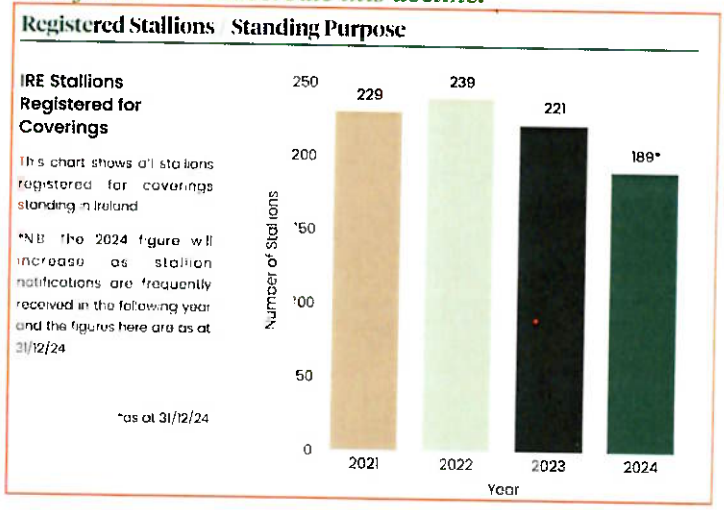
A horse stabled in a building with a lot of metallic structures and/or in a box with damp bedding, is more at risk of being a conductor of parasitic current.

To summarize

Wind turbines produce sounds and infrasound, vibrations, electromagnetic fields and parasitic current
To date, only parasitic currents are a real issue for horses, but vigilance is required nevertheless, due to our lack of knowledge.

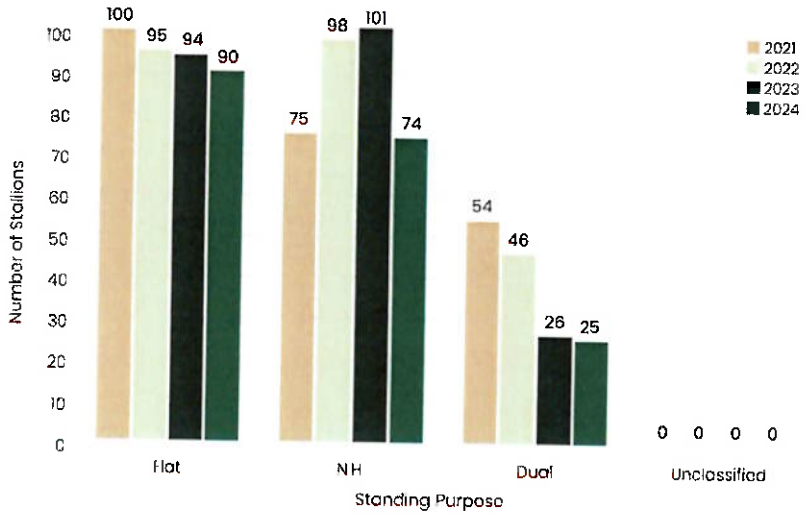
Reference 4: Racehorses & Stud farms
Renewable Energy Developments have to be balanced with equine facilities & this requires informed policy frameworks. Recent statements from Planning Authorities indicate the growing tension between renewable energy expansion and the protection of rural sensitive agricultural 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 No 5 : *2024 Weatherby's Fact Book: The tables indicate a serious decline in the Stud farm industry & Windfarms will exacerbate this decline.*



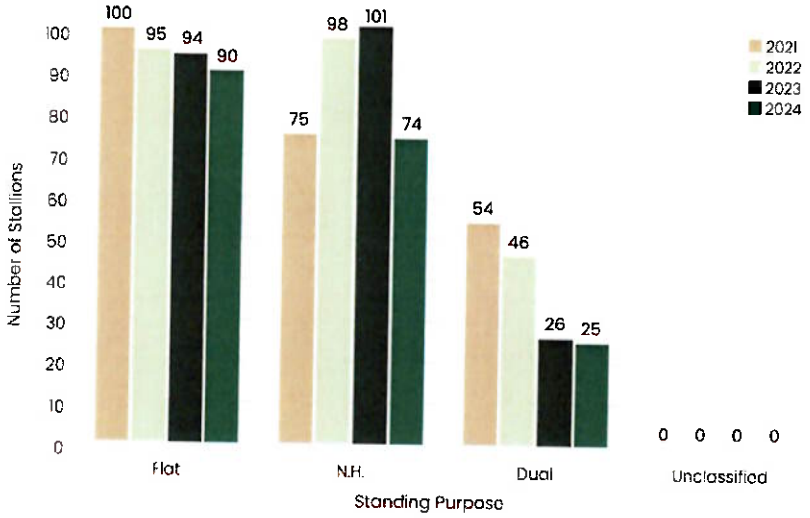
IRE Stallions Standing Purpose

The proportion of stallions standing for National Hunt purposes was higher than those standing for Flat purposes in 2022 and 2023, compared to 2021 when there were 11% less stallions standing for National Hunt purposes than for the Flat. We expect further stallion registrations for 2024 as noted above.



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Breeders by County

This table shows the distribution of the 6,354 breeders of Thoroughbreds between 32 Irish Counties. It also highlights the number of mares owned and number of foals produced by those mares. The largest number of individual breeders are found in County Cork, but the largest concentration of mares are in County Kildare.

Included in this data is a figure for breeders not resident in an Irish county, but which have breeding stock permanently domiciled in Ireland. This has been categorised as "Other".

County	Breeders	Mares	Foals
Co. Cork	810	1,611	1,021
Co. Tipperary	799	1,783	1,089
Co. Kildare	707	1,936	1,170
Co. Wexford	555	940	601
Co. Meath	440	1,033	676
Co. Kilkenny	425	1,080	662
Co. Waterford	254	609	340
Co. Limerick	242	574	343
Co. Galway	203	368	187
Co. Down	181	367	220
Co. Westmeath	180	773	479
Co. Wicklow	148	351	192
Co. Laois	145	251	138
Co. Carlow	137	414	252
Co. Offaly	117	289	185
Co. Dublin	105	182	112
Co. Clare	82	152	82
Co. Roscommon	60	115	59

County	Breeders	Mares	Foals
Co. Armagh	46	68	33
Co. Antrim	44	97	44
Co. Mayo	39	60	27
Co. Kerry	37	84	43
Co. Louth	35	68	37
Co. Tyrone	33	53	25
Co. Longford	23	38	19
Co. Monaghan	22	28	16
Co. Cavan	19	27	13
Co. Sligo	11	17	9
Co. Fermanagh	9	15	6
Co. Donegal	8	11	7
Co. Leitrim	8	12	5
Co. Londonderry	8	20	8
Sub Total	***5,832***	***13,445***	***7,978***
Other	422	972	565
Total	**6,354**	**14,418**	**8,543**

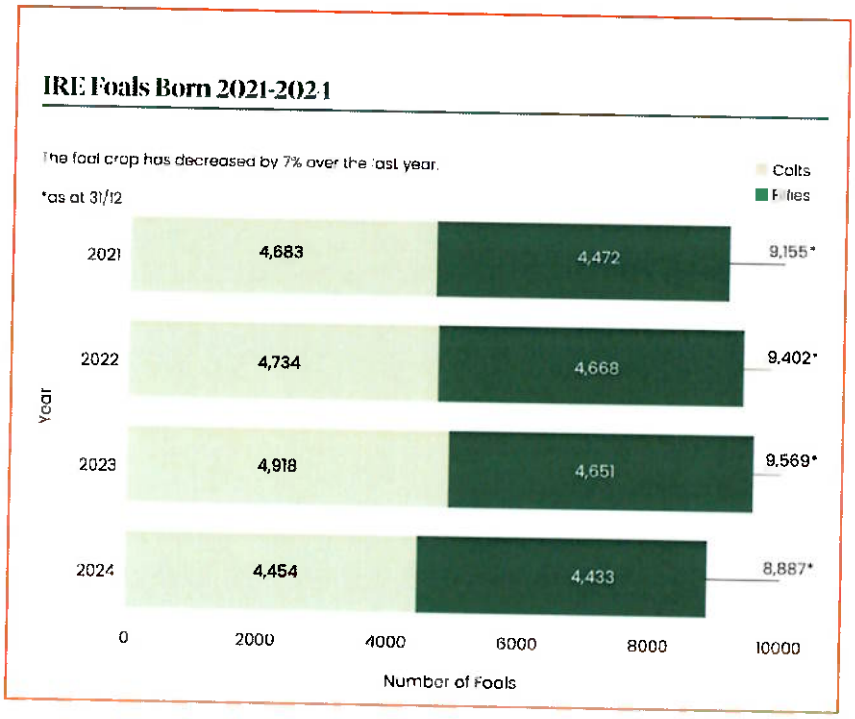
Number of IRE Broodmares Owned per Breeder

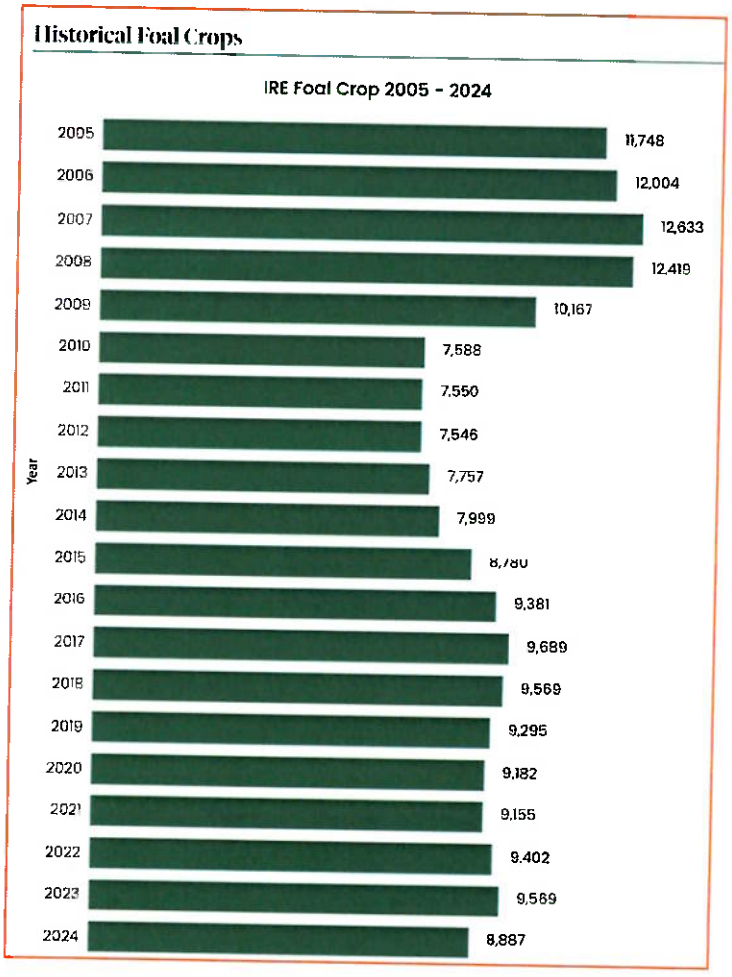
This table shows the distribution of Irish broodmares between breeders by county, with 92% of breeders owning fewer than 5 broodmares.

Included in this data is a figure for breeders not resident in an Irish county, but which have breeding stock permanently domiciled in Ireland. This has been categorised as "Other".

County	1-2	3-4	5-10	11-20	21-30	31+	Total
Co. Cork	689	84	46	7	3	1	**810**
Co. Tipperary	654	82	42	15	3	3	**799**
Co. Kildare	556	78	48	18	2	7	**707**
Co. Wexford	453	88	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**





Horses have been shown to have significant right forebrain dominance – they are exceptionally adept at processing sensory stimuli (Johnson et al. 2019). Because they are a prey species, the sensory systems of horses have evolved to enable a prompt detection of potential danger through a combination of visual, auditory and olfactory cues (Christensen et al. 2006, Saslow 2002, Tierartzliche Praxis 1997) and unexpected & hitherto unknown noises cause rapid flight reactions more frequently (Christensen et al. 2005, Algers 1984). Horses are most easily scared by noise that arises outside their field of binocular vision. Hearing ability is thus very important to the survival for horses over the centuries and a horse's ears can pick up sound at a lower level & at a greater distance than that detected by humans

(Saslow, 2002). A horse's range of hearing is greater than a humans to higher frequencies >33kHz while the range for humans is under 20kHz.

Horses can show unpredictable anxiety behaviours during any noise producing events, which include sweating, trembling, escape attempts, which may cause severe accidents for the horse and the rider/handler. More than 84% of horses show immediate avoidance and/or attempts to flee after perceived threats (Scopa et al. 2018).
Injury to riders/handlers, etc., is a significant occupational hazard and can extend to thousands of accidents with associated fatalities (Holler 1984, Gimsing 2001). Dealing with an anxious or fearful horse exacerbates this risk. There is a high rate of incidence of injury (26%) among horses rated as either anxious or very anxious in the face of noise and/or light related flashes, and simply moving horses to adjacent paddocks was found to be ineffective in 37% of cases (Gronqvist 2016) Noise has also been shown to elicit restlessness, vocalisation & colic/gastro-intestinal disturbances (Dai et al. 2020)

"Noise aversion" or "noise anxiety" are terms used when an animal overreacts to noise. Unpredictable noise causes the greatest fear reactions. These noises can have long lasting effects and have been reported to adversely affect food intake, growth and production rates (Broucek 2014, Tracy et al. 2007, Head et al. 1993).
Severe noise anxiety is reported to cause serious welfare consequences, impacting both the physiology and behaviour of the horse (Riva et al. 2022). Very anxious horses showed signs of noise reactivity and their reactions did not improve with time (they do not habituate with time). Very severe injuries can occur as a result of the unpredictable & very severe anxiety. Riva et al. have also shown that the effects of noise-related anxiety can persist for hours/days after the noise event. It is noteworthy that compared to visual and olfactory stimuli, unexpected unknown noises can cause rapid flight reactions.

Highly sensitive mares & newborn foals are particularly vulnerable to environmental stressors. O'Connor & Walsh (2021) emphasised that pregnant mares exhibit heightened sensitivity to noise and light fluctuations, which may interfere with gestation & increase the risk of premature birth or behavioural distress. Smith et al. (2020) reported that foals exposed to elevated noise levels during early development showed signs of sleep disruption, increased startle responses, and reduced social bonding behaviours. Green et al. (2021) noted that neonatal horses are especially susceptible to visual flicker and tonal noise, which can impair rest cycles and contribute to development instability. Chronic exposure to such stimuli may result in heightened stress responses, altered behaviour, and compromised physiological stability as evidenced by Jones et al (2019). They also noted increased agitation, visual stress, reduced rest patterns and avoidance behaviours in horses exposed to nearby wind farms.
Many management strategies are used to try to reduce the effects of noise and have been shown to be ineffective (Gronquvist, 2016). Placing horses in stables is unsatisfactory as those in single stables exhibit even stronger reactions to unknown stimuli with an increased risk of accidents and adverse effects on welfare, which can include long-term behavioural abnormalities (Lesimple et al. 2020). Sedation can often give disappointing results and cause undesirable side effects (Dai et al. 2020) & long-term sedation and or stabling is impractical & inhumane.

2025 Planning Authority Statements underscore the growing tension between renewable energy expansion and the protection of sensitive agricultural sectors, including equine studfarms. An Bord Pleanala (2025) reported that of the 69 energy cases reviewed in the period 2023 – 2024, several windfarms were refused as a result of objections citing proximity to studfarms. In several decisions, the Board cited concerns over elevated noise levels and their potential impact on equine welfare. The Board emphasised the need to balance strategic infrastructure development with environmental and agricultural sensitivities.

It is noted that ABP 23-225138 on appeal from Tipperary County Council 07/111 refused planning permission for a biogas & biodiesel production facility at Castleblake, Rosegreen, County Tipperary for the following reason:
"The site of the proposed development is located in open countryside in an area of national importance for the bloodstock industry alongside a major horse training establishment. It is the policy of the planning authority, as set out in the current South Tipperary Development Plan, to support the equine industry. It is also the policy of Government to support the equine sector. It is considered that the proposed development of this large scale industrial type facility at this location, employing the particular technology on the scale proposed, having regard to its nature, scale and visual impact, would be incompatible with equine related activities in the vicinity and would be prejudicial to the viability of the equine industry in this area(including undermining confidence therein). Notwithstanding the desirability of providing such facilities, it is considered that the proposed development would seriously injure the amenities of the area and property in the vicinity, would be incompatible with the surrounding land uses, and would, therefore, be contrary to the said Development Plan objectives and to national policy and to proper planning and sustainable development of the area."
"The equine industry and in particular the bloodstock industry is a highly competitive commercial industry, which needs a high quality in relation to environmental standards and what could best be described as a clean image. The

area of County Tipperary has developed a niche industry comparable with other bloodstock areas as for example Newmarket & Kentucky with major financial benefits to the area and any consideration of permitting development must have consider policy ENV11, for proposals for non-agriculture related development."

The Planning Inspector Derek Daly noted that it could be necessary and appropriate to invoke the Precautionary Principle *"as we are not talking about just any agricultural operation, but one of the international leaders, a business that carries Ireland's reputation in the bloodstock industry and one which the local economy benefits well beyond the level were it to be on only local, or minimal standing."*
The Planning Inspector's report also noted that it should be a consideration in the planning process if one successful enterprise of benefit to an area's economy is placed at risk by a development, which is not by its nature locationally tied to the area. The Planning Inspector stated that *"the onus is on any new development in the rural area and in particular non-agricultural development, which for reasons already outlined is not specifically locationally dependent to a rural area to demonstrate that it will not have a negative impact on the viability of existing stud farms or stables and that it is reasonable to consider the development in this context."*

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5.3.9 **Tourism**

5.3.9.1 **Tourism Numbers and Revenue**

Tourism is one of the major contributors to the national economy and is a significant source of full-time and seasonal employment. The report "Key Tourism Facts 2024"28, pertaining to domestic and international tourism volumes for Ireland, was published by Failte Ireland in August 2025 for the year 2024. In 2024, out-of-state (Overseas and Northern Ireland) tourist expenditure amounted to €6.6 billion. With a further €1.5 billion spent by overseas visitors on fares to Irish carriers, taking foreign exchange earnings to €8 billion. Domestic tourism expenditure amounted to €3.6 billion, making tourism a €12 billion industry. The Central Statistics Office's estimates the number of people employed in 'Tourism Industries' to be 226,300 in Q3 2024 through an alternative method of estimating employment using PAYE tax data. Note that self-employed and primarily pensioners are excluded from the headcount.

Key Tourism Facts 2024, published in 2025 does not provide the same level of detail in terms of tourist numbers and expenditure as previous years of the same report as a result of a change in the CSO's data collection methodology, however, it does note that

"Every €1m of tourist expenditure helps to support 20 employees in tourism industries."

The Republic of Ireland is divided into seven tourism regions. Table 5-6 shows the total revenue and breakdown of overseas tourist numbers to each region in Ireland during 2024 ('Key Tourism Facts 2024, Fáilte Ireland, August 2025).

Table 5-6 Overseas Tourists Revenue and Numbers 2014 (Source: Failte Ireland)

Region	Total Revenue (€m)	Total Number of Non-Domestic Tourists (000s)
Dublin	€2,383m	4,094
Mid-East/Midlands	**€536m**	804
South-East	€323m	530
South-West	€1,168m	1,442
Mid-West	€536m	827
West	€847m	1,226
Border	€376m	525
Total	**€6,169 m**	9,448

The Proposed Project is located within the Mid-East/Midland Region. According to "Island of Ireland Overseas Tourism Performance Facts and Figures 2023" (Tourism Ireland, 2023), the Mid-East/Midland Region which comprises Counties Offaly, Kildare, Laois, Longford, Louth, Meath, Westmeath and Wicklow, benefited from approximately 8.7% of the total number of overseas tourists to the country and approximately 9.0% of the associated tourism income generated in Ireland in 2023.

Response from MLavelle: 8 counties out of 26 counties receive 9% of income generated. It is obvious that Windfarms can be associated with these small amounts.

Table 5-7 presents the breakdown of overseas tourist numbers and revenue to the Midlands region during 2017 ('2017 Topline Tourism Performance by Region, Fáilte Ireland, August 2018)29. As can be seen below, County Offaly has the second highest number of overseas tourists visiting the Region during 2017 and tourism revenue at €46 million.

Response from MLavelle: Offaly receives €46million from €6,169million nationally or 0.745% of tourism income. So, Offaly has the highest number of MWper person per county from windfarms & has a miserable 0.745% tourist income. Obviously, windfarms don't attract tourists.

Table 5-7 Overseas Tourism to West Region during 2017 (Source: Fáilte Ireland)

County	Revenue Generated by Overseas and Domestic Tourists (€m)	No. of Overseas Tourists (000s)
Laois	44	43
Longford	28	24
Offaly	46	52
Westmeath	64	103

5.8.3.1.5 ***Tourism***

Pre-Mitigation Impact

Proposed Project

While there is a tourist attraction located within the Proposed Project site (i.e., Banagher Line), considering the human interference there is potential for a negative, slight, long-term impact on tourism, which is Not Significant, during the operational phase of the Proposed Project.

Response from MLavelle: This agent would describe the effects of the 1847 Famine similarly.

Reference Number : 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.

Table 3. Illustrative quotations regarding negative impacts of onshore-windfarms.

Visitors do not like wind-turbines in such an area of outstanding beauty they are noisy and ugly to look at
Visitors do not want to come to Northumberland because of Wind-turbines blighting the previous beautiful landscape and the noise
TOURISTS come to Northumberland for beautiful unspoilt countryside, not to see huge wind-turbines in every direction
People's perception of Northumberland is of a wild and beautiful place and the wind-turbines have immediately destroyed this perception and are an ugly intrusion into the loneliness of the last wildernesses in England
This county's assets – namely tranquillity/peace/landscapes is blighted by more than [its] fair share of windfarms. Def a turn off for visitors
Regular guests have said they won't return because of the number of wind-turbines has spoiled the landscape
People say they don't like them and we are ruining the countryside. They can't believe it
Most people we meet hate turbines
Potential visitors are put off because the inland areas they visit have been blighted by wind-turbines
Many [visitor] comments are along the lines of an amazement that we do not appreciate the amazing landscape that we have and seem prepared to intrude turbines into many of the most iconic views
Repeat business customers now going elsewhere, and new business customers have heard about the impact of OWTs on Northumberland

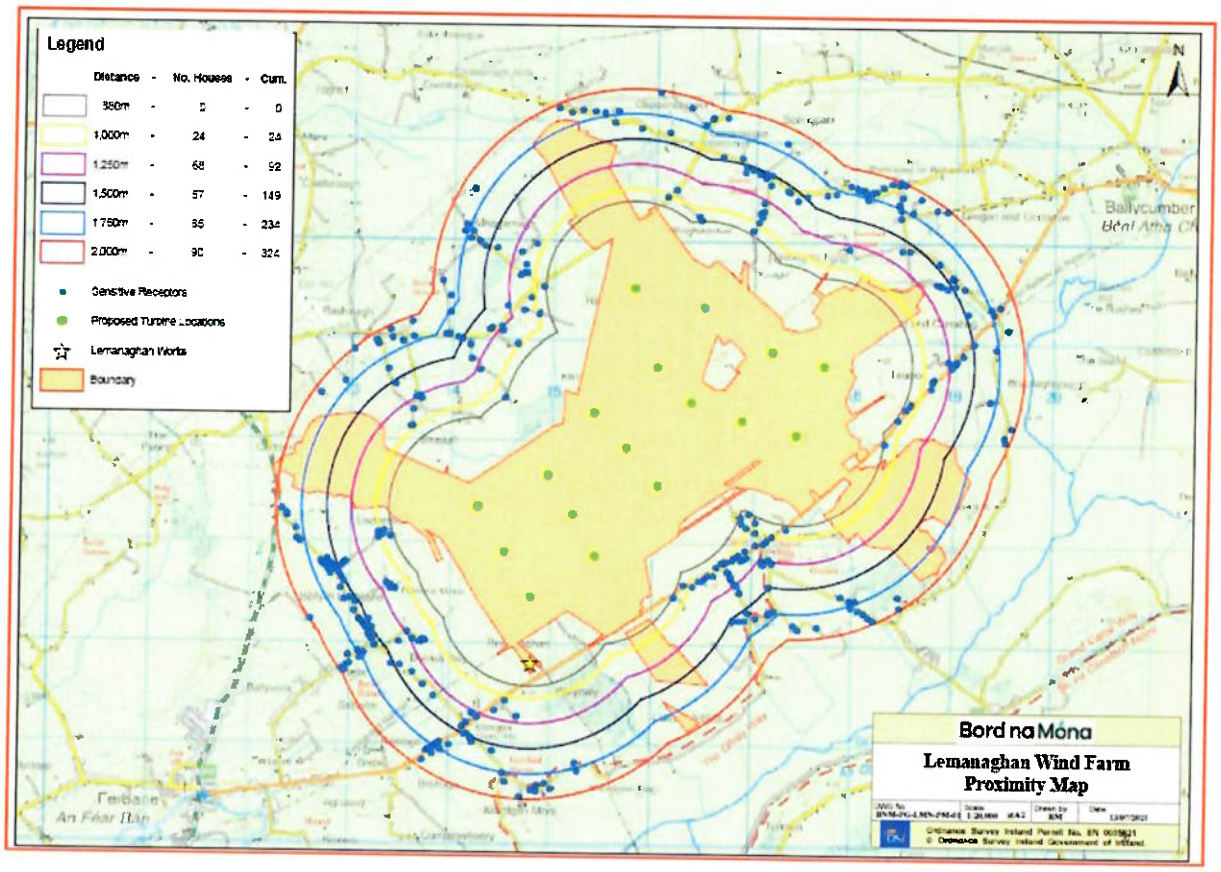
Table 4. Illustrative quotations on whether onshore-windfarms will affect business investment decisions.

I will not invest in something where visitors do not want to come because of the presence of wind-turbines
It they continue, we will consider selling and moving to another part of the UK
If tourists don't like them and numbers decrease why invest? I would rather invest in a Gite business in France!
No point investing in our property if values will be affected
My guests come here for its peace, tranquillity, silence and fantastic vistas. Ugly, useless turbines spoiling that will not help to attract business
Will direct investment to other parts of the country
People come to Northumberland top see the fabulous undeveloped countryside not look at vulgar man made monstrosities
We have reached a stage where the turbines are affecting the landscape, more will make this a less desirable destination not worth investing in!
Onshore windfarms are ruining the natural beauty of Northumberland, our guests will go elsewhere for a proper rural escape
They are an eyesore as we live in the country at the moment we have fabulous views. If a windfarm was to set up. We would close our wedding business, sell up and 22 jobs would be lost. This would be because no one would want to get married with a view to those ugly things. You would kill our business off, devalue our property and ensure that jobs are lost in an area where there are few jobs to begin with
We would consider buying property elsewhere to develop as tourism accommodation but not in any area where there is a windfarm
Windfarms will be impossible to avoid and are an anachronism to those coming to enjoy big skies and landscapes
If there will be more onshore wind-turbines planned in this area, we do not know if we want to stay here anymore/move the business elsewhere
There's absolutely no point in putting money into a holiday property indeed into our own home as we'll never get the value back when we sell if an array of turbines are built as proposed near our village
North Northumberland no longer offers the OWT free landscape required by many visitors

5.4.2 **Health Effects of Wind Farms: Studies**

While there are anecdotal reports of negative health effects on people who live very close to wind turbines, peer-reviewed research has generally not supported these statements. There is currently no published credible scientific evidence to positively link wind turbines with adverse health effects. The main publications supporting the view that there is no evidence of any direct link between wind turbines and health are summarised below.

Response from MLavelle: Absolute nonsense.



"Wind Turbine Sound and Health Effects – An Expert Panel Review" – American Wind Energy Association and Canadian Wind Energy Association, **December 2009**

'Wind Turbine Syndrome – An independent review of the state of knowledge about the alleged health condition' – Expert Panel on behalf of Renewable UK, **July 2010**

'Wind Turbines and Health: A Rapid Review of the Evidence' – Australian Government National Health and Medical Research Council (NHMRC), **July 2010**

'Position Statement on Health and Wind Turbines' – Climate and Health Alliance, **February 2012**

'Wind Turbine Health Impact Study – Report of Independent Expert Panel' –Massachusetts Departments of Environmental Protection and Public Health, **January 2012**

"Wind Turbines and Health, A Critical Review of the Scientific Literature"– Massachusetts Institute of Technology (Journal of Occupational and Environmental Medicine Vol. 56, Number 11, **November 2014**)

'Environmental Noise Guidelines for the European Region' – World Health Organisation, Regional Office for Europe **January 2019**

'Infrasound Does Not Explain Symptoms Related to Wind Turbines' – Finnish Government's Analysis, Assessment and Research Activities (VN TEAS), **June 2020**

'The Health Effects of 72 Hours of Simulated Wind Turbine Infrasound: A Double-Blind Randomized Crossover Study in Noise-Sensitive Health Adults' – Woolcock Institute for Medical Research et al. (Environmental Health Perspectives, Vol. 131, Number 3, **March 2023**

5.4.2.1 **Other Studies**

A further 25 reviews of the scientific evidence that universally conclude that exposure to wind farms and the sound emanating from wind farms does not trigger adverse health effects, were compiled in September 2015 by Professor Simon Chapman, of the School of Public Health and Sydney University Medical School, Australia, and is included as Appendix 5-1 of this EIAR. Another recent publication by Chapman and Crichton (2017) entitled "Wind turbine syndrome; A communicated disease" critically discusses why certain health effects might often be incorrectly attributed to wind turbines.

Response from MLavelle: Most of these references relate to a historic period over 12 years ago, when turbines were far smaller. Read Appendix 2 of this submission.

The following Response is from the Australian Parliament in a reference to Health issues from windfarms outlined by Chapman.

Reference No 6 : 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 theconsequences 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.6

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.11

2.16 The committee has had the opportunity to take evidence from researchers in the United States and Canada who expressed their concern with the health effects of turbines. Ms Lilli-Ann Green is the Chief Executive Officer of a healthcare consulting firm in the United States. In 2012, Ms Green and her husband conducted interviews with people living near wind turbines in 15 different countries. As she told the committee: We have interviewed people on three continents who live more than five miles from the nearest wind turbine and are sick since wind turbine wind turbines need to be sited from people in order to do no harm. People report to us that over time their symptoms become more severe. Many report not experiencing ill effects for some time following wind turbine construction, meanwhile their spouse became ill the day the wind turbines nearby became operational. They speak of thinking they were one of the lucky ones at first, but after a number of months or years they become as ill as their spouse. Not one person who stayed near wind turbines reported to us that they got used to it or got better; they all became more ill over time… I really believe that we just do not have enough information yet. But throughout the interviews, country by country, people described the same symptoms. Many times they used the same phrases to describe them and the same gestures—and they were not speaking English. There is a common thread here.

2.17 Dr Jay Tibbetts, a medical practitioner and vice chair of the Brown County Board of Health in Wisconsin, drew the committee's attention to the board's October 2013 finding that the Shirley wind farm was a 'human health hazard'. Dr Tibbetts described how the declaration came about:

The [Board of Health] has been studying adverse health effects for the past 4 ½ years in the Shirley Wind Project. We have reviewed many peer reviewed studies, at least 50 medical complaints including ear pain, pressure, headache, tinnitus, vertigo, nausea, chest pain, chest pressure, loss of concentration, sleep deprivation and more, as well as more than 80 other complaints from citizens of Shirley Wind. There have been 2 formal studies of infrasound/low frequency noise by acousticians in 2012 and 2014. The latter study revealed symptom generating [Infrasound/Low Frequency Noise] at a distance of 4 ½ [miles].

2.18 The committee also heard of detailed research by Professor Emeritus Robert McMurtry from Western University in Ontario, Canada. Professor McMurtry made a number of points to the committee:

• adverse health effects have been reported globally in the environs of wind turbines for more than 30 years with the old design of turbines and the new;
• the wind energy industry has denied adverse health effects, preferring to call it 'annoyance'. Annoyance is recognised and was treated by the World Health Organization as an adverse health effect, which is a risk factor for serious chronic disease including cardiovascular and cancer;
• the regulations surrounding noise exposure are based upon out-of-date standards ETSU-97, which fail to evaluate infrasound and low-frequency

Professor Chapman and his critics

2.19 Professor Simon Chapman AO, Professor of Public Health at the University of Sydney, has been an outspoken critic of those who suffer ill-effects from wind turbines. In both his written and oral submissions, Professor Chapman cited many of his own publications in support for his view that:

…the phenomenon of people claiming to be adversely affected by exposure to wind turbines is best understood as a communicated disease that exhibits many signs of the classic psychosocial and nocebo phenomenon where negative expectations can translate into symptoms of tension and anxiety.

2.20 Several highly qualified and very experienced professionals have challenged this argument. Dr Malcolm Swinbanks, an acoustical engineer based in the United Kingdom, reasoned:

The argument that adverse health reactions are the result of nocebo effects, ie a directly anticipated adverse reaction, completely fails to consider the many cases where communities have initially welcomed the introduction of wind turbines, believing them to represent a clean, benign form of low-cost energy generation. It is only after the wind-turbines are commissioned, that residents start to experience directly the adverse nature of the health problems that they can induce.

2.21 The committee highlights the fact that Professor Chapman is not a qualified, registered nor experienced medical practitioner, psychiatrist, psychologist, acoustician, audiologist, physicist or engineer. Accordingly:

• he has not medically assessed a single person suffering adverse health impacts from wind turbines;
• his research work has been mainly—and perhaps solely—from an academic perspective without field studies;
• his views have been heavily criticised by several independent medical and acoustic experts in the international community; and
• many of his assertions do not withstand fact check analyses.

2.22 Professor Chapman has made several claims which are contrary to the evidence gathered by this committee. First, he argues that the majority of Australia's wind turbines have never received a single complaint. There are various problems with this statement:

(i) wind turbines located significant distances from residents will not generate complaints;

(ii) many residents suffering adverse health effects were not aware of any nexus between their health and the impact of wind turbines in order to make a complaint;

(iii) just because residents do not lodge a formal complaint does not mean they are not suffering adverse health effects;

(iv) data obtained by Professor Chapman from wind farm operators of the numbers of complaints lodged cannot be relied upon; and

(v) the use of non-disclosure clauses and 'good neighbour agreements' legally restricts people from making adverse public statements or complaints.

2.23 Second, Professor Chapman has argued that complaints of adverse health effects from wind turbines tend to be limited to Anglophone nations. However, the committee has received written and oral evidence from several sources directly contradicting this view. The German Medical Assembly recently submitted a motion to the executive board of the German Medical Association calling for the German government to provide the necessary funding to research adverse health effects. This would not have happened in the absence of community concern. Moreover, Dr Bruce Rapley has argued that in terms of the limited number—and concentrated nature—of wind farm complaints:

It is the reporting which is largely at fault. The fact is that people are affected by this, and the numbers are in the thousands. I only have to look at the emails that cross my desk from all over the world. I get bombarded from the UK, Ireland, France, Canada, the United States, Australia, Germany. There are tonnes of these things out there but, because the system does not understand the problem, nor does it have a strategy, many of those complaints go unlisted.

2.24 Third, Professor Chapman has queried that if turbines are said to have acute, immediate effects on some people, why were there no such reports until recent years given that wind turbines have operated in different parts of the world for over 25 years. Several submissions to the committee have stated that adverse health effects from wind turbines do not necessarily have an acute immediate effect and can take time to manifest.

2.25 Fourth, Professor Chapman contests that people report symptoms from even micro-turbines. The committee heard evidence that once people are sensitised to low frequency infrasound, they can be affected by a range of noise sources, including large fans used in underground coal mines, coal fired power stations, gas fired power stations and even small wind turbines. As acoustician Dr Bob Thorne told the committee:

Low-frequency noise from large fans is a well-known and well-published issue, and wind turbines are simply large fans on top of a big pole; no more, no less. They have the same sort of physical characteristics; it is just that they have some fairly unique characteristics as well. But annoyance from low-frequency sound especially is very well known.

2.26 Fifth, Professor Chapman contends that there are apparently only two known examples anywhere in the world of wind turbine hosts complaining about the turbines on their land. However, there have been several Australian wind turbine hosts who have made submissions to this inquiry complaining of adverse health effects.

Paragraphs 2.11–2.12 (above) noted the example of Mr Clive Gare and his wife from Jamestown. Submitters have also directed attention to the international experience.

In Texas in 2014, twenty-three hosts sued two wind farm companies despite the fact that they stood to gain more than $50 million between them in revenue. The committee also makes the point that contractual non-disclosure clauses and 'good neighbour' agreements have significantly limited hosts from speaking out. This was a prominent theme of many submissions.

2.27 Sixth, Professor Chapman claims that there has been no case series or even single case studies of so-called wind turbine syndrome published in any reputable medical journal. But Professor Chapman does not define 'reputable medical journal' nor does he explain why the category of journals is limited to medical (as distinct, for assertion. However, the committee does note that a decision to publish—or not to publish—an article in a journal is ultimately a business decision of the publisher: it does not necessarily reflect the quality of the article being submitted, nor an acknowledgment of the existence or otherwise of prevailing circumstances. The committee also notes that there exist considerable published and publicly available reports into adverse health effects from wind turbines.

2.28 The committee also notes that a peer reviewed case series crossover study involving 38 people was published in the form of a book by American paediatrician Dr Nina Pierpont, PhD, MD. Dr Pierpont's *Report for Clinicians* and the raw case data was submitted by her to a previous Australian Senate inquiry (2011) to which Dr Pierpont also provided oral testimony. Further, at a workshop conducted by the NHMRC in June 2011, acoustical consultant Dr Geoffrey Leventhall stated that the symptoms of 'wind turbine syndrome' (as identified by Dr Pierpont), and what he and other acousticians refer to as 'noise annoyance', were the same. Dr Leventhall has also acknowledged Dr Pierpont's peer reviewed work in identifying susceptibility or risk factors for developing wind turbine syndrome / 'noise annoyance'. Whilst Dr Leventhall is critical of some aspects of Dr Pierpont's research, he does state:

Pierpont has made one genuine contribution to the science of environmental noise, by showing that a proportion of those affected have underlying medical conditions, which act to increase their susceptibility.30

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 Number 7 :

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:*
    - *Cows: Reduced fertility (Canada); fertility and structural issues (Japan); and mortality (France)*
    - *Goats: Reduced fertility and health problems (Canada)and mortalities in 450 of 700 (Taiwan)*
    - *Horses: Leg deformities (Portugal)*
    - *Emu: Mortalities in 30 of 38 and reduced laying (Canada)*
    - *Mink: 1600 miscarriages and birth defects (Denmark)*
    - *Badgers: High cortisol levels, an indicator of stress (UK)*
    - *Other effects.*

Reference Number : 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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An tOifig Náisiúnta um Sláinte
Chomhshaoil
Feidhmeannacht na Seirbhise Sláinte,
Urlár 2, Teach na Darach, Ascaill na Teile
Páirc na Milaoise, An Nás, Co. Chill Dara.

National Office for Environmental Health Services
2nd Floor, Oak House, Lime Tree Avenue
Millennium Park, Naas, Co. Kildare
Eircode: W91KDC2

T: 045 880 442
ehnationaloffice@hse.ie

HSE EIA Scoping

Environmental Health Service Submission Report

Date:	31.5.21
Our reference:	EHIS 1781
Report to:	Mr David Naughton, MKO, Tuam Road, Galway
Consultant's reference:	200804
Type of Consultation:	EIA Scoping
Proposed development:	Proposed Lemanaghan Wind Farm, Co. Offaly
Applicant:	Bord na Mona Powergen Ltd

The following HSE departments were made aware of the consultation request for the proposed development on 5.5.21-

- Emergency Planning – Brendan Lawlor
- Estates – Helen Maher

- Assistant National Director for Health Protection – Kevin Kelleher /Laura Murphy
- CHO – Pat Bennett

The following documents should be taken into consideration when preparing the Environmental Impact Assessment Report:

- Guidelines on the information to be contained in EIS (2002), 187kb
- Advice Notes on Current Practice in the preparation of EIS (2003), 435kb
- Guidelines for Planning Authorities and An Bord Pleanála on carrying out Environmental Impact Assessment

https://www.housing.gov.ie/sites/default/files/publications/files/guidelines_for_planning_authorities_and_an_bord_pleanála_on_carrying_out_eia_-_august_2018.pdf

EU publication: Environmental Impact Assessment of Projects Guidance on the preparation of the Environmental Impact Assessment Report, EU, 2017

http://ec.europa.eu/environment/eia/pdf/EIA_guidance_EIA_report_final.pdf

Adoption of the Directive (2014/52/EU) in April 2014 initiated a review of the above guidelines. The draft new guidelines can be seen at:

http://www.epa.ie/pubs/consultation/reviewofdrafteisguidelinesadvicenotes

Generally the Environmental Impact Assessment should examine all likely significant impacts and provide the following information for each:

a) Description of the receiving environment;

b) The nature and scale of the impact;

c) An assessment of the significance of the impact;

d) Proposed mitigation measures;

e) Residual impacts.

Directive 2014/52/EU has an enhanced requirement to assess likely significant impacts on Population and Human Health. It is the experience of the Environmental Health Service (EHS) that impacts on human health are often inadequately assessed in EIAs in Ireland. It is recommended that the wider determinants of health and wellbeing are considered in a proportionate manner when considering the EIA. Guidance on wider determinants of health can be found at www.publichealth.ie

In addition to any likely significant negative impacts from the proposed development, any positive likely significant impacts should also be assessed.

The HSE will consider the final EIAR accompanying the planning application and will make comments to the relevant planning authority on the methodology used for assessing the likely significant impacts and the evaluation criteria used in assessing the significance of the impact.

This report only comments on Environmental Health Impacts of the proposed development. It is based on an assessment of the correspondence submitted to this office dated 4th May 2021.

The Environmental Health Service (EHS) recommends that the following matters are included and assessed in the EIAR

- Public Consultation
- Decommissioning phase
- Siting and location of turbines
- Opportunity for Health Gain
- Noise & Vibration
- Shadow Flicker
- Air Quality
- Surface and Groundwater Quality
- Geological Impacts
- Ancillary facilities and cumulative impacts

Public Consultation

It is strongly recommended that early and meaningful public consultation with the local community is carried out to ensure all potentially significant impacts have been adequately addressed.

All parties affected by the proposed development, including those who may benefit financially from the project, must be fully informed of what the proposal entails especially with regard to potential impacts on surrounding areas.

Sensitive receptors and other stakeholders should be identified to ensure all necessary and appropriate mitigation measures are put in place to avoid any complaints about the proposed wind farm development in the future.

It is acknowledged that current restrictions around public gatherings as a result of Covid 19 prevention measures will impact on opportunities for public consultation events. However it is expected that meaningful public consultation, where the local community is fully informed of the proposed development, will be undertaken. Members of the public should be given sufficient opportunities to express their views on the proposal wind farm and any concerns raised should be addressed within the EIAR.

The Environmental Impact Assessment Report (EIAR) should clearly demonstrate the link between public consultations and how those consultations have influenced the decision-making process in the EIA.

To assist with the consultation and planning process it is recommended that the applicant develops a dedicated website for the proposed wind energy project. All correspondence, maps, project updates and documentation including the EIAR should be uploaded to the website.

Decommissioning Phase

The EIAR should detail what the eventual fate of the turbines and associated material will be, i.e. will the material be recycled or how will it be disposed of.

Information should also be provided regarding the proposed methodology to be used for the disposal of the materials forming the foundations of the wind turbines.

The EIAR should indicate the proposed future use of the wind farm site at the end of the planning permission period.

Siting, Location and details of Turbines

The EIAR should include a map and a description of the proposed location of each of the proposed wind turbines.

The Environmental Health Service expects that details (height and model) of the turbines to be installed will be available at the time planning permission is sought and will be included in the EIAR.

Details of turbine foundation structures, including depth, quantity and material to be used should also be included in the EIAR.

Opportunity for Health Gain

The EPA has issued guidance with regard to meeting the requirements of Directive 2014/52/EU which assesses the impact of certain public and private projects on the environment. The proposed development should be assessed with a view to the potential to include opportunities for health gain within the site of the proposed wind farm by including greenways, cycle-paths or walking trails within the development site.

Assessment of Consideration of Alternatives

The EIAR should consider an assessment of alternatives. The EHS recommends that alternative renewable energy options to on shore wind farms should be assessed as part of the EIAR.

Noise & Vibration

The potential impacts for noise and vibration from the proposed development on all noise sensitive locations must be clearly identified in the EIAR. The EIAR must also consider the appropriateness and effectiveness of all proposed mitigation measures to minimise noise and vibration.

A baseline noise monitoring survey should be undertaken to establish the existing background noise levels. Noise from any existing turbines in the area should not be included as part of the back ground levels.

In addition, an assessment of the predicted noise impacts during the construction phase and the operational phase of the proposed wind farm development must be undertaken which details the change in the noise environment resulting from the proposed wind farm development.

The Draft Revised Wind Energy Development Guidelines were published in December 2019. Whilst these have yet to be adopted, any proposed wind farm development should have consideration of the draft Guidelines.

https://www.housing.gov.ie/sites/default/files/public-consultation/files/draft_revised_wind_energy_development_guidelines_december_2019.pdf

Shadow Flicker

It is recommended that a shadow flicker assessment is undertaken to identify any dwellings and sensitive receptors which may be impacted by shadow flicker. The assessment must include all proposed mitigation measures. Dwellings should include all occupied properties and any existing or proposed properties for which planning consent has been granted for construction or refurbishment.

It is recommended that turbine selection will be based on the most advanced available technology that permits shut down during times when residents are exposed to shadow flicker. As a result no dwelling should be exposed to shadow flicker.

Air Quality

Due to the nature of the proposed construction works generation of airborne dust has the potential to have significant impacts on sensitive receptors. A Construction Environmental Management Plan (CEMP) should be included in the EIAR which details dust control and mitigation measures. Measures should include:

- Sweeping of hard road surfaces
- Provision of a water bowser on site, regular spraying of haul roads
- Wheel washing facilities at site exit
- Restrict speed on site
- Provide covers to all delivery trucks to minimise dust generation
- Inspect and clean public roads in the vicinity if necessary
- Material stockpiling provided with adequate protection from the wind
- Dust monitoring at the site boundary
- Truck inspection and maintenance plan

- Details of a road maintenance agreement between the wind farm operator and the Local Roads Authority to clarify responsibility for the upkeep and repair of access roads during the construction phase of the project.

Surface and Ground Water Quality

The proposed development has the potential to have a significant impact on the quality of both surface and ground water. All drinking water sources, both surface and ground water, must be identified. Public and Group Water Scheme sources and supplies should be identified. Measures to ensure that all sources and supplies are protected should be described. The Environmental Health Service recommends that a walk over survey of the site is undertaken in addition to a desktop analysis of Geological Survey of Ireland data in order to identify the location of private wells used for drinking water purposes.

Any potential significant impacts to drinking water sources should be assessed. Details of bedrock, overburden, vulnerability, groundwater flows, aquifers and catchment areas should be considered when assessing potential impacts and any proposed mitigation measures.

Geological impacts

A detailed assessment of the current ground stability of the site for the proposed wind farm and all proposed mitigation measures should be detailed in the EIAR. The assessment should include the impact construction work may have on the future stability of ground conditions, taking into consideration extreme weather events, site drainage and the potential for soil erosion.

Information should be provided on the make and model of the turbines and on construction details for the turbine foundations, including the depth and volume of concrete required. An accurate assessment of the potential impacts of the foundations on water quality and peat stability cannot be undertaken without this information.

Ancillary Facilities

The EIAR should include details of the location of all site office, construction compound, fuel storage depot, sanitary accommodation and canteen, First Aid facilities, disposal of wastewater and the provision of a potable water supply to the site canteen.

Cumulative Impacts

It is noted from the information provided in the Scoping document that, should the proposed Lemanaghan Wind Farm be granted planning permission, there will be between 49 and 53 wind turbines within 20km of the proposed site. The cumulative impact on sensitive receptors of the proposed wind farm when considered with other wind farms in the vicinity should be addressed in the EIAR

The location and number of turbines in existing or proposed wind farm developments in the vicinity should be clearly identified in the EIAR.

The EIAR should state clearly if there is any future proposal to extend the proposed Lemanaghan Wind Farm.

Caroline Hueston
Environmental Health Officer
Environment Operational Unit
HSE West
Ennistymon Health Centre
Ennistymon
Co. Clare

Edel Mulholland

From: Andrew Sulley <Andrew.Sulley@hse.ie>
Sent: Wednesday 4 December 2024 13:29
To: Edel Mulholland
Subject: Scoping EIA for Lemanaghan Wind Farm Offaly HSE Observations
Attachments: Proposed Lemanaghan Wind Scoping EIA HSE Observations (4312).pdf

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Caution: This is an external email and may be malicious. Please take care when clicking links or opening attachments.

FAO: Edel Mulholland
Graduate Environmental Scientist
McCarthy Keville O'Sullivan Ltd
E-mail: emulholland@mkoireland.ie
Your ref:

Client:	Lemanaghan Wind Farm DAC
Project Title:	Proposed Lemanaghan Wind Farm, Co. Offaly
Project Number:	200804
Document Title:	EIAR Scoping Document
Document File Name:	Revised EIAR Scoping Doc – F – 2024.10.22- 200804

Please find observations of the HSE National Environmental Health Service on the scoping of the EIA for the above project.

Could we put on record that any formal consultation in the planning process with the HSE should always be adressed to National Environmental Health Service at: environmental.health@hse.ie
This will ensure any stakeholders in the HSE are informed of the consultation. This should include notification of applications made directly to An Bord Pleannala.

Regards,

Andrew Sulley

Oifigeach Sláinte Comhshaoil Sinsearach/Senior Environmental Health Officer
Timpeallacht Athrú Aeráide Aonad Tacaíochta Líonra/Environment Climate Change Network Support Unit

Seirbhís Náisiúnta Sláinte Comhshaoil, FSS/ National Environmental Health Service, HSE
Holland, Páirc Theicneolaíochta Plassey, Luimneach/ Holland Road, Plassey Technological Park, Limerick

"Tá an fhaisnéis sa ríomhphost seo (ceangaltáin san áireamh) faoi rún. Bíodh sé ceaite amháin agus tá sé ar intinn go bhfaighfidh sladsan amháin é agus gurb ladsan amháin a dhéanfaidh breithniú air. Más rud é nach tusa ar duine ar leis é, tá cosc iomlán ar aon fhaisnéis ata ann, a úsáid, a chraobhscaoileadh, a scaipeadh, a nochtadh, a fhoilsiú, ná a chóipeáil. Séanis gurb iad tuairimí pearsanta an údair atá san ríomhphost agus nach tuairimí FSS iad.

Má fuair tú an ríomhphost seo trí dhearmad, bheadh muid buíoch dá gcuirfea in iúl don Deasc Seirbhísí ECT ar an nguthán ag +353 818 300300 nó ar an ríomhphost chuig service.desk@hse.ie agus ansin glan an ríomhphost seo de' chóras."

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Feidhmeannacht na Seirbhíse Sláinte,
Urlár 2, Teach na Darach, Ascaill na Teile
Páirc na Milaoise, An Nás, Co. Chill Dara.

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Eircode: W91KDC2

FAO: Edel Mulholland

Graduate Environmental Scientist
McCarthy Keville O'Sullivan Ltd
E-mail: emulholland@mkoireland.ie
Your ref:

Client:	Lemanaghan Wind Farm DAC
Project Title:	Proposed Lemanaghan Wind Farm, Co. Offaly
Project Number:	200804
Document Title:	EIAR Scoping Document
Document File Name:	Revised EIAR Scoping Doc – F – 2024.10.22- 200804

HSE EIA Scoping

National Environmental Health Service Submission Report

Date:	2nd December 2024
Our reference:	EHIS ID4312
Report to:	Edel Mulholland
Type of Consultation:	EIA Scoping

Proposed development:

Lemanaghan Wind Farm, Co. Offaly

The following HSE stakeholders were consulted on the scoping on the 24th October 2024:

- Emergency Planning
- National Capital Estates Office
- Director of National Health Protection
- REO Dublin and Midlands

Clarification on the content of this submission should be made, in the first instance, to Andrew.sulley@hse.ie

General Introduction

The following documents should be taken into consideration when preparing the Environmental Impact Assessment Report:

- Guidelines for Planning Authorities and An Bord Pleanála on carrying out Environmental Impact Assessment

https://www.housing.gov.ie/sites/default/files/publications/files/guidelines_for_planning_authorities_and_an_bord_pleanála_on_carrying_out_eia_-_august_2018.pdf

EU publication: Environmental Impact Assessment of Projects Guidance on the preparation of the Environmental Impact Assessment Report, EU, 2017

http://ec.europa.eu/environment/eia/pdf/EIA_guidance_EIA_report_final.pdf

Adoption of the Directive (2014/52/EU) in April 2014 initiated a review of the National Guidance for EIA and the EIAR accompanying a planning application. New guidelines can be seen at:

https://www.epa.ie/publications/monitoring--assessment/assessment/guidelines-on-the-information-to-be-contained-in-environmental-impact-assessment.php

The introduction of the new Guidance is supported by a Webinar produced by the EPA and can be found at:

https://www.youtube.com/embed/ejKVFUztxBY

The applicant should also consider the findings of the High Court judgement issued in the judicial review of the Derryadd Wind Farm. (2021 IEHC 390 [20202 No. 557 JR] P. Sweetman v An Bord Pleanála)

Generally the Environmental Impact Assessment should examine all likely significant impacts and provide the following information for each:

a) Description of the receiving environment;

b) The nature and scale of the impact;

c) An assessment of the significance of the impact;

d) Proposed mitigation measures;

e) Residual impacts.

Directive 2014/52/EU has an enhanced requirement to assess likely significant impacts on Population and Human Health. It is the experience of the National Environmental Health Service (NEHS) that impacts on human health are often inadequately assessed in EIAs in Ireland. It is recommended that the wider determinants of health and wellbeing are considered in a proportionate manner when considering the EIA. Guidance on wider determinants of health can be found at www.publichealth.ie

In addition to any likely significant negative impacts from the proposed development, any positive likely significant impacts should also be assessed.

The HSE will consider the final EIAR accompanying the Planning application and will make comments to the Local Planning Authority on the methodology used for assessing the likely significant impacts and the evaluation criteria used in assessing the significance of the impact.

The National Environmental Health Service (EHS) recommends that the following matters are included and assessed in the EIAR

- Public Consultation
- Decommissioning phase of the proposed wind farm
- Siting and location of turbines
- Noise & Vibration
- Shadow Flicker
- Air Quality
- Surface and Groundwater Quality
- Geological Impacts
- Ancillary facilities
- Cumulative impacts

Public Consultation

It is recommend that early and meaningful public consultation with the local community is undertaken to ensure all potentially significant impacts of the proposed windfarm development have been adequately addressed.

All parties affected by the proposed development, including those who may benefit financially from the project, must be fully informed of what the proposal entails especially with regard to potential impacts on surrounding areas.

Sensitive receptors and other stakeholders should be identified to ensure all necessary and appropriate mitigation measures are put in place to reduce the likelihood of any complaints about the proposed wind farm development in the future.

The National Environmental Health Service expects that meaningful public consultation, where the local community is fully informed of the proposed development, will be undertaken. Members of the public should be given sufficient opportunity to express their views on the proposed windfarm development.

The Environmental Impact Assessment Report (EIAR) should clearly demonstrate the link between public consultations and how those consultations have influenced the decision-making process in the EIA.

To assist with the consultation and planning process it is recommended that the applicant develops a dedicated website for the proposed windfarm development. All correspondence, maps, project updates and documentation including the EIAR should be uploaded to the website

The EIAR should state the period of planning permission sought, the length of time construction is estimated to take and if it is anticipated that the windfarm development will be decommissioned and removed or will continue to operate (following any further planning consent) at the end of this period of planning permission (should permission be granted)

Decommissioning

The EIAR should detail the eventual fate of the wind turbines and associated material i.e. will the material be recycled or how will it be disposed of.

Information should also be provided regarding the proposed methodology to be used for the disposal of the materials forming the foundations of the wind turbines.

The EIAR should indicate the proposed future use of the development site at the end of the planning permission period.

Siting, Location and details of Turbines

The EIAR should include a map and a description of the proposed location of each of the proposed wind turbines.

The National Environmental Health Service expects that details (height and model) of the turbines to be installed will be available at the time planning permission is sought and will be included in the EIAR.

Details of the foundations for the wind turbine including depth, quantity and material to be used should be included in the EIAR.

Assessment of Consideration of Alternatives

The EIAR should consider an assessment of alternatives. The NEHS recommends that alternative renewable energy options to on- shore wind farms should be assessed as part of the EIAR.

Noise & Vibration

The potential impacts for noise and vibration from the proposed development on all noise sensitive locations must be clearly identified in the EIAR. The EIAR must also consider the appropriateness and effectiveness of all proposed mitigation measures to mitigate noise and vibration.

A baseline noise monitoring survey should be undertaken to establish the existing background noise levels. Noise from any existing turbines in the area should not be included as part of the back ground levels.

In addition, an assessment of the predicted noise impacts during the construction phase and the operational phase of the proposed windfarm development must be undertaken which details the change in the noise environment resulting from the proposed development.

The Draft Revised Wind Energy Development Guidelines were published in December 2019. Whilst these have yet to be adopted, any proposed wind farm development should have consideration of the draft Guidelines.

https://www.housing.gov.ie/sites/default/files/public-consultation/files/draft_revised_wind_energy_development_guidelines_december_2019.pdf .

Shadow Flicker

It is recommended that a shadow flicker assessment is undertaken to identify any dwellings and sensitive receptors which may be impacted by shadow flicker. The assessment must include all proposed mitigation measures. Dwellings should include all occupied properties and any existing or proposed properties for which planning consent has been granted for construction or refurbishment.

It is recommended that turbine selection will be based on the most advanced available technology that permits shut down during times when residents are exposed to shadow flicker. As a result no dwelling should be exposed to shadow flicker.

Air Quality

Due to the nature of the proposed construction works generation of airborne dust has the potential to have significant impacts on sensitive receptors. A Construction Environmental Management Plan (CEMP) should be included in the EIAR which details dust control and mitigation measures. Measures should include:

- Sweeping of hard road surfaces
- Provision of a water bowser on site, regular spraying of haul roads

- Wheel washing facilities at site exit
- Restrict speed on site
- Provide covers to all delivery trucks to minimise dust generation
- Inspect and clean public roads in the vicinity if necessary
- Material stockpiling provided with adequate protection from the wind
- Dust monitoring at the site boundary
- Truck inspection and maintenance plan
- Details of a road maintenance agreement between the wind farm operator and the Local Roads Authority to clarify responsibility for the upkeep and repair of access roads during the construction phase of the project

Surface and Ground Water Quality

The proposed development has the potential to have a significant impact on the quality of both surface and ground water. All drinking water sources, both surface and ground water, must be identified. Public and Group Water Scheme sources and supplies should be identified in addition to any private wells supplying potable water to houses in the vicinity of the proposed development. Measures to ensure that all sources and supplies are protected should be described. The National Environmental Health Service recommends that a walk over survey of the site is undertaken in addition to a desktop analysis of Geological Survey of Ireland data in order to identify the location of private wells used for drinking water purposes.

Any potential significant impacts to drinking water sources should be assessed. Details of bedrock, overburden, vulnerability, groundwater flows, aquifers and catchment areas should be considered when assessing potential impacts and any proposed mitigation measures.

Any impacts on surface water as a result of the construction of the underground cables should be identified and addressed in the EIAR.

Geotechnical and Peat Stability Assessment

A detailed assessment of the current ground stability of the site for the proposed windfarm development and all proposed mitigation measures should be detailed in the EIAR. The assessment should include the impact construction work may have on the future stability of ground conditions, taking into consideration extreme weather events, site drainage and the potential for soil erosion.

Information should be provided on the make and model of the turbines and on construction details for the turbine foundations, including the depth and volume of concrete required. An accurate assessment of the potential impacts of the foundations on water quality and peat stability cannot be undertaken without this information.

Reference is made to a peat slide which occurred near Ballybofey in Co. Donegal on 13th November 2020 which may have been linked to construction activity at Meenbog Wind Farm. Potential impacts on water supply associated with contamination following a peat slide include sedimentation and alteration of pH levels.

The National Environmental Health Service recommends that a detailed Peat Stability/Geotechnical Assessment should be undertaken to assess the suitability of the soil for the proposed development. The EIAR should include provision for a peat stability monitoring programme to identify early signs of potential bog slides ('pre-failure indicators' see the Scottish Government's 'Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Developments 2017) https://www.gov.scot/binaries/content/documents/govscot/publications/advice-and-guidance/2017/04/peat-landslide-hazard-risk-assessments-best-practice-guide-proposed-electricity/documents/00517176-pdf/00517176-pdf/govscot%3Adocument/00517176.pdf

Ancillary Facilities

The EIAR should include details of the location of all site office, construction compound, fuel storage depot, sanitary accommodation and canteen, First Aid facilities, disposal of wastewater and the provision of a potable water supply to the site canteen.

Cumulative Impacts

All existing or proposed wind farm developments in the vicinity should be clearly identified in the EIAR.

The impact on sensitive receptors of the proposed development combined with any other wind farm/renewable energy developments in the vicinity should be considered. The EIAR should include a detailed assessment of any likely significant cumulative impacts of the proposed windfarm development.

Andrew Salley
Senior Environmental Health Officer

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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.

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RE: YSYS-RH-2026-02-0384 Internal Review

Dear Ms Dowling,

Thank you for your request for an internal review into your Your Service Your Say complaint, received by my department on April 9, 2026.

As Regional Director of Public Health and as a rural resident, I can understand concerns in relation to any new developments, and their potential environmental and human health impacts.

Our department works very closely with our colleagues in the National Environment Health Service [NEHS] and its regional principal environmental health officers in all aspects of potential environmental hazards and risks that may have an impact on human health.

The HSE has a statutory remit in making observations in relation to any and all planning applications in the country. This remit is non-compulsory, meaning the HSE and its regional authorities will not make an observation on every development application. Primarily and ordinarily, in the first instance, the NEHS is the lead authority in making observations in relation to environmental health impacts of a proposed development. Procedurally, where a potential environmental risk has been identified by HSE Environmental Health, Public Health will be notified and a risk assessment team may be convened to advise the next steps in relation to population health.

As previously stated, at present, there is currently no active, official Public Health guidance in relation to wind turbines in Ireland. In 2025, the HSE withdrew its previously published public health advice relating to same following concerns that some elements of the position paper were outdated. Therefore, the National Health Protection Office (NHPO) is now planning to review and update the withdrawn advice, with the view of presenting and establishing new guidance that is robust in current expert-led evidence, in line with international standards. This will enable us to formally comment on planning issues similar to the planning application in question.

The absence of such guidelines does not preclude Public Health from exercising the precautionary approach. The precautionary approach, in this instance, must be supported by an evidence-based mechanism, through HSE Environmental Health or/and established patterns—or risks thereof—of ill health and wellbeing among an exposed population. We have not received either.

It is best practice to follow a national, standardised approach of making such observations. Otherwise, there is a high risk of inconsistent or contradictory Public

Health advice and recommendations that would create more confusion and distrust. In this instance, we are bound by national guidelines which are currently unavailable.

However, I am of the firm view that Public Health needs guidelines in the interim. That is why we will be writing to the HSE National Health Protection Office to prioritise the completion of the new guidance, in addition to producing interim guidance so that we can act in a timely manner where local authorities require our observations on such applications.

Your correspondence, views, and concerns are appreciated and understood, and is an impetus for us to suggest improvements in our service.

Independent Review

If you remain dissatisfied following the outcome of the HSE review, you may refer your complaint to the Office of the Ombudsman for an independent review.

The Ombudsman is independent of the HSE and can examine complaints about public services.

You can contact the Office of the Ombudsman at:

Website: www.ombudsman.ie

Telephone: 01 639 5600

Email: info@ombudsman.ie

Please note that the Ombudsman will generally expect that all stages of the HSE complaints process have been completed before accepting a complaint.

I hope that the above explanation is helpful to you.

Yours Sincerely

Mai Mannix

Dr Mai Mannix

Regional Director of Public Health.

Public Health HSE Mid West

This response is made within the clearly stated objective of the National Environmental Health Service (NEHS) submission dated 22nd January 2025:

The objective of any observations by the NEHS are to inform the Planning Authority on any likely significant effects on Public Health and give an opinion on any proposed mitigation to protect Public and Environmental Health. Any observations made are to inform and assist the decision making of the Planning Authority in the planning process.

Response of the NEHS

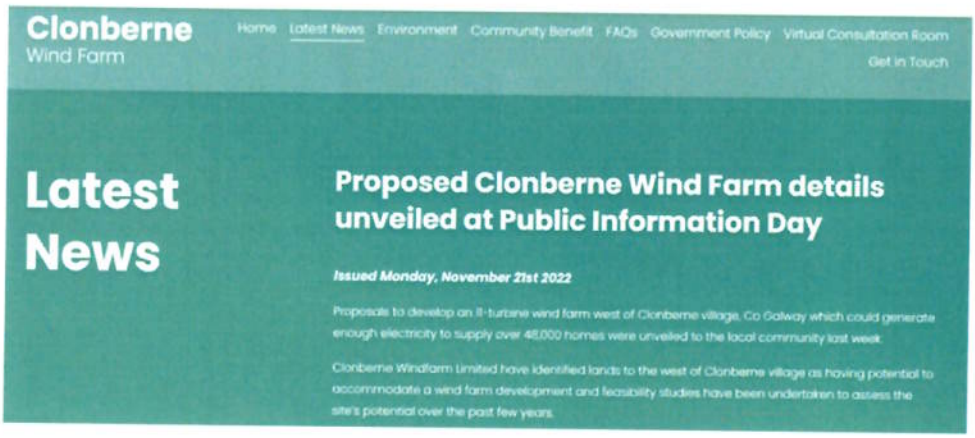
General Comments

The notification to the Developer by ACP dated 22nd December 2025 clearly states that notification of the additional information should be published on the dedicated website for the development.

From the EIAR

Project Website

A dedicated project website (https://www.clonbernewindfarm.com) was designed and went live on November 17th, 2022, in the immediate aftermath of the Public Information Event. The website was regularly updated with the latest information over the following months as the project plans took shape. The website contained an FAQ section answering the most frequently asked questions about the Proposed Project, as well as details about the government's wind energy policies under the Climate Action Plan. The website also contained contact information for the project CLO.



As of the 21st of January 2026, this website has no public record of being updated since the 21st of November 2022. The website does not contain any details of the EIA or the Planning Application or the Additional Information. There is no public evidence to support the statement that this has been regularly updated. It is a statutory requirement that the public have access to environmental information and public consultation in the EIA process

FI response on Webster/Rollo v Meenaclogher (Wind) limited (2014 IEHC 136) 8th March 2024 [7].

The Submission then refers to the 2019 Draft WEDG [6], 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* [7]. This was a private nuisance case in respect of noise received at a dwelling from the operation of a nearby wind turbine development. NEHS note that the judge stated that she could consider nuisance irrespective of any compliance with consent conditions. Whilst this is true, it is nothing new, and TNEI recognise that compliance with a set of conditioned noise limits is not usually sufficient on its own to demonstrate that no nuisance is present. This is the case for all noise generating developments, not just wind turbines. Care needs to be taken, however, 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, although the following is noted from the NEHS submission, which states (in respect of the High Court Decision);

'the judgement is clear in paragraph 277 that consent decisions for development based on strong rationale and consideration of best practice are more likely to be considered reasonable protection from nuisance than those where "for example the planning permission is opaque in its rationale, where the science in the area has moved on since the grant of permission or where the particular matt er complained is incompletely regulated by the permission (paragraph 277)".

In this regard we would note that the assessment of operational noise for the Proposed Development has been undertaken in accordance with recognised best practice and with due regard to the latest science. This is discussed in detail in Section 2.1.2.

The NEHS is aware that Planning and Nuisance operate under different legal frameworks and makes the following comments in response to the FI response:

a) Care has been taken not to confuse the difference between the statutory planning regime and private nuisance actions.
b) The NEHS is aware that potential noise nuisance is not limited to wind farm developments.
c) No statutory function or activity of any State Agency operates within a legal silo that has no cognisance to rulings of the Courts in areas that might have relevance to their decision making. It's perfectly reasonable to consider this judgement within the planning regulatory framework.
d) The judgement is project and materially specific, but the judgement was that there was a nuisance during the operation of the wind turbines. It is reasonable to consider what elements caused this that are specific to wind turbines when considering consent for a similar project.
e) It is reasonable to consider the judgement when making a decision on the adequate protection of Public Health for this proposed development. The Planning Authority should be satisfied that, as far as is reasonably foreseeable, the wind farm they are consenting will not create the same nuisance and they are conditioning adequate mitigation to prevent nuisance, if required.

2.1.1 NEHS Submission – 'Project Specific Guidance for Wind Energy Development'

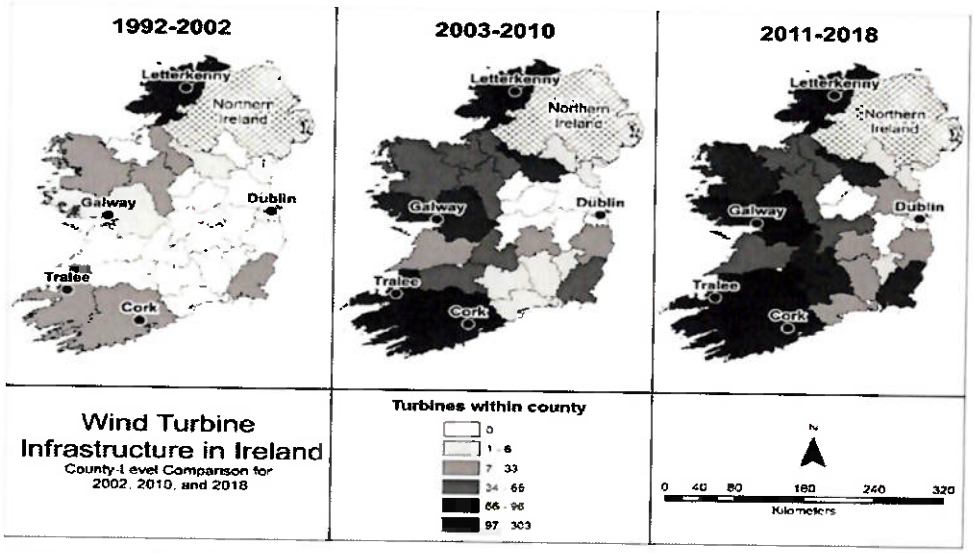
The NEHS Submission states that the current guidelines for wind energy development are the 2006 Wind Energy Development Guidelines (WEDG 2006) but goes on to note that since the publication of those guidelines the nature of wind turbine development has changed e.g. larger turbines, cumulative effects 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 (addressed below).

The Submission then refers to the 2019 Draft WEDG [6], 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.

The NEHS makes the following comments on the above:

Change in Location of Wind Turbine Development

In 1996 when the ETSU R-97 Guidance was drafted, which were subsequently adopted as the assessment methodology in the Irish WEDG 2006, wind turbines were typically located in rural areas in coastal regions with high separation distances from communities. (Ref: Adaptive responses to landscape changes from onshore wind energy development in the Republic of Ireland, September 2020, Land Use Policy, 97:104751, DOI: 10.1016/j.landusepol.2020.104751)



Wind turbine distribution in Ireland from 1992-2002, 2003-2010, and 2011-2018. Although only nine counties remained without reported turbines in 2018, development followed a temporally and spatially uneven trajectory The Border, Southwestern, and Western counties experienced sustained construction from the onset, while Midwestern and Southeastern counties experienced construction beginning in the early 2000s, and the Mideastern, Midlands, and Dublin-area counties have little development.

Change in Scale and Size of Wind Turbine Development

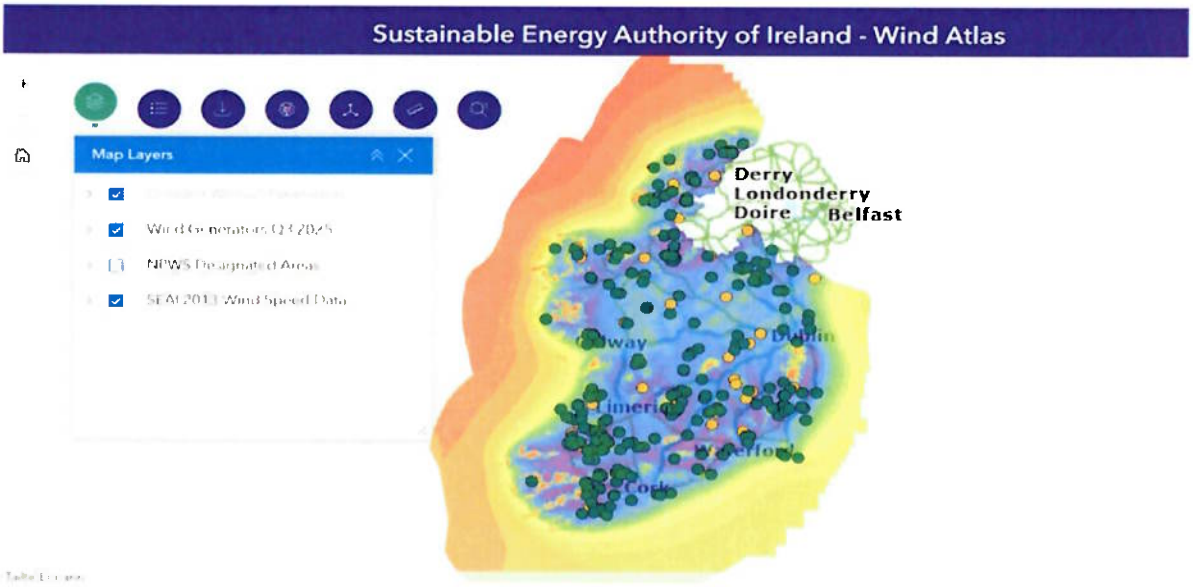
Prior to the publication of the WEDG 2006 the average hub height was between 80 to 100m (source https://www.seai.ie/sites/default/files/publications/Community-Toolkit-Onshore-Wind.pdf)

Current wind energy development have proposed hub heights of up to 200m with the highest operating is currently **176m** at the Oweninny Wind Farm.

When considering any guidance in a development process it is perfectly reasonable to consider it in a context of the following - if the nature and scale of the development has significantly changed then elements of the guidance might not continue to meet the objectives of the guidance.

Change in Number of Wind Turbine Development and Proximity to Previous Development

Ireland now has over 300 Windfarms. They are often developed in the same areas of wind resources and consequently cumulative impacts are significantly different than in 1996.



Lived Experiences of Communities

Since the publication of ETSU R 97 and the adoption of methodology into the WEDG 2006 decision makers now have the benefit of submissions from lived experiences of communities around wind turbine development. This is the basis for the NEHS statement about the change in our body of knowledge around the effects of development.

Noise assessment in EIA is predictive methodology, and it is completely reasonable when using predictive methodology over a period of time (In this case nearly 20 years) to also consider the outcomes of implementing the predictive methodology on those impacted by it. There are significant community concerns (this development had 184 3rd party submissions) pre wind farm development and post wind farm development (for example details of 270 reported complaints for wind farm development in Offaly released by the Local Authority). This is a common pattern. The NEHS considers all large scale development of wind turbines and in the last 5 years cannot identify a single proposed development that has not had significant concerns raised by the community pre-construction.

The NEHS position is as stated and can be summarised as:

1. The nature, characteristic and location of wind farm development has changed since the issuing of ETSU R 97 and the WEDG 2006.
2. There are now potential cumulative impacts of a magnitude that might not have been envisaged when WEDG 2006 was published.
3. There is a growing body of people who are impacted by wind farm development who either don't think implementation of ETSU R 97 and the current WEDG 2006 will adequately protect their health (submissions pre-development) or don't think the implementation of the predictive methodology has adequately protected their health (post development complaints). These are genuine concerns and warrant consideration by the National Environmental Health Service and the Planning Authorities in their decision making.
4. It should be noted that the NEHS has not formed an opinion on the merits of pre -development submissions or post development complaints around wind farms, but it is reasonable and rational for the NEHS to bring these concerns to the attention of the Planning Authority to add to their body of knowledge when making decisions.

With regard to the FI response stating it is not clear whether the NEHS supports the use of the draft 2019 Guidelines.

NEHS are stating that there are 2019 draft Guidelines and this is a clear indication that the WEDG 2006 require updating. Whilst they have not yet been adopted, the Planning Authority should be aware that there was a consensus 7 years ago that the existing Guidance needed updating and a process started.

On launch of the consultation the Minister said that:

The draft guidelines propose the following main changes to the current Guidelines:

- new noise standards: The draft guidelines include proposed new standards aimed at reducing noise nuisance from wind energy developments for local residents and communities. The proposed new standards are in line with the most up-to-date international standards, as incorporated in the 2018 World Health Organisation Environmental Noise Guidelines for the European Region. The permitted noise levels will take account of certain noise characteristics specific to wind energy projects i.e. tonal, amplitude modulation and low frequency noise and provide penalties for tonal noise and amplitude modulation and a threshold for low frequency noise above specified limits which, if breached, will result in turbine shut down. The implementation of a new robust noise monitoring framework is also proposed

https://www.gov.ie/en/department-of-housing-local-government-and-heritage/press-releases/ministers-murphy-and-bruton-publish-draft-wind-energy-development-guidelines-for-public-consultation/

The draft 2019 Guidance has not been adopted but that does not mean that the issues that they are addressing around noise, are not relevant to the current decision making.

2.1.2 NEHS Submission – 'Likely Significant Effects from Noise and Vibration'

Part 2 of the Submission is split out into eight paragraphs denoted as *a-h*. 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. It is noted that the EIA has used the upper limit of 40 dB for evaluation of significance.*

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).

This FI response is clarification on the WEDG 2006 noise exposure criteria. The NEHS submission is stating that using these criteria permits a significant change in the existing noise environment in existing low background areas. Low background areas are areas where any change in the noise environment will have an effect. Significant changes of over 10 dB(A) will have a significant effect.

a) The rationale given in WDG 2006 as to where the limit should be set between 35dB(A) or 40 dB(A) is based on the ETSU R 97

22. In low noise environments the day-time level of the $L_{A90,10min}$ of the wind farm noise should be limited to an absolute level within the range of 35-40dB(A). The actual value chosen within this range should depend upon a number of factors:

- the number of dwellings in the neighbourhood of the wind farm
- the effect of noise limits on the number of kWh generated
- the duration and level of exposure.

There are no criteria for any of these variables specified. The default position in EIA is 40 dB(A) which then permits significant increasing above the existing, low, background noise environment. The draft 2019 Guidance states 35dB(A) will be the default position in low background areas. The rationale given for this is the protection of residents from nuisance noise.

The quote in the FI response from the WEDG 2006

> **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).

These are adopted limits from ETSU R 97 but doesn't represent the rationale for setting the noise limits. The rationale in ETSU R 97 is clear in that it is a standard that primarily facilitates development and not health protection standard; for example:

INTRODUCTION

1. This document describes a framework for the measurement of wind farm noise and gives indicative noise levels thought to offer a reasonable degree of protection to wind farm neighbours, without placing unreasonable restrictions on wind farm development or adding unduly to the costs and administrative burdens on wind farm developers or local authorities.

11. The recommendation of the Noise Working Group is that, generally, the noise limits should be set relative to the existing background noise at nearest noise-sensitive properties and that the limits should reflect the variation in both turbine source noise and background noise with wind speed. We have also considered whether the low noise limits which this could imply in particularly quiet areas are appropriate and have concluded that it is not necessary to use a margin above background approach in such low-noise environments. This would be unduly restrictive on developments which are recognised as having wider national and global benefits. Such low limits are, in any event, not necessary in order to offer a reasonable degree of protection to the wind farm neighbour.

https://assets.publishing.service.gov.uk/media/5a798b42ed915d07d35b655a/ETSU_Full_copy_Searchable_.pdf

It is reasonable and rational for the NEHS to make observations to the Planning Authority that the use of this standard permits an increase in the existing noise levels of over 10 dB(A) in low noise background areas and the reason why this standard permits this is because, if it didn't, it would be 'unduly restrictive on development'.

c) *This 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 [8], 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 assessment 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's a reasonable and rational assumption to make that if you increase the noise exposure in a residential building of up to 15 dB(A) there is likely to be complaints about it. Especially if the existing background noise level is low.

If it was a comment of interpretation and implementation of BS4142 then the NEHS makes the following response:

a) The NEHS observations do not at any stage purport to interpret BS4142 methodology or assessment criteria. The reference to BS4142 is purely to demonstrate that there are authoritative Standards that recognise a change in a noise environment can have significant adverse effects and a magnitude of 10 dB(A) would be considered significant. The technicalities of rating and assessment are not the relevant aspects of the content of the NEHS submission.
b) The NEHS does not completely disregard any assessment methodology in the submissions. No regard is being made to the assessment methodology either stage 1 or stage 2 in the submission. The fundamental point that the NEHS has made - that an increase of up to 15 dB(A) from existing background noise levels is likely to be a significant impact - is not addressed in the FI response.
c) The NEHS submission does not state that BS4142 is an appropriate methodology for assessing wind farm development and does not make any observations in this regard. The FI response seems to infer that the NEHS is recommending this, which we are not.

d) *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.*

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-97is 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 [9]), 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."*

The NEHS considers any Guidance and Standards within an Irish context and not within a context of instruction given by the UK Government to their Regulatory Authorities. The 'final position' of the UK Government and how this impacts on the development process in the UK is a matter for the UK Government.

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 2025. 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 [12]. The Inspector nonetheless considered the approach appropriate and this was upheld when it was again challenged at a subsequent Judicial Review.

In the Case: Nagle View Turbine Aware Group v An Bord Pleanála, and Coom Green Energy the Office of Planning Regulator key takeaways included:

In the context of Section 28 guidelines, it is in principle lawful to have regard to draft guidelines as part of the evolving scientific context or in "illuminating what amounts to best practice", particularly where the existing guidelines are potentially viewed as outdated.

file:///C:/Users/andrewsulley/Downloads/Issue%2008_June%202025.%20Learning%20from%20Litigation%20Legal%20Bulletin%20(1).pdf

The Judicial Review supports the position of the NEHS that consideration should be given to evolving evidence and good practice in the protection of Public Health in the decision making process.

f) *The NEHS would consider the most appropriate criteria for assessing significance of the predicted noise is consideration if 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* [4]

g) *The WHO is the most authoritative body with regards to the evidence base that sets health protection standards.*

h) *The NEHS would consider it appropriate for the Planning Authority to use the existing noise data to carry out an assessment against the WHO 2018 Guidance noise criteria. This should include cumulative noise impacts from existing and planned wind farm development.*

TNEI Response: TNEI do not agree that the Environmental Noise Guidelines for the European Region, WHO 2018 (the WHO Guidelines) [13] 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.

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 2013 Guidelines are primarily an evaluation standard for health protection and are not an assessment methodology. It is reasonable and rational for the NEHS to consider a standard set by WHO to protect human health from exposure to noise, when making observations to a Planning Authority. Whether this is the appropriate criteria to assess likely significant effect on Population and Human Health in any consenting process for development, is a matter for the Planning Authority.

It should be noted though that in the Judicial Review Case the applicant specifically refers to as supporting current noise assessment methodology (Nagle View Turbine Aware Group v An Bord Pleanála, 2015) the 2019 Draft Guidelines are considered part of the 'illuminating what amounts to best practice'. The Who Guidelines are specifically referenced.

5.7.4 Preferred Draft Approach

The "preferred draft approach", announced by DHPCLG and DCCAE on 13th June 2017, proposed noise restriction limits consistent with World Health Organisation Guidelines, proposing a relative rated noise limit of 5dB(A) above existing background noise within the range of 35 to 43dB(A), with 43dB(A) being the maximum noise limit permitted, day or night. The noise limits will apply to outdoor locations at any residential or noise sensitive properties.

The preferred draft approach is based on 5 dB(A) above existing background noise with rating penalties to be applied if certain characteristics arise in the noise emanating from a wind energy development.

The preferred draft approach imposed the lower 35 dB(A) limit as a default until the 5 dB above background relative level exceeds this. This approach would ensure that noise levels from wind energy development are maintained at lower levels than those permitted under the 2006 planning guidelines.

https://assets.gov.ie/static/documents/draft-revised-wind-energy-development-guidelines-december-2019-385c92c2-16f9-4511-80bf.pdf

Reference Number 9: 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.

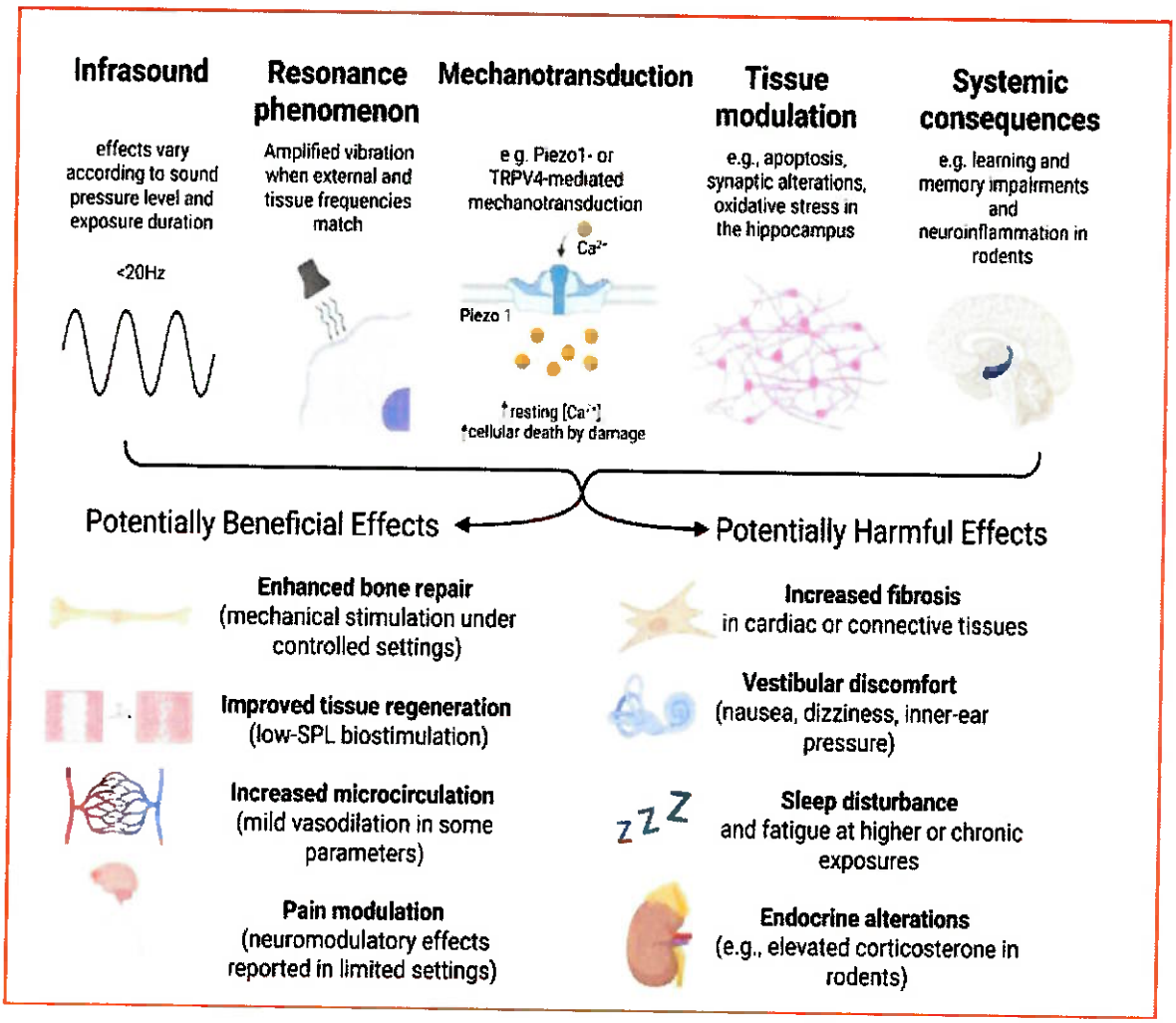
Exploratory field studies have suggested possible associations between low frequency components of wind turbine noise (20–200 Hz) and altered heart rate variability, but these findings cannot be attributed to infrasound and remain inconclusive.

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.



Overview of the biological mechanisms of infrasound. SPL—sound pressure level; TRPV4—transient receptor potential cation channel subfamily V member 4. Created with BioRender.com.

Research and case studies have shown that wind turbine noise can diminish concentration and cognitive performance. Correlation factors include sleep disturbances, increased annoyance, and stress. Lab studies that include EEG and

fMRI data show that relaxation and concentration become more difficult as infrasound levels increase. Thus, it can be assumed that, in proximity to wind turbines, there is a diminished cognitive function.

Sound-level weighting filters are commonly applied to account for the human ear's varying frequency sensitivity. A-weighting emphasizes mid-range frequencies (around 500 Hz–6 kHz) where human hearing is most sensitive, attenuating low- and high-frequency sounds, and is widely used for general noise assessment. C-weighting flattens the response at higher sound levels, giving more weight to low frequencies, and is often used to evaluate loud environments. G-weighting targets infrasound, emphasizing frequencies below 20 Hz and reflecting pressure fluctuations interacting with the body rather than perceived loudness. Z-weighting applies no frequency correction, providing a flat response across the audible and low-frequency ranges, which is essential for capturing the full energy content of environmental sound.

Salt and Kaltenbach demonstrated this underestimation in wind turbine sounds. At 10 Hz, A-weighting recorded no measurable sound, while C- and G-weighted measures, as well as unweighted measures, indicated pressures of 40–60 dB. In the 1 Hz range, C- and G-weighted measures remained similar, whereas the unweighted measure reached ~90 dB. These levels can stimulate inner hair cells on the basilar membrane and in various body cavities, demonstrating that sub-10 Hz turbine sounds are potent biological stimuli. The C-weighted scale, which reflects ear sensitivity at higher sound levels, provides a uniform gain from ~50 Hz to ~10 kHz and may capture effects on other organ systems. In contrast, the G-weighted scale, which is less aligned with perceived loudness, better represents pressure fluctuations that interact with the human body's intrinsic properties.

Individual sensitivity and context play major roles in occupational risk. Studies investigating highly sensitive populations, such as paramedics, have demonstrated that personal factors, including sensory processing sensitivity, age, and experience, can influence perceived burdensomeness of noise and infrasound exposure. Moreover, phenomena such as motion sickness, simulator sickness, or idiopathic environmental intolerance illustrate that symptoms may emerge even at exposure levels below conventional safety thresholds.

These findings highlight the need for occupational health protocols to consider both physical measurements and psychosocial factors when assessing potential risks, particularly in environments combining noise, vibration, confinement, and high cognitive demand.

Exposure to infrasound is an important environmental stressor that has received little attention and can have significant biological impacts on various body systems. Scientific evidence from cellular and animal studies, as well as limited human studies, indicates that high-intensity infrasound can induce oxidative stress, mitochondrial dysfunction, calcium accumulation, and activation of apoptotic pathways, ultimately leading to tissue damage and functional disorders in cardiovascular, nervous, and other systems. In vitro rodent models also provide compelling evidence of myocardial fibrosis, neuronal apoptosis, and oxidative imbalance in the hippocampus. Although human studies have yielded conflicting results, they indicate vascular and neurophysiological sensitivities at higher and chronic exposure levels. Ongoing research on PIEZO channels is increasingly revealing their importance in individual organs. Overall, evidence suggests that infrasound can modulate mechanical and biological pathways, thereby affecting the body's homeostatic balance.

5.5 Property Values

5.5.1 **Property Values and Wind Farms**

This section summarises the largest and most recent studies from the United States and the UK and also provides a summary of an Irish working paper from the Centre for Economic Research on Inclusivity and Sustainable (CERIS).

In 2023, CERIS published a working paper entitled "Wind Turbines and House Prices Along the West of Ireland: A Hedonic Pricing Approach".

Centre for Economic Research on Inclusivity and Sustainability (CERIS), 2023. Wind Turbines and House Prices Along the West of Ireland: A Hedonic Pricing Approach, Centre for Economic Research on Inclusivity and Sustainability (CERIS) Working Paper Series, 2023/01.

This paper looked at wind turbine developments in Donegal, Leitrim, Sligo, Mayo, Galway, Kerry and Cork and associated property values. This working paper utilised satellite imagery to identify individual turbines and sourced its housing data from www.daft.ie; while the published price on Daft.ie is not equivalent to the final agreed sale price, it was assumed that the listing and transaction prices are correlated. The findings of this research revealed a potential decrease in property values of 14.7% within a 0-1 km radius of a wind turbine. However, the sample size of only 225 houses within this range does not adequately represent the broader landscape of Irish rural housing and the distribution of wind turbines. The author states that there are "no significant reductions in house prices beyond 1km" and that the effects seen within the 1 km band were not persistent and diminished over the operational lifetime of the turbines. Considering that this is a working paper which has not been subject to peer review, and that it is based on a small sample size where local conditions have the potential to disproportionately impact the local housing market, further research is required before relying on its findings.

One of the largest studies of the impact of wind farms on property values has been carried out in the United States. "The Impact of Wind Power Projects on Residential Property Values in the United States: A multi-Site Hedonic Analysis", Hoen, B., Wiser, R. H., Cappers, P., Thayer, M. A., Sethi, G., 2009.

The Impact of Wind Power Projects on Residential Property Values in the United States: A multi-Site Hedonic Analysis was carried out at the Lawrence Berkley National Laboratory (LBNL) for the U.S Department of Energy. This study collected data on almost 7,500 sales of single-family homes situated within c. 16km (ten miles) of 24 existing wind farms in nine different American states over a period of approximately ten years. The conclusions of the study are drawn from eight different pricing models including repeat sales and volume sales models. Each of the homes included in the study were visited to demonstrate the degree to which the wind facility was visible at the time of the sale, and the conclusions of the report state that "The result is the most comprehensive and data rich analysis to date on the potential impacts of wind energy projects on nearby property values."

The main conclusion of this study is as follows:

"Based on the data and analysis presented in this report, no evidence is found that home prices surrounding wind facilities are consistently, measurably, and significantly affected by either the view of wind facilities or the distance of the home to those facilities. Although the analysis cannot dismiss the possibility that individual or small numbers of homes have been or could be negatively impacted, if these impacts do exist, they are either too small and/or too infrequent to result in any widespread and consistent statistically observable impact."

In September 2023, Brunner et al. published "Commercial wind turbines and residential home values: new evidence from the universe of land-based wind projects in the United States". Brunner, E.J., Hoen, B., Rand, J., Schwegman, D., 2023. Commercial wind turbines and residential home values: new evidence from the universe of land-based wind projects in the United States. Energy Policy, 185, 113837. This study targeted urban counties in the United Stated with populations over 250,000 persons, and found that on average, after a commercial wind energy project is announced, houses located within c. 1.6km (1 mile) of a proposed wind energy project experience a decrease in value of **11%** relative to homes located within c. 4.8-8km (3-5 miles) of the proposed wind energy project. The decline in property values was found to recover post construction with property value impacts becoming relatively small (~2%) and statistically insignificant 9 years or more after project announcement (roughly 5 years after operation begins).

A study was commissioned by RenewableUK and carried out by the Centre for Economics and Business Research (Cebr) in **March 2014**. The findings of the study were produced in a report titled "The effect of wind farms on house prices

A study issued in **October 2016** 'Impact of wind Turbines on House Prices in Scotland' was published by Climate Exchange. The report presents the main findings of a research project estimating the impact on house prices from wind farm developments. It is based on analysis of over 500,000 property sales in Scotland between 1990 and 2014.

The UK's scientific literature is strong in its conclusions that there are no significant effects on the change in price of properties close to wind farm developments, and that generally the county-wide property market drives local house prices, not the presence or absence of wind farms. This literature is contradictory to the working paper containing the only Irish study on the topic.

5.8.2.1.4 ***Property Values***

Pre-Mitigation Impact

Proposed Wind Farm

As noted in Section 5.5.1 above, the available scientific literature demonstrates that there is insufficient evidence from the scientific literature and studies conducted to determine that there is the potential for a significant effect on property values as a result of the Proposed Wind Farm. The impact assessment on property values outlined below takes a precautionary approach and assumes that based on the inconclusive evidence summarised above in Section 5.5.1, there is the potential for negative, slight, short-term impacts on property values, which is Not Significant, located within 1 km of the proposed turbines during the construction phase of the Proposed Wind Farm.

5.8.3.1.4 ***Property Values***

Pre-Mitigation Impact

Proposed Wind Farm

As noted in Section 5.5.1 above, the available scientific literature demonstrates that there is insufficient evidence from the scientific literature and studies conducted to determine that there is the potential for a significant effect on property values as a result of the Proposed Wind Farm. The impact assessment on property values outlined below takes a precautionary approach and assumes that based on the inconclusive evidence summarised above in Section 5.5.1, there is the potential for negative, slight, short-term impacts on property values, which is Not Significant, located within 1 km of the proposed turbines during the early operational phase of the Proposed Wind Farm.

Response from MLavelle: The quoted studies are from a time when wind turbines were a lot smaller than the present application.

Note the wind turbine sizes in Perceval 2003. They were far smaller:

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 [20]	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 [9]	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.* 1996; 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.

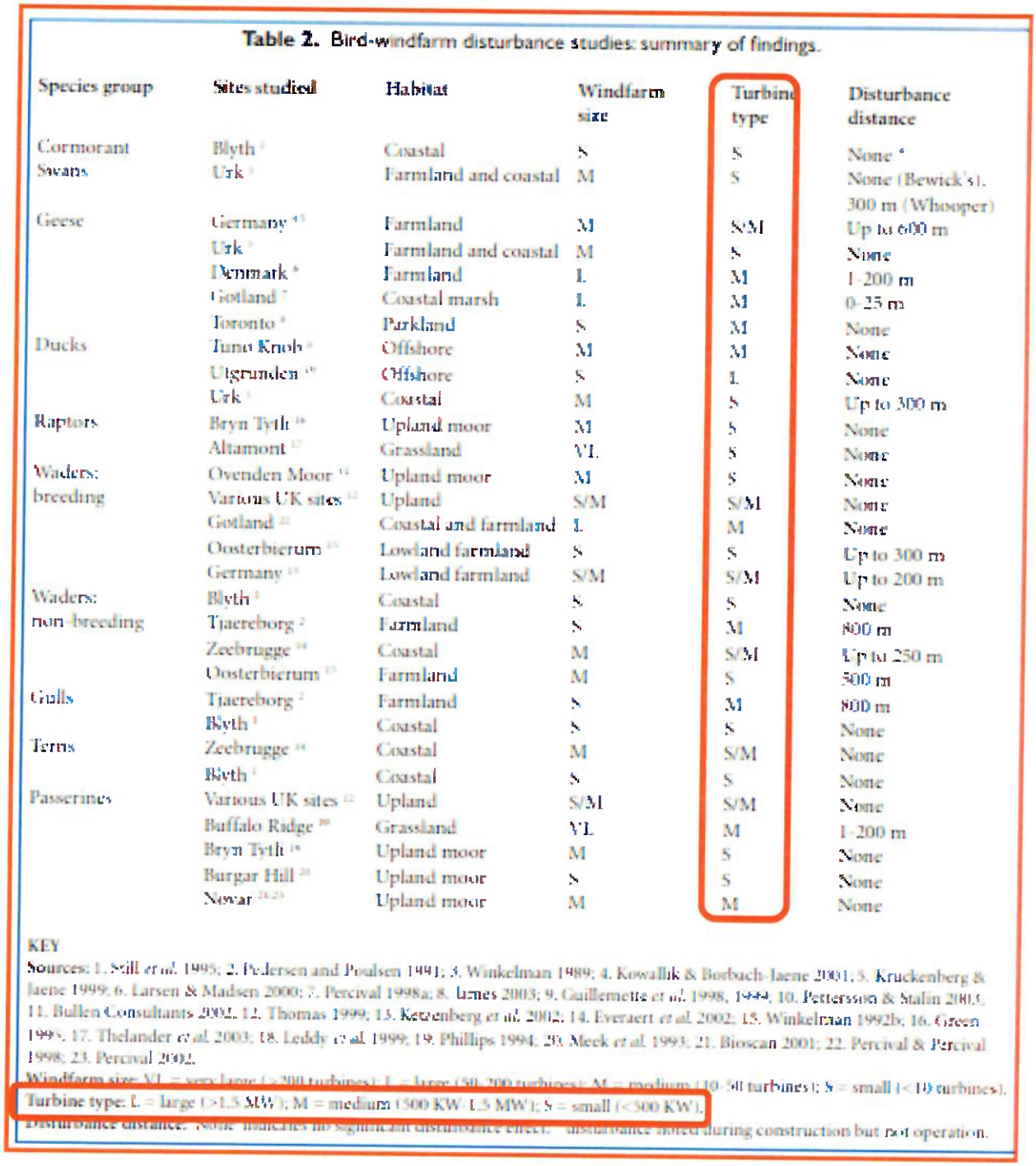


Table 2. Bird-windfarm disturbance studies: summary of findings.

Species group	Sites studied	Habitat	Windfarm size	Turbine type	Disturbance distance
Cormorant	Blyth [1]	Coastal	S	S	None [a]
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	Tuno Knob [9]	Offshore	M	M	None
	Utgrunden [10]	Offshore	S	L	None
	Urk [3]	Coastal	M	S	Up to 300 m
Raptors	Bryn Tyth [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
	Germany [13]	Lowland farmland	S/M	S/M	Up to 200 m
Waders: non-breeding	Blyth [1]	Coastal	S	S	None
	Tjaereborg [2]	Farmland	S	M	800 m
	Zeebrugge [14]	Coastal	M	S/M	Up to 250 m
	Oosterbierum [15]	Farmland	M	S	500 m
Gulls	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 [20]	Grassland	VL	M	1–200 m
	Bryn Tyth [16]	Upland moor	M	S	None
	Burgar Hill [21]	Upland moor	S	S	None
	Newar [23,24]	Upland moor	M	M	None

KEY

Sources: 1. Still *et al.* 1995; 2. Pedersen and Poulsen 1991; 3. Winkelman 1989; 4. Kowallik & Borbach-Jaene 2003; 5. Kruckenberg & Jaene 1999; 6. Larsen & Madsen 2000; 7. Percival 1998a; 8. Ames 2003; 9. Guillemette *et al.* 1998, 1999; 10. Pettersson & Stalin 2003; 11. Bullen Consultants 2002; 12. Thomas 1999; 13. Kruckenberg *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: [illegible] indicates no significant disturbance effect; [illegible] disturbance noted during construction but not operation.

Reference Number 10 : The visual effect of wind turbines on property values is small and diminishing in space and time. Wei Guoa, Leonie Wenzc, and Maximilian Auffhammere. Edited by Geoffrey Heal, Columbia University, New York, NY; received June 3, 2023; accepted January 10, 2024. 121 (13) e2309372121. https://doi.org/10.1073/pnas.2309372121

Results Property Value Impacts.

We find that having at least one wind turbine in a home's viewshed (10 km radius) reduces the sales price of such a property on average by 1.12%.

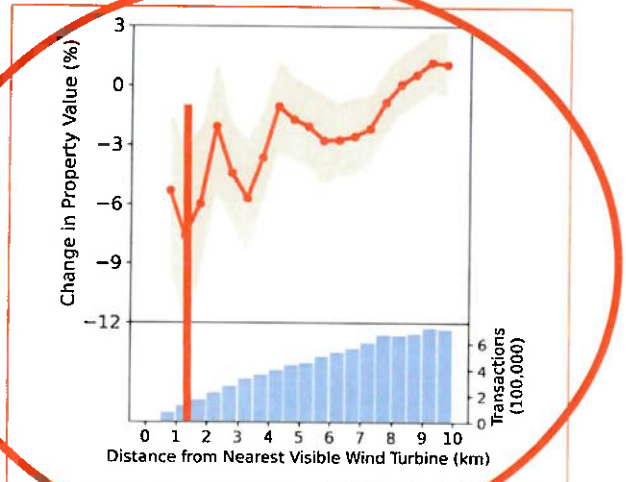


Fig. 2. Effect of wind turbine visibility on property value by distance. The effect of wind turbine visibility on property values for different distance bins. Each distance bin represents a 500-m range, determined by the distance from the nearest visible wind turbine. Red dots indicate estimated coefficients, as obtained by interacting the coefficient of interest from the difference-in-difference model (interaction between post-treatment status and treatment assignment) with distance bin indicators. Shaded areas represent 95% CIs constructed using two-way clustered SEs at the census tract and year level. Bars in the *Lower* panel show the number of transactions within each distance bin, corresponding to the right y-axis.

Note -9% for 1km separation distance

The impact of visual disamenity created by wind turbines may also vary depending on the distance from the nearest visible turbine. To test how the effect varies by distance, we re-run the baseline specification with the indicators of interest interacted with 500-m (_ 0.3-mile) distance bin indicators for the proximity of the closest wind turbine. The effect of wind turbine visibility decreases as distance increases (Fig. 2). **The effect is largest in immediate proximity of wind turbines—with the visual disamenity reducing property values by up to 8% within a neighborhood range of 1.5 km (_ 0.9 miles). Even though this number is economically large, there are two noteworthy caveats. First, the CI is sizable including reductions in property value between 3 and 13%. Second, the number of properties within this distance bin is small. Nationally, there are fewer than 250,000 transactions within 1.5 km of the nearest wind turbine, as opposed to approximately 8.5 million transactions within 10 km.**

Moreover, we find that properties within 10 km from wind turbines are 1.16 to 1.7% lower in sales price than those 10 to 50 km away. These gaps are not driven by differences in the housing characteristics of properties located in different communities. Therefore, the cross-sectional difference in property value between visible and non-visible areas as well as between proximate and distant areas indicates a potential selection effect that is consistent with the siting of wind turbines in places with lower property values.

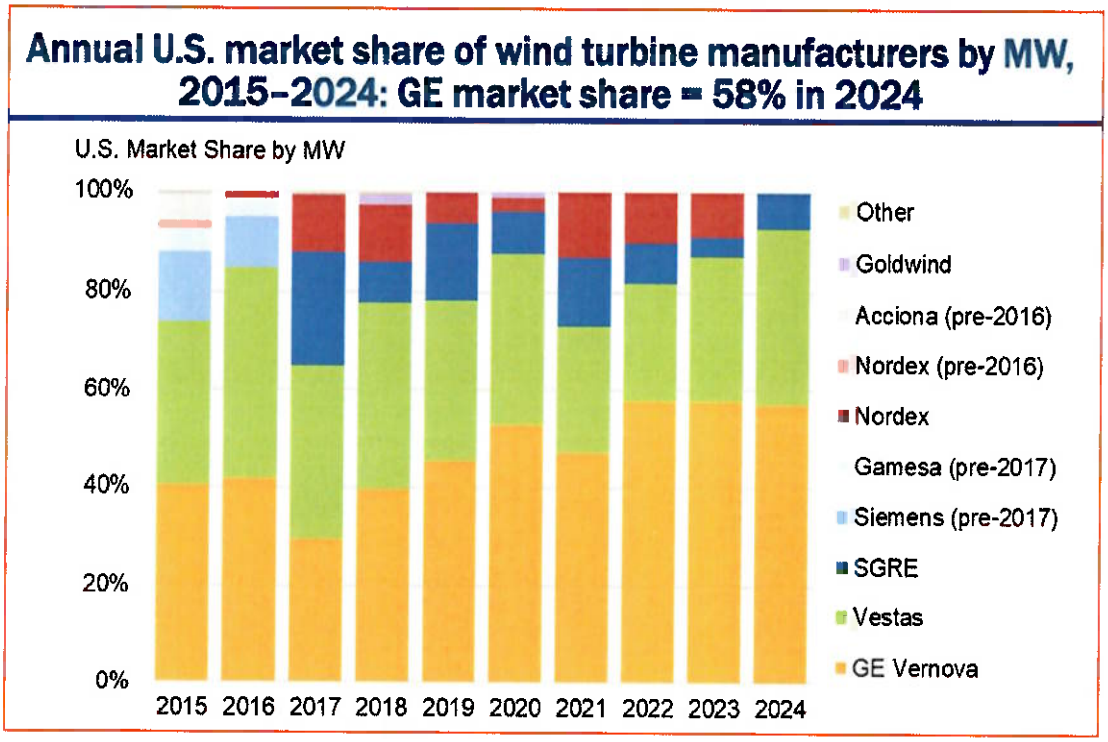
We investigate whether the visual impact of wind turbines varies with the intensity of visibility using two measures: The number of wind turbines in view and the intensity classified by whether there are more than 20 turbines in sight. We find that the capitalization of the visual disamenity increases with the treatment intensity, with every additional 10 wind turbines in view reducing the property value by an additional 0.2% [Table 1, column (2)]. Furthermore, wind farms with more than 20 turbines reduce the property value in visible areas by an average of 2.48%, whereas those with less than 20 turbines have a reduction effect of only 1.02% on visible areas [Table 1, column (3)]. These findings suggest that the density of wind turbines in view plays a role in driving the magnitude of the visual disamenity valuation.

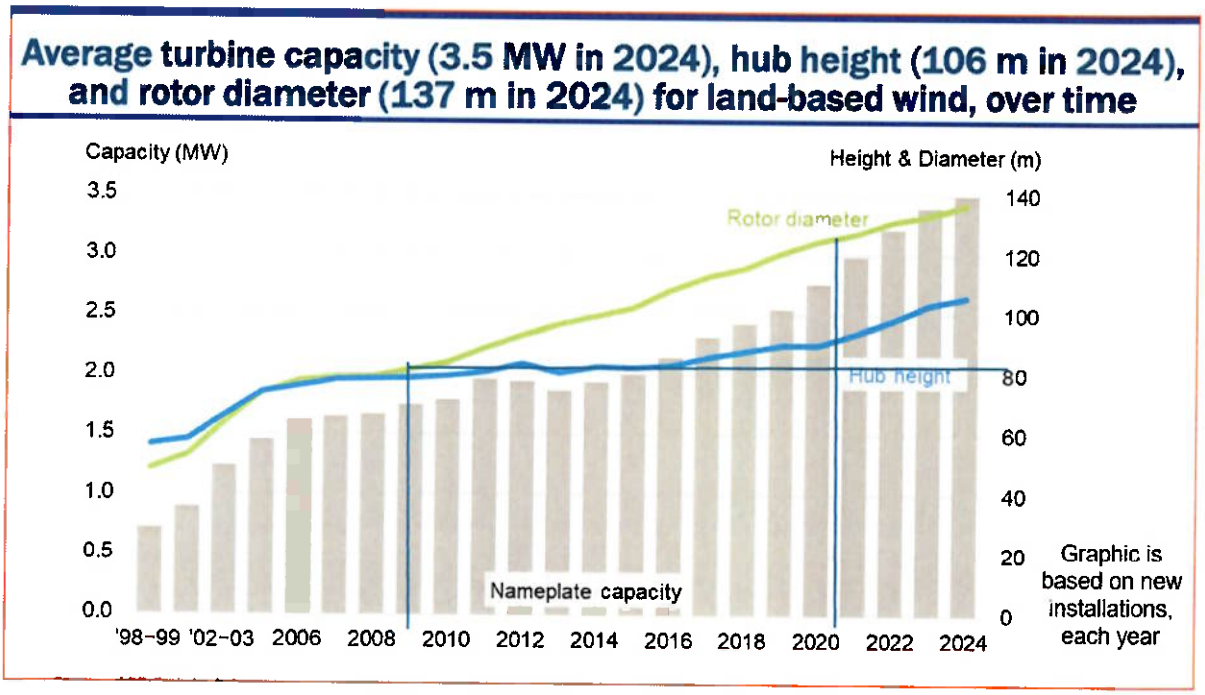
The findings indicate that wind turbines have a negative effect on property value in locations where they are visible. On average, across the whole sample, house prices decrease by up to 8% after the construction of a wind turbine within viewshed and close neighborhood range from the property, with the effect decaying as the distance increases. The average effect falls to a 1% reduction for houses within 10 km of visible wind turbines. It also diminishes over time—both in terms of more recent installations having a smaller disamenity effect and in the sense that the reduction in value a property experiences peaks 3 y after the installation and then becomes smaller the more years pass. These findings are consistent with a cognitive model where people get used to new structures in their environment over time.

The reduction in property values resulting from wind turbine installations raises questions about how this might affect siting decisions for future wind farms. This paper highlights the externality of wind power developments as they are capitalized in the housing markets. These estimates could also serve as a future basis for calculating compensation to local homeowners for placing a new wind turbine within their viewshed."

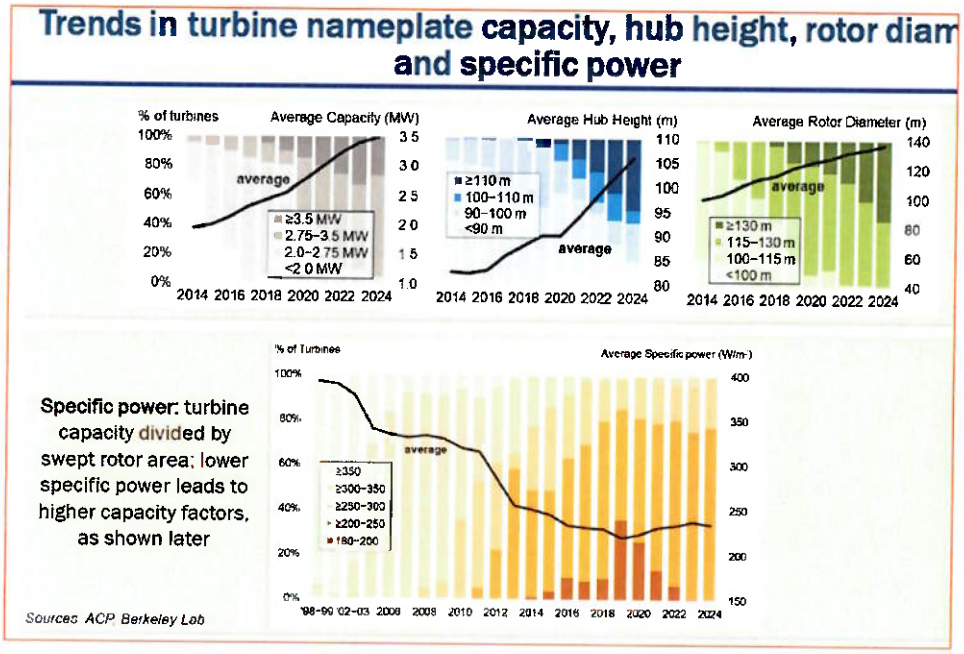
Reference Number 11 : Commercial wind turbines and residential home values: New evidence from the universe of land-based wind projects in the United States, Eric J. Brunner, Ben Hoen, Joe Rand, David Schwegman. Energy Policy Volume 185, February 2024, 113837. https://doi.org/10.1016/j.enpol.2023.113837

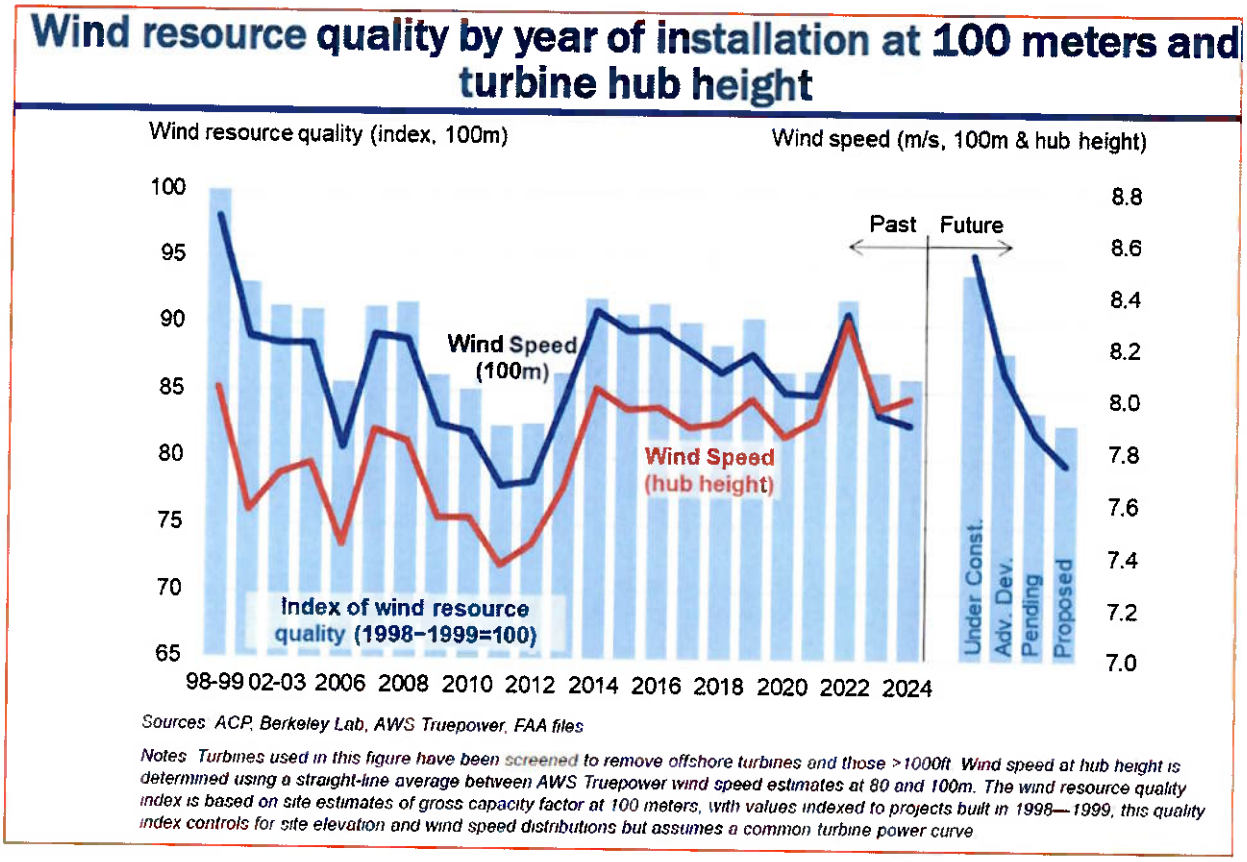
We examine the impact of proximity to land-based commercial wind turbines on residential home values in the United States using data on the universe of commercial wind turbines and residential property transactions from 2005 to 2020. Using event study and difference-in-differences identification strategies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





Note wind turbines in 2010 had a Capacity of 2Mw, Hub height of 80m & Rotor diameter of 85m. The height to the tip of the wind turbine would have been 80+42.5=122.5m. The present application is for a 7.2Mw capacity with a tip height of 185m. These are not comparable. The 2016 scenario for Scotland is similar. Comparing property prices from 2016 is irrelevant to present day sizes.





Reference Number 12 : 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 Number 13 : 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 Number 14 : 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 Number 15 : 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 Number 16 : 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 Number 17 : Impact Analysis of the Niyol Wind Farm on Surrounding Rural Residential and Agricultural land Values in Logan County Colorado. June 11, 2020. FORENSIC APPRAISAL GROUP 116 E. Bell Street Neenah, WI 54956 ph (920) 558-4638 www.forensic-appraisal.com.

- *The Landsink (Ontario, CA) study found a loss range of -8.85% to -50%, with a loss average of -39% for residential homes within 664ft to 2,531ft of a wind farm.*
- *The Appraisal Group One Wisconsin Study found a typical loss of 1-10 acre residential lots within ½-mile of wind turbines to be -19% to -40%.*
- *The Clarkson University upstate New York study of both residential and agricultural properties found a loss ranging from -15.6% to -31% within 1-3 miles of a wind farm.*
- *The Forensic Appraisal Coral Springs (WY) study of large residential lots (35 acres) which would be abutting a proposed wind farm suffered a value impact of -25% to -44%.*
- *The McCann study (IL) of residential properties found an average impact of -25% within 2-miles of a wind farm.*
- *The Forensic Appraisal Big Sky (IL) study found a loss range of -12% to -25% of residences within 0.31mi to 1.72mi of a wind turbine, with an average impact of -19% at an average distance of 0.65 miles to a wind turbine.*
- *The Twin Grove II Wind Farm (McLean County, IL) study of a 198MW wind farm comprised of 120 turbines being 397ft in height over an 11,000 acres area.*

A paired sales analysis of residential property within the influence of the wind farm found the improved property is negatively impacted by the presence of wind turbines. The impact measured ranged from -46.6% to -7.7%, with the higher impact closest to the wind turbines and the impact diminishing as the distance is increased. The distances measured ranged 1,483ft to 5,481ft away from a residence.
The Twin Grove II Wind Farm also found an overall impact of -6.63% to -8.5% for vacant agricultural properties within the wind farm zone.
Properties within the Wind Farm Footprint= -35% impact on property value

Properties : 1-Mile outside of the Wind Farm Footprint = -22%
impact on property value : Agricultural Properties within the Wind Farm Footprint= 8.5% impact on property value
Application of these estimated losses to the client's property value is:

Niyol Wind Farm Loss to Property Value Estimate			
	Total assessed value	*impact*	*value loss*
Properties within the footprint	*$6,948,960*	*-35%*	*-- $1,405,051*
Properties 1-mile outside of the Footprint	*$4,014,430*	*-22%*	*-$1,528,771*
			-$2,933,822

Reference Number 18 : Wind Turbines and House Prices Along the West of Ireland: A Hedonic Pricing Approach. Gillespie T, McHale P (2023), Centre for Economic Research on Inclusivity and Sustainability (CERIS) Working Paper Series, 2023/01.

Despite the benefits associated with wind energy, wind turbines impose undesirable externalities on residents mainly through aural and visual pollution. In this paper, I perform a preliminary evaluation on the effect of wind turbines on listed house prices in Ireland. I employ a unique dataset of exact turbine locations with housing and amenity data in seven counties along the west and southern coast of Ireland. With this I conduct a hedonic pricing analysis incorporating spatial and temporal fixed effects. The analysis finds a robust and significant reduction in property value of -14.7% within 1km of a turbine. The effect increases with turbine height, count, and level of urban influence. However, there is evidence that the price effect decays over time, becoming insignificant after 10 years. Furthermore, exhibited effects likely persist beyond 1km, although they are not significant in this analysis. In short, the results presented in this paper are consistent with existing European studies, enforcing the recommendation that turbines should be constructed in highly remote areas to minimise impacts on residents.
The estimated effects from proximity to a wind turbine on house price for dwellings In three of the six area classes: rural areas with high urban influence, rural areas with moderate urban influence, and highly rural/remote areas. Cities, satellite towns, and independent urban towns are not reported due to sample size concerns. There are fewer than 10 observations within 1km of a turbine and no more than 60 observations within 1-2km across all three urban classes combined. Proximity to a wind turbine has a significant negative effect across all three rural classes with the greatest estimated effects in rural areas with moderate urban influence at −20.1%.

Reference Number 19 : The impact of on-shore and off-shore wind turbine farms on property prices. May 2018. Cathrine Ulla Jensen, Toke Emil Panduro, Thomas Lundhede, Bo Jellesmark Thorsen. Energy Policy 116(1):50-59 DOI: 10.1016/j.enpol.2018.01.046
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. In the case of off-shore wind turbine farms, we do not find a significant effect of having an off-shore wind farm in view from a property itself or from the nearest beach, likely because the closest off-shore turbine is 9 km from the closest traded home. We illustrate the policy relevance of our findings by providing maps showing how the marginal impact of a wind turbine varies across the landscape according to the spatial distribution of home density and homes values in the proximity of a wind turbine site. The results suggest that ceteris paribus, wind turbine farms should be built quite far away from residential areas with turbines gathered in larger wind farms rather than installed as single turbines.

Reference Number 20 : Wind turbines, solar farms, and house prices. August 2021. Martijn I. Dröes. Hans R.A. KosterEnergy Policy 155(1):112327. DOI: 10.1016/j.enpol.2021.112327. License CC BY 4.0

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.

Reference number 21 : The impact of on-shore and off-shore wind turbine farms on property prices. May 2018. Cathrine Ulla Jensen, Toke Emil Panduro, Thomas Lundhede, Bo Jellesmark Thorsen. Energy Policy 116(1):50-59 DOI: 10.1016/j.enpol.2018.01.046

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. In the case of off-shore wind turbine farms, we do not find a significant effect of having an off-shore wind farm in view from a property itself or from the nearest beach, likely because the closest off-shore turbine is 9 km from the closest traded home. We illustrate the policy relevance of our findings by providing maps showing how the marginal impact of a wind turbine varies across the landscape according to the spatial distribution of home density and homes values in the proximity of a wind turbine site. The results suggest that ceteris paribus, wind turbine farms should be built quite far away from residential areas with turbines gathered in larger wind farms rather than installed as single turbines.

Reference Number 22: Investigating the welfare impacts of wind turbines and solar panels on grazing livestock. August 2024. Isabel Blanco-Penedo. Javier Álvarez-Rodríguez. Yolanda Mena. Carlos Palacios Riocerezo. DOI: 10.13140/RG.2.2.26545.60008. Conference: WAFL 2024



↑discriminative and preferential grazing capacity when ↑ grass quality.
↓ heat stress (access to shade)
↑ resting time lying down and rumination
↑ possibility of scratching.

↓ grazing time
↓ feed intake and weight gain
Modification of social behaviour
Modification of grazing behaviour and habitat use.
↑ in stress hormones

Summary of the effects of wind energy on livestock species. The list only includes factors whose effects on livestock species are documented (adapted from Helldin et al. 2012). *Reliability (from 1: Studies are lacking to 4: The knowledge base is sound and provides a reliable assessment).

Impact factor	Reliability* (1-4)	Effect (negative)	Spatial scope	Temporary Scope
Disturbances during construction	2	Moderate	Minor	Short-Long
Noise/visual disturbances from operating turbines	3	Weak	Minor	Long
Disturbances caused by utility traffic	2	Weak	Minor	Long
Habitat changes	2	Weak-Moderate	Minor	Long/Permanent
Corridor power lines and soil conductivity	1	Moderate	Minor	Long
Electromagnetism	2	Weak	Minor	Long

Proposal of impact assessment points, measures to be carried out and risk thresholds described.

Impact	Sensors and measurements	Risk threshold
Noise/visual damage from operating turbines	Sound measurements with sound level meter at a height of 1 m above the ground	Noise <85 dB (decibels) (Royal Decree 159/2023).
	Distance of the animals from the wind turbines/solar farms	
Electromagnetism	Magnetic field meters at a height of 1 m, from solar turbines/plates (and their power lines) up to 200 m away(2)	Magnetic field <1 mG (milligauss) (McCallum et al., 2014).
Habitat changes under the turbines/solar panels	Analysis of livestock grazing circuits	Reduced grazing and reduced nutritional value of vegetation under and around the facilities.
	Occupation of space	
	Distribution of daily behavioural activities and stereotypies	

Wind turbines: Mitigation strategies should consider the location, magnitude and distance to livestock farms, as risk factors are inherent to the geographical location and structure of these elements and are therefore key to the potential severity of risks affecting animal welfare.
Solar panels: The installation should consider the possibility of integrating livestock species that make best use of the existing vegetation cover under the infrastructure, and only then can animal welfare be improved by providing shade that reduces heat stress and increases forage quality and grazing time.

5.8.2.1.2 ***Employment and Investment***

Pre-Mitigation Impact

Proposed Project

The design, construction, operation and decommissioning of the Proposed Project will provide employment for technical consultants, contractors and maintenance staff. Up to approximately 100-120 jobs are likely to be created during the construction phase of the Proposed Project. The construction phase of the Proposed Project will last between approximately 24-30 months, and the decommissioning phase will likely last approximately 12 months.

The Proposed Project 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 impact 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. This will have a positive, moderate, long-term, indirect impact, which is Not Significant. Wind Energy Association estimates that there are over 5,000 people employed in roles related to wind energy in Ireland in 2023. This figure is anticipated to grow significantly in the coming years as the race to achieve the targets set out in CAP25 accelerates.

Reference Number 23 : Wind Turbines and Solar Panels are Aging Prematurely

IER INSTITUTE FOR ENERGY RESEARCH.

Wind Turbines and Solar Panels are Aging Prematurely

February 28, 2024

Key Takeaways

1 Wind turbines and solar panels are not living up to their longevity claims, increasing costs and filling up waste disposal sites.

2 Inverters in solar facilities, required to convert direct current into grid-ready alternating current, are failing in 10 to 15 years.

3 A new Australian study blames early failure of solar panels and inverters on humidity and excessive heat from the sun–the source of photovoltaic cells' energy generation.

4 Governments have hastily rushed to embrace renewable energy at the expense of consumers and taxpayers, with apparently little insight into some of the shortcomings of the technologies.

The claimed 25-year life span of wind turbines has in reality been just 7-10 years before having to be replaced along with their enormous blades. That has significantly increased the operating costs of the wind farms and created a huge waste disposal issue that neither the industry nor state regulators were prepared to deal with. As a result, massive wind graveyards have popped up such as two gigantic ones on the outskirts of Sweetwater, Texas. The issue has been exacerbated by the government providing the tax subsidy again to wind turbines that have repowered, replacing their blades. Similarly, operators and manufacturers in the solar industry are now seeing premature ageing of their solar panels due mainly to their inverters. Many older inverters are failing in about 10-15 years. Further, most of the manufacturers of these inverters — the companies that were supposed to maintain them and guarantee their performance over time — have gone out of business. Energy being sold as "green" is proving to require more "green" money – from consumers and taxpayers.

Despite being designed for 20-25 year lifespans, the first and second generation inverters are having a 15-year average lifespan, which means the market will have to repair many inverters over the next ten years. According to projections by Wood Mackenzie, about 23 gigawatts of U.S. solar — residential, commercial and utility-scale — will approach

the 15-year benchmark in the next five years. The repowering of aging solar generating units could tax aspects of the industry's already strained supply chain, particularly due to fewer businesses as many did not survive the market.

Given the complexity of switching out inverters on some of these early solar installations, some solar equipment dealers recommend knocking out a host of potential upgrades all at once: replacing old panels and wiring with new equipment to maximize efficiencies, or installing batteries for a solar plus storage facility. Similar to wind turbine blades, disposal of the solar panels that may be removed and replaced during the inverter upgrades would cause a major waste issue.

It sounds similar to the electric bus industry with e-buses sitting idle due to lack of parts and the bankruptcy of electric bus manufacturer, Proterra. Like Proterra, these solar companies, many of which are defunct, have been heavily-subsidized by the government. Many of them did not have the private capital investment needed to sustain them over the longer term.

Australia's Solar Panel Aging Problem Due to Rising Temperatures

New research in Australia has revealed that the country's solar panels are degrading at faster rates due to increasing temperatures and humidity, raising concerns about the longevity of photovoltaic (PV) modules and the potential rise in energy costs. While large scale commercial PV modules are designed for a typical lifespan of 20 to 25 years, they naturally degrade or lose their efficiency over time. However, the current degradation rates are being exacerbated by temperature increases, according to an Australian researcher—precisely the resource that is supposed to create the electricity via the solar panel!

The dominant solar technology is silicon, whose wafers are stiff and brittle. The silicon modules degrade due to stress from the environment (wind, rain, snow, sun, and humidity), voltage changes and mechanical stresses. Hotter, more humid conditions can accelerate degradation in several ways:

- Delamination: heat and humidity can cause the bonds holding the different layers of the cell together to lose adhesion
- Discolored Encapsulant: intense sunlight and extra moisture can damage or discolor the encapsulant, the polymer used to adhere layers within the solar cell together
- Ribbon Corrosion: humidity can increase the chances moisture can accumulate and begin corroding the internal ribbon connections of the cell
- Internal Circuit Failure: solar cells experience regular temperature fluctuations, daily and seasonally that can cause circuits to fail over time.

The researchers found that solar in Australia's hot, humid north will degrade fastest due to its more humid elements, while solar in the arid interior and more moderate climates in the south will fare better.

Solar Waste to Pile Up Worldwide

The world has installed more than one terawatt of solar capacity on rooftops and at solar farms. Solar panels have an average capacity of about 400 watts, resulting in as many as 2.5 billion solar panels worldwide. As the solar panels are retired, many of the panels end up in waste disposal sites as the infrastructure to scrap and recycle them is lacking. Because each solar panel contains only tiny fragments of precious materials, copper, silicon and silver, and those fragments are intertwined with other components, it has not been economically viable to separate them. Over 60 percent of the mineral value is contained in just 3 percent of the weight of the solar panels. The International Renewable Energy Agency's official projections claim that "large amounts of annual waste are anticipated by the early 2030s" and could total 78 million metric tons by 2050 based mostly on a 30 year life cycle for the solar panels.

Conclusion

While solar panels are supposed to last 20 to 25 years, the industry is finding that not to be the case due to inverter failures that occur in about 15 years and to weather, particularly humidity. Power output from solar PV drops as solar panels degrade over time, but different climates, different materials and different manufacturing techniques can lead to faster or slower degradation. This is true of most green technologies as cold weather affects the range that EV batteries can perform and humidity affects the longevity of solar panel wafers. These issues can mean that solar panels will pile

up in waste disposal sites, as retired wind turbines are doing, faster than expected as there are few recycling centers available. Politicians, regulators and the industry have not dealt with the solar waste disposal problem that will begin to loom in the near future.

Wind Energy Development Guidelines

The relevant considerations under the 'Wind Energy Development Guidelines for Planning Authorities'(Department of the Environment, Heritage and Local Government (DoEHLG), 2006) ('the DoEHLG 2006 Guidelines') have been taken into account during the preparation of the EIAR.

The DoEHLG 2006 Guidelines were the subject of a targeted review. The proposed changes to the assessment of impacts associated with onshore wind energy developments were outlined in the document Draft Revised Wind Energy Development Guidelines (Department of Housing, Planning and Local Government (DoHPLG), 2019) ('the Draft DoHPLG 2019 Guidelines'). At time of writing, the Draft DoHPLG 2019 Guidelines have not yet been adopted, and the relevant guidelines, remain to be the DoEHLG 2006 Guidelines. Notwithstanding this, however, due to the timelines associated with the planning process for renewable energy projects it is possible that the Draft DoHPLG 2019 Guidelines may be adopted during the consideration period for the current planning application. Should the Draft DoHPLG 2019 Guidelines be adopted in advance of a planning decision being made on this application, the Proposed Wind Farm will be capable adhering to the relevant noise and shadow flicker standards.

While the final updated Guidelines have not yet been published it should be noted that noise and shadow flicker are controllable and are discussed further in Chapter 12 and Chapter 5 of the EIAR, respectively. The Proposed Wind Farm achieves the recommended distance of 4 times turbine tip height from proposed turbines to third party sensitive receptors, which has become a recognised standard for the purposes of protecting residential visual amenity, as currently outlined in the Draft DoHPLG 2019 Guidelines.

Planning History

A planning search was carried out through the National Planning Application Database and ACP online planning portals in February 2026 for relevant planning applications lodged within the past 10 years that fall within the red line boundary of the Proposed Project.

The Proposed Project site was subject to industrial-scale peat extraction which was permanently ceased in June 2020; decommissioning activities as required by Condition 10 of the IPC Licence are currently ongoing. The ongoing decommissioning and maintenance activities will ensure compliance with BnM's IPC Licence (Ref P0500-01). An application for substitute consent was submitted to ACP (Case Ref: SU19.323676) on 12th September 2025, for peat extraction and ancillary works from July 1988 to June 2020 that were carried out within Lemanaghan Bog.

A planning search was carried out to establish proposed, permitted and operational wind energy developments within 25km of the Proposed Wind Farm turbines. In total, 17 no. applications relating to wind energy were identified within 25km of the proposed turbines, 5 no. of which relate to single turbine developments and a further 5 no. of which relate to amendments to permitted developments.

Scoping and Consultation

An EIA scoping report, providing details of the Proposed Project, was prepared by MKO and circulated in May 2021 and March 2025. MKO requested the comments of the relevant personnel/bodies in their respective capacities as consultees with regards to the EIAR process. As part of the constraints mapping process telecommunications operators were contacted in November 2020 (and again in October 2024 and March 2025) in order to determine the presence of telecommunications links either transversing the site or in close proximity to the Proposed Wind Farm site. Chapter 2 includes a list of scoping consultees and responses received, with full copies of all scoping responses received set out in Appendix 2-1 of the EIAR.

Pre-planning meetings were undertaken with Offaly County Council under the provisions of Section 247 of the Planning Act, and ACP under the provisions of Section 37B of the Planning Act. A letter received from ACP dated the

3rd March 2026 stated that under Section 37B (4)(A), it is the opinion of ACP that the Proposed Project falls within the scope of the paragraphs 37A(2)(a) and (b) of the Planning Act. This confirmed that the Proposed Project constitutes Strategic Infrastructure Development.

Community engagement has been undertaken by the Applicant, details of which can be found in Appendix 2-2 of this EIAR. The Applicant has carried out consultation in relation to the Proposed Project with local residents surrounding the proposed Wind Farm site and interested parties in the wider community. The objective of the consultations was to ensure that the views and concerns of all were considered as part of the Proposed Project design and EIA process. The development of the Proposed Project will provide an enduring economic benefit to the communities surrounding the Proposed Project, through the potential community benefit package for residents and community groups, employment during the construction and operation of the Proposed Project and through the annual rates payable to the Local Authority.

Cumulative Impact Assessment

The EIA Directive and associated guidance documents state that as well as considering any direct, indirect, secondary, transboundary, short, medium, and long-term, permanent and temporary, positive and negative effects of the project the description of likely significant effects should include an assessment of cumulative impacts that may arise.

To gather a comprehensive view of cumulative impacts on these environmental considerations and to inform the EIAR process being undertaken by the consenting authority, each relevant chapter within the EIAR includes a cumulative impact assessment where appropriate. The potential for cumulative impacts arising from other projects and land uses within the cumulative study area has therefore been fully considered within the EIAR.

The Proposed Project has been designed to avoid and mitigate impacts on the environment, and a suite of mitigation measures is set out within the EIAR. A detailed cumulative impact assessment for each discipline within the EIAR is provided in each impact assessment chapter detailing the potential significant cumulative effects arising and, where appropriate, the specific suite of relevant mitigation measures proposed. The mitigation measures set out in the EIAR will ensure that significant cumulative effects do not arise during the construction, operational or decommissioning phases of the Proposed Project. A long list of all plans and/or projects considered by each of the different disciplines in their cumulative impact assessment are included in Appendix 2-3 of the EIAR.

3 Site Selection and Reasonable Alternatives

Chapter 3: Site Selection and Reasonable Alternatives of the EIAR introduces the reasonable alternatives studied by the Applicant which are relevant to the Proposed Project and its specific characteristics and an indication of the main reasons for the option chosen, taking into account the environmental effects. The consideration of alternatives typically refers to alternative design, technology, location, size and scale. A 'Do-Nothing Alternative' i.e., an outline of what is likely to happen to the environment should the Proposed Project not be implemented, has also been considered.

Alternative Site Locations

In order to identify sites within its landbank which might be suitable for wind energy development, BnM conducted a two-stage assessment process. The first stage comprised the identification of a number of candidate sites via desk studies and on-site surveys of the landbank. Known constraints, derived from various industry and regulatory guidelines, available GIS datasets and on-site surveys (carried out as part of the peat extraction activity), were then applied to the dataset, including:

- Planning Policy Context;
- Proximity to Sensitive Receptors;
- Proximity to the national electricity grid;
- Proximity to National and European Designated sites and onsite Environmental Sensitivities;
- Peat depths, and;
- Suitable wind speeds.

The second stage of the assessment was used to select the sites with the best potential to deliver a successful wind farm project by 2030 to be further developed.

Due to its relatively low potential for environmental effects and the close proximity of its potential grid connection which would provide environmental and project viability benefits Lemanaghan Bog was progressed for detailed assessment and planning consideration.

Alternative Renewable Energy Technologies

To achieve the same maximum estimated electricity output from solar energy as is expected from the Proposed Wind Farm (c. 90MW), a larger development footprint would be required. As detailed in Section 1 above, the site encompasses an area of approximately 1,258 hectares. The permanent footprint of the Proposed Project measures approximately 34.3 hectares, which represents approximately 3% of the site. For a solar PV array of the scale necessary to provide the same electricity output as the Proposed Wind Farm, it would require a footprint of approx. 114 hectares or 11% of the site.

Although the screening exercise was based on identifying lands for onshore wind development; another alternative source of renewable electricity generation would be offshore wind energy. However, it is considered that due to delays with the regulatory process for offshore development, a combination of both onshore and offshore wind farm development will continue to be required to deliver on the ambitious renewable energy targets set out under CAP25 which include focusing on onshore wind energy developments to reach the 2025/2030 renewable energy targets. As such, the Applicant's primary focus is on onshore wind farms, and the Applicant will continue to explore potential development offshore in tandem with delivering suitable sites onshore such as the Proposed Project.

Alternative Turbine Numbers and Model

It is proposed to install 15 no. turbines at the Proposed Project site which will have an estimated installed capacity of 90MW. Such a wind farm could also be achieved on the site by using smaller turbines (for example 2.5MW machines). However, this would necessitate the installation of approximately 36 turbines to achieve a similar output.

The Applicant is intentionally mixing up the capacity & output. The V150 has an output of 3MW. See power curves in section .....

The use of smaller turbines would not make as efficient use of the wind resource available at higher elevations above ground level, having regard to the nature of the site and would result in the wind farm occupying a greater footprint within the site, with a larger amount of supporting infrastructure being required (i.e., roads, steel, etc.), thus increasing the potential for negative environmental impacts to occur.

Alternative Turbine Layout and Development Design

The design of the Proposed Wind Farm has been an informed and collaborative process from the outset, involving the designers, developers, engineers, landowners, environmental, hydrological, geotechnical, archaeological, and traffic specialists.

Throughout the preparation of the EIAR, the layout of the Proposed Wind Farm has been revised and refined to take account of the findings of all site investigations and baseline assessments, which have brought the design from its first initial layout to the Proposed Wind Farm layout. The design process has also taken account of the recommendations and comments of the relevant statutory and non-statutory organisations, the local community and local authorities, while still seeking to ensure that a viable project can ultimately be constructed and connected to the national grid.

The final design of the Proposed Wind Farm is based on the results of all site investigations that have been carried out during the EIAR process and the EIA scoping process with statutory and non-statutory consultees. As information regarding the Proposed Project was compiled and assessed, the number of turbines and the proposed layout have been revised and amended to take account of the physical constraints of the Proposed Project site and the requirement for buffer zones as well as wind-take and the separation distance to be maintained between turbines, landscape and visual, cultural heritage, noise and shadow flicker impacts. The EIAR and Proposed Project design process was an iterative process, where findings at each stage of the assessment were used to further refine the design, always with the intention of minimising the potential for environmental impacts.

There were several reviews of the specific locations of the various turbines during the optimisation of the Proposed Wind Farm layout. The initial constraints study identified a significant viable area within the overall study area of the site. The proposed 15-turbine final layout has been refined following feedback from the project team, the local community, and the need to ensure sufficient separation distances are maintained for on-site constraints.

Alternative Grid Connection Options

A key consideration in determining the grid connection method for a proposed wind energy development is whether the cabling is underground or run as an OHL or a combination thereof. While DoEHLG 2006 Guidelines indicate that underground cables are the preferred option for connection of a wind energy development to the national grid, it was determined that due to the proximity of the existing OHL, it was more environmentally prudent to connect the Proposed Wind Farm to the national grid via either OHL or a combination of OHL and underground cable.

The MW output of the Proposed Wind Farm is such that it needs to connect to a substation with voltage capacity of at least 110kV.

The TLI Group was engaged by the Applicant to carry out a preliminary grid route assessment for the Proposed Project, including feasibility of proposed substation locations. A desktop analysis wasAlternative Turbine Numbers and Model

It is proposed to install 15 no. turbines at the Proposed Project site which will have an estimated installed capacity of 90MW. Such a wind farm could also be achieved on the site by using smaller turbines (for example 2.5MW machines). However, this would necessitate the installation of approximately 36 turbines to achieve a similar output. The use of smaller turbines would not make as efficient use of the wind resource available at higher elevations above ground level, having regard to the nature of the site and would result in the wind farm occupying a greater footprint within the site, with a larger amount of supporting infrastructure being required (i.e., roads, steel, etc.), thus increasing the potential for negative environmental impacts to occur.

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There were several reviews of the specific locations of the various turbines during the optimisation of the Proposed Wind Farm layout. The initial constraints study identified a significant viable area within the overall study area of the site. The proposed 15-turbine final layout has been refined following feedback from the project team, the local community, and the need to ensure sufficient separation distances are maintained for on-site constraints.

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A key consideration in determining the grid connection method for a proposed wind energy development is whether the cabling is underground or run as an OHL or a combination thereof. While DoEHLG 2006 Guidelines indicate that underground cables are the preferred option for connection of a wind energy development to the national grid, it was determined that due to the proximity of the existing OHL, it was more environmentally prudent to connect the Proposed Wind Farm to the national grid via either OHL or a combination of OHL and underground cable.

The MW output of the Proposed Wind Farm is such that it needs to connect to a substation with voltage capacity of at least 110kV.

The TLI Group was engaged by the Applicant to carry out a preliminary grid route assessment for the Proposed Project, including feasibility of proposed substation locations. A desktop analysis was undertaken using identified constraints to identify three potential substation locations and associated connection options.

The final Proposed Grid Connection layout comprises the proposed onsite 220kV substation and associate telecommunications tower, 4 no. new steel masts, 2 no. gantry structures, 2 no. crane pads and 2 no. tower pads and all ancillary infrastructure.

The chosen Proposed Grid Connection design was considered to be the most environmentally prudent and practical option for a grid connection.

General Construction and Operational Entrances

The Proposed Project site is currently served by a number of existing tracks and access roads due to its previous use as a commercially harvested bog.

Due to the nature of the Proposed Project, all proposed works will be local to the Proposed Project site and the construction phase will utilise 4 no. site entrance locations for construction material delivery. Of the 4 no. site entrance locations, 3 no. are existing site entrances that will be upgraded, and 1 no. is a proposed new entrance on the northern side of the L7002. An existing agricultural site entrance off the L7001 local road network will be upgraded to facilitate construction phase access to the Proposed Grid Connection infrastructure located under the existing Shannonbridge-Maynooth 220kV OHL.

4.7.1 Site Entrances

The Proposed Project site is currently served by a number of existing tracks and access roads due to its previous use of industrial peat etxraction. As part of the Proposed Project, it is proposed to upgrade 3 no. existing entrances and facilitate 2 no. new site entrances. These site entrances will be used throughout the construction, operation, and decommissioning phases of the Proposed Project to enable delivery of materials and turbine components (construction

phase), amenity access and maintenance and monitoring use (operational phase), and removal of Proposed Project infrastructure (decommissioning phase).
Due to the nature of the Proposed Project, all proposed works will be local to the Proposed Project site and as such, the construction phase will utilise 4 no. site entrance locations. Of the 4 no. site entrance locations, 3 no. are existing site entrances that will be upgraded, and 1 no. is a proposed new entrance on the northern side of the L7002 local road. An existing agricultural site entrance off the L7001 local road network will also be upgraded to facilitate construction phase access to the Proposed Grid Connection infrastructure located under the existing Shannonbridge-Maynooth 220kV OHL.
Is this 4 or 5 site entrances?

These site entrances will be used throughout the construction, operation, and decommissioning phases of the Proposed Project to enable delivery of materials and turbine components (construction phase), amenity access and maintenance/monitoring (operational phase), and removal of Proposed Project infrastructure (decommissioning phase).

Alternative Amenity Track

The amenity tracks were designed as part of the overall Proposed Project design process and during public consultation. The amenity tracks were designed to take account of the rich cultural heritage on-site and in the local areas, with proposed amenity track being redesigned to avoid a historic connection from a derelict house known locally as Derryvane Cottage in the centre of the Proposed Wind Farm to farmland to the west. The proposed amenity design was further refined during the constraints review with input from the Project Archaeologist.

As part of the amenity proposals for the site, there will be signposts throughout the amenity informing visitors of the rich cultural heritage of the Lemanaghan Bog and focal points of interest. Information on the historical connection detailed above, as well as other cultural heritage monuments and recorded structures within and around the site, will be provided on these signposts.

Alternative Mitigation Measures

Mitigation by avoidance has been a key aspect of the Proposed Project's evolution through the selection and design process. Avoidance of the most ecologically and environmentally sensitive areas of the site limits the potential for environmental effects. As noted above, the site layout aims to avoid any environmentally sensitive areas. Where loss of habitat occurs in the site, dedicated enhancement and mitigation have been proposed, the design of which has been refined through the constraints -led iterative design process.

The best practice design and mitigation measures set out in this EIAR will contribute to reducing any risks and have been designed to break the pathway between the site and any identified environmental receptors. The alternative is to either not propose these measures or propose measures which are not best practice and effective and neither of these options is sustainable.

Lemanaghan Wind Farm, Co. Offaly Ch. 11 Climate - F - 2026.03.19 - 200804 Table 11-3
Data from Met Éireann Weather Station at Birr 1979-2008

Table 11-3 Data from Met Éireann Weather Station at Birr 1979-2008

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
WIND (knots)													
Mean monthly speed	7.9	8.0	7.8	6.5	6.2	5.8	5.6	5.6	6.0	6.8	7.0	7.5	6.7
Max. gust knots m/s	75 38.58	77 39.6	64 32.9	58 29.8	55 28.29	49 25.2	49 25.2	46 23.66	51 26.23	64 32.9	54 27.77	69 35.49	59.2 30.45
Max. mean 10-minute speed	40	38	33	29	29	27	24	27	30	37	32	38	32
Mean num. of days with gales	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.5

Are these Birr Wind speeds at 220m above ground level? Note knots converted to m/s in red.

Reference No 24 : Birr Windspeeds

Met Eireann Birr maximum wind gusts 1850 – 2010 in m/s. converted from Knots - Factor[1/1.944]
Survival wind speed for Vesta V117-4.2 is ≤57m/s
Note all cells highlighted in yellow ≥57m/s. It should be also noted that Birr data is at ground level plus 10m, which would be far lower than Seskin top of turbine heights.

Birr m/s WIND GUST SPEEDS

Year	Jan	Feb	March	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec
1850	48	21.3	5.3	42	37.1	21	41.7	24.4	35.2	20.3	36.4	31.9
1851	74.4	9.5	37.5	17	14.9	45.3	46.8	29.2	15.6	46.9	20.8	26.9
1852	57.9	38.1	15.7	16.7	22.6	93.6	45.9	43.1	10.4	22.2	92.1	82.1
1853	51.2	15.6	35.9	38.1	13.4	35.2	44.5	39	25.5	75.1	40.3	9
1854	44.1	10	14.9	2.9	72.8	55.8	41	29.2	14.9	21.5	26.2	33.7
1855	5.3	19.9	45.5	13.4	29.5	28.4	40.9	43.9	18.7	38.9	16.5	20.3
1856	41.9	27.8	8.3	42.6	75.1	37	29.5	41	39.2	33	13.2	47.2
1857	33.5	20.9	33.9	54.8	28.6	39.6	19.3	21.2	41.6	31.3	35.2	14.3
1858	24.9	16.5	20.3	52.5	36.3	11.7	36.3	27.1	36.5	39.5	21.5	54.6
1859	27.8	17.6	33.3	45.9	4.6	20.9	21	27.5	63.1	22.6	46.8	44.2
1860	62.5	18.6	39.5	34.1	44.2	67.7	39.8	75.8	20	32	36.1	28.2
1861	24.3	27.2	50.4	11.3	4.2	48.4	108.2	66.4	67.2	48.4	43.9	25.3
1862	52.4	14.8	50.2	38.4	50.6	37	45.3	38.2	19.8	63.5	25.5	37.9
1863	40.7	21.6	33.1	16.3	13.2	11.8	4.3	49.3	47.9	55	53.2	36.6
1864	23.7	8.9	34.5	15.3	21.6	42.4	10.6	22.6	43.6	49	56.6	28
1865	50.7	35.4	23.5	13.7	48.2	11.1	41.4	36.8	6.3	52.7	55	40.4
1866	54.1	33.8	31.7	23.4	14.9	33.6	11.9	48.1	60	28.3	38.5	46.2
1867	34.4	31.2	29.4	38.8	40.1	13.3	49.9	37.8	17.2	61.4	16.6	14.9
1868	41.4	32	40.7	28.8	28.6	20.3	31.6	64	36.8	29.9	30.2	54.4
1869	53	33.7	23.3	36.6	48.6	19.8	28.1	27.1	80.2	8.1	38.2	67
1870	38.5	22	28	12.3	28.9	10.2	21.5	21.3	45.9	95.1	18.1	23.9
1871	37.3	27.4	26.5	27.3	26.5	37.7	68.2	28.8	8.4	45.7	22.2	31.4
1872	45.1	31.4	28	30	26.9	43.1	28.6	63.5	42.8	58.6	48.6	68.9
1873	69.9	11.8	54.9	23.4	27.6	18.7	54.9	64.1	53.3	51	26.6	14.9
1874	35.8	21.3	22.8	23.4	29.8	22.8	37.9	67.7	50.6	51.9	47	54.7
1875	63.4	15.4	13.7	10.3	25.4	41.8	33.8	40.1	85.6	39.9	34.2	25.6
1876	15.8	54.4	58	26.9	9.8	20.5	22.2	44.8	57.9	41.8	32.7	64.4
1877	61.9	30.3	34.6	39.4	27.1	48.7	30.3	57.1	33.7	45.7	71.1	43.8
1878	37.3	21.5	15.8	18.7	44.7	67.5	33.4	49.5	40.7	37.7	23	16
1879	22	43	20.8	29.3	33.3	64	39.2	59.3	60.1	16.2	11.2	24.3
1880	12.8	35.1	46.4	53	18.2	37.1	95.9	22.1	27.3	33.1	46.9	40
1881	8.9	43.4	30.3	17.6	32.5	53.7	24.6	61.7	51.7	32.7	53.4	62.9
1882	29.9	30.6	32.8	40.5	35.9	39.5	56.7	43	21.5	43.8	69.5	44
1883	64.7	47	8.2	22.6	33.6	22.5	51	51.9	44.4	46.8	55	24.3
1884	46.5	44.2	37	20.5	28.2	11.1	41.9	17	23.3	32	42.2	54.2
1885	28.9	38.2	21.3	42.2	28.1	15.5	28.1	40.7	66.5	49.1	24.6	12.6
1886	52.7	23.8	37.1	26.1	41.3	23.7	31.2	28.8	40.6	56.2	40.5	64.3
1887	36.7	16.3	17.1	24.7	18.1	4.4	38	32.5	21.8	34.5	28.5	34
1888	28	8	40.5	21.3	27.3	63.1	58.4	31.5	9.3	17.9	32.2	50.4

1889	28.9	22.2	18.7	24.2	42.8	16	24.8	63.1	11.5	40.9	20.1	40.5
1890	76.4	10.6	40.7	9.1	19.7	32.7	29.1	43.2	42.4	30.9	69.7	25.3
1891	24.7	2.2	18.8	24.6	40.6	39.7	28	91.3	26.5	44.7	35	78.2
1892	22.9	38.1	7.6	13.2	61.7	24.9	48.1	102.4	57.3	30	50.8	16.9
1893	37.8	38.8	10.1	10.7	35.4	34.3	28.6	49.2	30	41.1	24.6	52
1894	51.3	42.6	27.3	63.8	32.7	24.9	52.9	40	4	43.1	45.6	37.8
1895	28.9	11.2	38.9	25.2	9	10.7	46.8	63.5	5.8	37.4	57.4	48.4
1896	13	19	60.3	11.8	4.4	27.8	69.9	33.7	72.6	32.5	13.7	55.8
1897	23.8	21.4	60.3	56.7	17.4	49.5	30.5	55.1	29.1	34.6	67.3	51
1898	24.3	21	10.5	46.7	34.8	42.9	14.5	82.9	39.4	27.4	67.6	32
1899	45.2	29.8	16.6	38.7	43.9	24.2	44.8	57.5	30.7	20.8	36.8	50.9
1900	53.7	30.7	9.7	28.2	30	50.6	23.5	97.9	18.3	57.3	53.8	52.9
1901	35.9	17.1	37.9	26.2	23.7	37	15.9	36.2	50.8	34.4	53.8	39
1902	39.7	26.2	30.2	26.1	26	19.9	25.7	32	20.5	22	60.9	38.1
1903	62	42.3	71.7	18.2	21.8	15.5	66.4	68	41.7	58.3	32.8	34.2
1904	46.1	57.9	36.5	26.2	42.5	21.2	48.5	42.7	30.7	32.4	31	25
1905	30.1	20.6	55.4	24.3	11.9	19.2	17.6	70.6	18.6	17.5	32.4	24.8
1906	52.1	34.8	29.6	22.3	46.2	29.5	45.6	45.5	15.3	60.5	21.7	30.9
1907	15	22.5	35.8	32.6	37.7	39	64.1	42.8	13.6	63	36.9	46.2
1908	39.4	30.6	38.4	22.7	36.8	20.5	33.4	49.1	70.9	20.5	32.3	41.6
1909	36.3	12.7	39.8	55.3	34	22.5	25.8	15.4	27.4	56.3	25.8	48.4
1910	46.8	55	25.7	35.5	27.8	48.9	39.3	58	9.1	22.1	37.7	40.4
1911	21.9	35.1	17.2	21.3	16.5	28.9	37.5	31.1	21.8	53.3	53.4	66.8
1912	35.2	41.7	46.8	13	17.4	64.8	62.4	60.4	5	28.3	22.2	53.6
1913	62.3	16.5	51.5	51	45.3	42.8	13.4	16.9	41.8	47.4	40.2	33.1
1914	16.1	58.8	44.7	27.3	20.7	11.9	31.2	53.9	22.1	23.9	46	69.5
1915	52.8	54.2	10.4	22.5	6.4	25.7	60.3	51.7	19	38.2	39.5	55.6
1916	33.1	54.2	26.3	39.1	65	37.4	36.2	41.4	31.7	77.7	48.9	38.9
1917	12.8	23.8	32.1	15	43	20.2	33.9	117.9	22.8	51	32.5	18.9
1918	28.6	49	27.9	13.5	26.7	15.6	45.4	31	68.9	47.3	40	62
1919	36.2	17.8	24.3	19.7	33	49.1	23.1	30.7	33.5	12	27.1	68.2
1920	58.2	48	36.9	38.8	34	15.7	56.8	27.8	22.1	75.6	39.1	34.6
1921	48.4	12	37	10.3	26.3	9.9	52.4	43.9	28.7	34.5	36.8	54.9
1922	37	51.5	21.5	29.6	24.1	17.9	34.4	41.5	49.9	15.1	11	52.4
1923	38.3	62.4	30.8	37.9	17.4	12.2	36.9	70.2	43.7	58.7	38.6	41.7
1924	51.6	16	10.1	43.3	55.3	37.7	38.5	49.3	88.2	45	53.4	70.1
1925	43.1	68.8	6.1	49.6	62.1	7.2	51.9	23.9	24.1	28.3	28	22.5
1926	59.4	28.4	13.5	24.4	33.6	34.1	65.3	38.3	27	28.7	43.6	12.9
1927	44.2	31.7	45	20.1	10.3	36.3	38.7	56.1	63.8	24.9	32.5	28.2
1928	50.8	50.9	42.3	24.1	28.3	56.9	27.5	53.5	20.2	70.9	51.1	46
1929	19.2	43	6.9	11.8	33.6	22.1	45.4	64.8	10.8	53.1	52	84.9
1930	64.3	7.3	48.9	23.9	21.5	23.6	41	74.6	50.5	60.6	38.5	45.1
1931	24.2	33	27.6	39.6	36.8	52.4	51.2	33.3	32.7	25.8	80.5	28.3
1932	51.5	3	16.5	29	35.9	7.4	48.3	19.1	48.5	43.1	16.8	56.9
1933	37.3	30.3	43.4	12.9	26.4	32.8	40.7	30.5	18.3	27.6	15	25.2

1934	58	2.2	38	24.7	26.1	25.2	23.6	59.8	65.6	45.3	17.8	67.1
1935	16.2	39.4	17.8	23.1	13.6	62.4	12.3	42.2	74	50.6	52.6	19.3
1936	51.7	23.3	20.1	29.8	12.9	38.7	80.2	25.1	61	25.5	40.1	40.9
1937	58.5	54.3	26.9	34.7	35.9	26.7	50.3	43.5	52.3	25.2	19.2	25.4
1938	57.4	18.9	17.7	2	47.4	45	87.6	53.4	26.6	95.1	61.1	43.2
1939	65.7	35.8	35.2	14.1	17.4	29.8	47	18.9	29.4	11.3	96.6	29
1940	32.4	50.5	27.7	32.9	11.8	14	44.2	6.6	27.6	81.2	54.7	45.8
1941	28.9	47.8	30	21.8	34.3	9.8	36.4	40.4	12.7	34.9	63.4	30.2
1942	54.4	12.3	36.5	24.2	45.7	4	50.5	71.1	57.4	32.7	8.6	48.9
1943	65.6	23	11	19.7	42.1	39.3	26.1	58.1	32.7	49.2	35.5	28.9
1944	52.2	18.1	7.2	20.4	41.8	23	39.9	49.7	57	58.1	66.2	50.5
1945	26.3	40.8	22.2	17.2	42.4	47.6	54.9	30.6	47.2	38	8.7	54.3
1946	64.5	67.9	18.9	13.7	26.4	46.4	60.4	88.2	68.7	17.2	47.2	63.2
1947	46.1	24.7	59.5	50.5	60.2	58.5	37.8	10.9	48.9	49.6	56.7	37.7
1948	91.6	28.4	36.9	26.6	31.2	50.3	26.3	37.4	43.1	49.3	38.1	74.5
1949	26	34	29.6	29.9	22.9	9.4	38.3	50.6	13.2	83.2	42.3	53
1950	16.7	51.7	22.1	34.1	15.9	24.3	70.3	57.8	71	41.1	36.3	29.4
1951	48.9	33.4	50.4	23.5	23	18.1	21.2	53.2	59.5	25.4	40.5	74.4
1952	58.1	11.3	14.6	25.3	49.7	29	20.9	38	27.7	67.6	26.5	38.5
1953	20.7	20.3	5.6	37.7	22.5	12.9	43	62.3	35.3	40.5	35.5	36.5
1954	28.2	53.3	30.7	15.6	52.2	31.9	46.6	53.7	63.9	64.8	51.3	50.1
1955	34.8	31	19.2	35.9	42.5	54	6.9	17.1	45.3	20.2	33.3	56
1956	38.4	11.2	25.8	11.5	17.4	30.7	59.8	66.2	61.4	31.6	24.7	55
1957	54.4	40	47.8	20.7	26.8	10.8	59.4	22.6	44.7	55.2	9.2	35.8
1958	49.2	44.7	20.3	19.3	52.1	43.8	51.5	78.9	52	23.7	26.5	45.6
1959	27.4	14.7	28.7	45.2	23.5	29.9	33.7	9.5	18.6	73.4	41.9	92.5
1960	43.6	22.9	21.6	30.5	35.4	40.5	74.8	57.9	66.9	34.5	78	65.6
1961	68.1	39.8	6.9	61.5	29.8	24.7	50.3	32.7	49.1	43.2	30	30.5
1962	44.8	16.9	28.2	25.5	35.3	18.7	27.2	59.4	75.7	16.7	39.6	39.3
1963	4.8	15.8	43.5	22.6	29.2	29.3	32.2	41.3	26.3	61.3	59.2	12.2
1964	22.4	12.8	39.2	37.9	36.2	26.8	37.4	52.1	24.7	39.2	29.7	70.7
1965	57.3	4.1	46.1	35.4	46.4	40.5	48.6	45.4	35.1	17.4	42.6	60.2
1966	37	38.8	22.1	48.5	40	58.3	22.8	50.9	35.2	70.9	23.4	43.7
1967	31.7	45.9	19.7	16.7	59.6	10.3	18.2	36.2	47.6	74.5	33.2	28.1
1968	54.6	7.1	32.2	26.7	38	29.5	12.7	43.8	56.5	42.6	52.7	65
1969	53.7	16.9	21.1	29.7	24.1	27.9	16.3	16.1	13.3	17.5	43	39.2
1970	24.4	45.5	19.4	50.7	15.5	21	39	26.6	47.2	36.4	69.3	17.5
1971	22.3	24.7	30.7	20.4	30.9	26.6	22.7	29.5	15.2	35.6	36.2	22.6
1972	42	22.8	32.8	32.2	45.6	27.5	33	24.9	5.6	22.7	53.7	37.6
1973	28.7	20.5	11.9	20.9	34.1	9.3	49.5	46.4	39.6	33.1	61.2	32
1974	74.3	28.7	14.8	15.3	30.8	24	50.5	45.8	61.7	26	30.6	39.5
1975	68	18.8	13.7	20.2	14.7	3.7	38.9	14.3	63.8	42.2	24.2	21.9
1976	36.2	22	28.9	13.6	35.5	15.2	28	3.2	41.3	66.7	31.9	29
1977	26	60.4	30.1	37.2	11.8	39.6	18.4	55	25.6	49.2	39.6	36.4
1978	37.6	26.6	40	25.6	7.6	25.8	34.3	31.4	21.6	23.5	40.9	57.2

1979	24.2	21.5	33.7	40.3	48.8	23.9	13.9	53.8	20.8	46.3	47.9	59.7
1980	28.1	35	41.5	18.6	14.2	25.1	53.1	36.4	50.9	47.2	35.4	45.1
1981	19.8	29.9	44.8	6.9	59.7	33.1	29.1	11.9	58	42.5	30.6	30.9
1982	34.3	33.1	43.7	12.2	26.5	44.1	7.7	56.6	32	59.5	55	47.4
1983	51.7	20.6	46.8	33.8	62.2	26.5	26.7	33.2	52.2	51.1	13.6	65.2
1984	66.2	28.7	30.3	18.3	9.4	13.8	18.7	50.7	41.9	40.4	48.6	43.7
1985	11.9	13.1	31.8	25.8	36.8	35	51.6	91.6	28.1	30.8	23.9	44.8
1986	41.3	1.2	45.3	28.5	52.5	52	28.5	71.8	1.2	51.7	48.4	65.4
1987	14	24.2	28.5	32.2	6.6	59.6	13	28.1	48.9	47.3	33	25.2
1988	63.3	31	51.6	6	39.9	24.3	49.4	45.2	28.1	43.6	22.2	19.2
1989	30.9	38.3	49.4	27.2	10.5	30.9	6.3	46.3	32	44.7	14.4	29.5
1990	53.9	86.9	7.8	24.8	12.4	32	28.5	22.5	10.5	73.3	32	49.9
1991	39.9	31.3	28.1	54.3	2.3	46.9	32.9	38.1	25.8	50.1	45.3	17.1
1992	33.6	21.1	44.7	38.9	25.8	16.7	33.5	59.8	44	25.3	43.4	35.2
1993	41.3	7	22.1	56.7	44.1	55.9	25.5	18.4	47.3	18.4	29.9	79.7
1994	55.4	40.9	49.4	51.6	29.8	21.7	32.9	33.1	43.6	28	30.3	71.6
1995	76.9	58.5	35.3	15	19.3	9.1	30.3	18	23	72.4	43.6	24.6
1996	40.1	46.4	51.4	31.8	28.2	13.5	26.9	49.7	14.5	71	44	13.4
1997	13.7	63.5	9	20.1	38.6	59.3	39.6	87.9	17.2	59.7	39.9	36.8
1998	52.1	13.4	43.7	45.3	13	84.8	40.7	26.1	32.2	67.1	50.6	47.1
1999	57.6	17.1	29	24.9	28.8	34.4	19.7	21.8	70.2	24.7	46.9	85.3
2000	27.9	50.1	16.1	23.9	29.2	21	32.8	34.8	51.3	70.8	67.8	38.6
2001	14.4	21	33.7	44.2	20.6	29.8	18.9	48.4	27.4	46.1	21.2	15.9
2002	58.2	64.4	21.9	37.3	56.4	52.1	33.8	26.5	12.1	63.7	67	39.6
2003	22.1	13.2	18.8	22.9	52.1	36.1	37.1	4.2	19.7	15.6	32.9	28.8
2004	41.7	14.2	29.8	26.1	15.4	25.8	21.6	36.8	36.4	74.6	29.3	40.1
2005	59.8	21.1	32.5	38	27.5	15	43.5	27	29.8	49.8	36.6	25.3
2006	16.6	19.2	62.1	23.6	43.8	13.7	33.8	59.5	55.4	68.6	52.3	62.1
2007	39.2	32.6	31.6	4.9	24	97.7	87.2	55.2	12.7	16.5	45	44
2008	95.8	17.4	42.5	7	7	28.2	63.6	105.3	55.1	56	27.4	30.8
2009	41.3	12	19.8	43.2	38.6	23.8	65	63	21	28.1	84.7	27
2010	39	30.2	36.6	19	16.7	23.1	76.3	22.8	67.7	32.3	74.6	6.4

Summary of Birr Wind gusts greater than 57kph by Decade: 13% (1 failure in every 7.7 months) **of months above SURVIVAL SPEED is not proper planning or sustainable development**		
Decade	Number of Months with wind gusts > 57kph	% of monthly failures over 120 months per decade & over 1,920 months per 150 years
1850 – 1859	9	8
1860 – 1869	12	10
1870 – 1879	20	17
1880 – 1889	9	8
1890 – 1889	19	16
1900 – 1909	14	12
1910- 1919	14	12
1920 – 1929	15	13
1930 – 1939	19	16
1940 – 1949	21	18

1950 – 1959	17	14
1960 – 1969	19	16
1970 – 1979	10	8
1980 – 1989	11	9
1990 – 1999	18	15
2000 – 2009	20	17
Total over 160 years	**247**	**13**

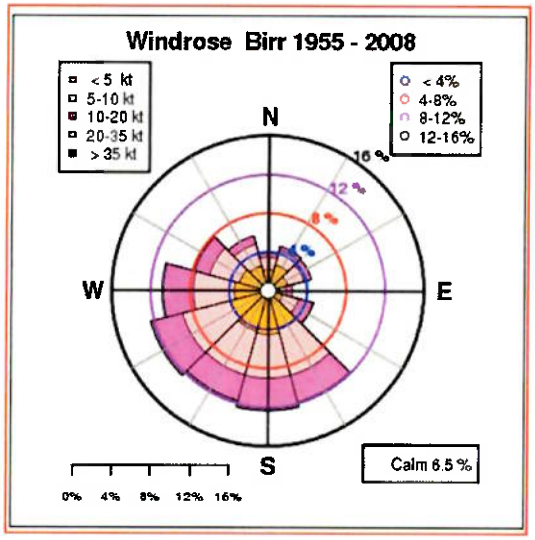
Table 2: Birr Wind gust speeds 1850 to 2010 in knots

Easting	Northings	Latitude	Longitude	elevation (metres)	Station	County						
208016.8	203400.5	53.08143	-7.88109	73	Birr	Offaly						
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1850	93.3	41.5	10.3	81.7	72.2	40.9	81	47.5	68.4	39.5	70.8	62
1851	144.7	18.4	72.9	33.1	28.9	88	90.9	56.7	30.3	91.2	40.5	52.2
1852	112.6	74	30.6	32.5	43.9	181.9	89.3	83.7	20.3	43.1	179.1	159.6
1853	99.6	30.3	69.8	74	26.1	68.4	86.5	75.9	49.5	146	78.4	17.5
1854	85.7	19.5	28.9	5.6	141.6	108.5	79.8	56.7	28.9	41.7	50.9	65.6
1855	10.3	38.7	88.4	26.1	57.3	55.3	79.5	85.4	36.4	75.7	32	39.5
1856	81.5	54	16.1	82.9	146	72	57.3	79.8	76.2	64.2	25.6	91.8
1857	65.1	40.6	65.9	106.5	55.6	77	37.5	41.2	80.9	60.9	68.4	27.8
1858	48.4	32	39.5	102.1	70.6	22.8	70.6	52.6	70.9	76.8	41.7	106.2
1859	54	34.2	64.8	89.3	8.9	40.6	40.9	53.4	122.7	43.9	90.9	85.9
1860	121.5	36.2	76.8	66.2	85.9	131.6	77.3	147.4	38.9	62.3	70.1	54.8
1861	47.3	52.8	97.9	22	8.1	94	210.3	129.1	130.7	94	85.4	49.2
1862	101.9	28.7	97.5	74.7	98.3	71.9	88.1	74.2	38.4	123.4	49.5	73.7
1863	79.2	41.9	64.3	31.7	25.7	22.9	8.4	95.8	93.2	106.9	103.4	71.1
1864	46	17.3	67.1	29.7	41.9	82.5	20.6	43.9	84.8	95.2	110	54.4
1865	98.6	68.8	45.7	26.7	93.7	21.6	80.5	71.6	12.2	102.4	106.9	78.5
1866	105.2	65.8	61.7	45.5	29	65.3	23.1	93.5	116.6	55.1	74.9	89.9
1867	66.8	60.7	57.1	75.4	78	25.9	97	73.4	33.5	119.4	32.3	29
1868	80.5	62.2	79.2	55.9	55.6	39.4	61.5	124.5	71.6	58.2	58.7	105.7
1869	103.1	65.5	45.2	71.1	94.5	38.4	54.6	52.6	156	15.7	74.2	130.3
1870	74.9	42.7	54.4	23.9	56.1	19.8	41.7	41.4	89.2	184.9	35.1	46.5
1871	72.6	53.3	51.6	53.1	51.6	73.2	132.6	55.9	16.3	88.9	43.2	61
1872	87.6	61	54.4	58.4	52.3	83.8	55.6	123.4	83.3	114	94.5	133.9
1873	135.9	22.9	106.7	45.5	53.6	36.3	106.7	124.7	103.6	99.1	51.8	29
1874	69.6	41.4	44.4	45.5	57.9	44.4	73.7	131.6	98.3	100.8	91.4	106.4
1875	123.2	30	26.7	20.1	49.3	81.3	65.8	78	166.4	77.5	66.5	49.8
1876	30.7	105.7	112.8	52.3	19	39.9	43.2	87.1	112.5	81.3	63.5	125.2
1877	120.4	58.9	67.3	76.5	52.6	94.7	58.9	111	65.5	88.9	138.2	85.1
1878	72.6	41.7	30.7	36.3	86.9	131.3	65	96.3	79.2	73.2	44.7	31.2
1879	42.7	83.6	40.4	56.9	64.8	124.5	76.2	115.3	116.8	31.5	21.8	47.2
1880	24.9	68.3	90.2	103.1	35.3	72.1	186.4	42.9	53.1	64.3	91.2	77.7
1881	17.3	84.3	58.9	34.3	63.2	104.4	47.8	119.9	100.6	63.5	103.9	122.2
1882	58.2	59.4	63.8	78.7	69.8	76.7	110.2	83.6	41.7	85.1	135.1	85.6
1883	125.7	91.4	16	43.9	65.3	43.7	99.1	100.8	86.4	90.9	106.9	47.2
1884	90.4	85.9	71.9	39.9	54.9	21.6	81.5	33	45.2	62.2	82	105.4

1885	56.1	74.2	41.4	82	54.6	30.2	54.6	79.2	129.3	95.5	47.8	24.4
1886	102.4	46.2	72.1	50.8	80.3	46	60.7	55.9	79	109.2	78.7	125
1887	71.4	31.7	33.3	48	35.1	8.6	73.9	63.2	42.4	67.1	55.4	66
1888	54.4	15.5	78.7	41.4	53.1	122.7	113.5	61.2	18	34.8	62.5	98
1889	56.1	43.2	36.3	47	83.3	31.2	48.3	122.7	22.4	79.5	39.1	78.7
1890	148.5	20.6	79.2	17.6	38.3	63.5	56.6	84	82.4	60	135.5	49.2
1891	48.1	4.3	36.5	47.8	79	77.1	54.5	177.5	51.6	86.9	68.1	152
1892	44.5	74	14.8	25.7	120	48.5	93.6	199	111.4	58.4	98.8	32.8
1893	73.5	75.5	19.7	20.8	68.9	66.7	55.6	95.6	58.3	79.9	47.9	101
1894	99.7	82.8	53.1	124	63.6	48.4	102.9	77.7	7.8	83.7	88.6	73.4
1895	56.1	21.7	75.7	49	17.4	20.8	90.9	123.4	11.3	72.8	111.6	94.1
1896	25.3	36.9	117.3	23	8.6	54.1	135.9	65.6	141.2	63.2	26.7	108.5
1897	46.2	41.6	117.3	110.2	33.8	96.2	59.3	107.1	56.5	67.2	130.9	99.2
1898	47.3	40.9	20.4	90.8	67.6	83.4	28.1	161.1	76.6	53.2	131.5	62.3
1899	87.8	58	32.3	75.3	85.3	47	87	111.7	59.7	40.4	71.6	99
1900	104.4	59.7	18.8	54.9	58.4	98.3	45.7	190.4	35.5	111.3	104.6	102.9
1901	69.7	33.3	73.7	51	46	71.9	31	70.3	98.7	66.8	104.5	75.9
1902	77.1	50.9	58.7	50.7	50.5	38.7	49.9	62.2	39.8	42.8	118.4	74
1903	120.6	82.2	139.4	35.3	42.4	30.1	129	132.1	81	113.3	63.8	66.4
1904	89.7	112.5	70.9	51	82.7	41.3	94.3	83	59.7	63	60.2	48.6
1905	58.5	40.1	107.7	47.2	23.1	37.3	34.2	137.3	36.1	34	63	48.2
1906	101.3	67.6	57.6	43.4	89.8	57.4	88.7	88.4	29.8	117.7	42.2	60
1907	29.1	43.7	69.5	63.4	73.3	75.9	124.7	83.2	26.4	122.5	71.7	89.8
1908	76.6	59.4	74.7	44.2	71.6	39.8	64.9	95.5	137.8	39.9	62.7	80.9
1909	70.6	24.6	77.4	107.6	66	43.7	50.1	29.9	53.3	109.5	50.1	94
1910	90.9	106.9	50	69	54	95	76.4	112.7	17.6	42.9	73.2	78.6
1911	42.6	68.2	33.5	41.4	32	56.1	72.9	60.4	42.4	103.6	103.9	129.8
1912	68.5	81	90.9	25.3	33.8	125.9	121.3	117.5	9.7	55.1	43.2	104.2
1913	121.2	32	100.1	99.2	88.1	83.2	26	32.9	81.3	92.2	78.2	64.3
1914	31.3	114.3	86.9	53	40.2	23.1	60.7	104.7	42.9	46.5	89.4	135.2
1915	102.7	105.3	20.3	43.8	12.4	50	117.2	100.5	37	74.2	76.8	108
1916	64.4	105.3	51.2	76	126.3	72.8	70.3	80.4	61.7	151.1	95.1	75.6
1917	24.8	46.3	62.4	29.2	83.6	39.2	65.9	229.2	44.3	99.1	63.2	36.8
1918	55.6	95.2	54.2	26.2	51.9	30.3	88.3	60.2	133.9	92	77.7	120.5
1919	70.4	34.7	47.2	38.3	64.1	95.5	45	59.7	65.1	23.3	52.6	132.5
1920	113.1	93.3	71.8	75.5	66.1	30.5	110.4	54	42.9	146.9	76	67.2
1921	94.1	23.4	71.9	20.1	51.1	19.3	101.9	85.4	55.8	67.1	71.5	106.8
1922	71.9	100.2	41.8	57.5	46.9	34.8	66.9	80.6	97.1	29.3	21.3	101.8
1923	74.4	121.4	59.8	73.7	33.8	23.7	71.8	136.5	85	114.1	75	81.1
1924	100.3	31.1	19.7	84.1	107.5	73.2	74.8	95.8	171.5	87.4	103.9	136.2
1925	83.8	133.7	11.9	96.5	120.8	13.9	100.9	46.4	46.8	55.1	54.4	43.8
1926	115.5	55.2	26.3	47.4	65.3	66.2	127	74.4	52.5	55.7	84.8	25
1927	85.9	61.7	87.5	39.1	20.1	70.6	75.3	109.1	124	48.5	63.1	54.9
1928	98.7	98.9	82.3	46.8	55	110.6	53.5	104.1	39.3	137.9	99.4	89.4
1929	37.4	83.5	13.4	23	65.3	42.9	88.2	126	21	103.2	101	165
1930	125	14.1	95	46.5	41.8	45.8	79.8	145	98.1	117.8	74.8	87.6
1931	47	64.2	53.7	77	71.5	101.8	99.5	64.8	63.5	50.1	156.5	55.1

1932	100.1	5.9	32.1	56.4	69.8	14.4	93.8	37.2	94.3	83.8	32.6	110.6
1933	72.6	59	84.3	25.1	51.3	63.7	79.2	59.2	35.6	53.6	29.2	49
1934	112.7	4.2	73.9	48.1	50.7	49	45.8	116.2	127.6	88.1	34.7	130.5
1935	31.4	76.6	34.6	44.9	26.5	121.4	23.9	82.1	143.9	98.4	102.3	37.5
1936	100.5	45.3	39	58	25	75.2	156	48.8	118.5	49.5	77.9	79.6
1937	113.7	105.5	52.3	67.5	69.7	52	97.8	84.6	101.7	48.9	37.3	49.3
1938	111.6	36.7	34.4	3.9	92.2	87.5	170.3	103.9	51.7	184.9	118.8	84
1939	127.7	69.6	68.5	27.4	33.8	57.9	91.3	36.8	57.1	22	187.8	56.4
1940	62.9	98.1	53.8	63.9	23	27.3	85.9	12.8	53.6	157.9	106.3	89.1
1941	56.1	93	58.4	42.4	66.7	19.1	70.8	78.6	24.7	67.9	123.3	58.7
1942	105.8	24	71	47.1	88.8	7.7	98.2	138.2	111.6	63.6	16.7	95.1
1943	127.6	44.7	21.4	38.3	81.9	76.4	50.8	112.9	63.5	95.7	69.1	56.1
1944	101.4	35.1	14	39.7	81.2	44.7	77.5	96.7	110.9	113	128.7	98.2
1945	51.1	79.4	43.1	33.4	82.4	92.6	106.8	59.5	91.8	73.9	17	105.6
1946	125.3	132	36.7	26.6	51.4	90.2	117.4	171.4	133.5	33.4	91.7	122.9
1947	89.7	48	115.6	98.2	117	113.8	73.5	21.2	95	96.4	110.2	73.2
1948	178	55.2	71.8	51.8	60.6	97.8	51.2	72.8	83.7	95.9	74.1	144.9
1949	50.6	66	57.6	58.1	44.5	18.2	74.4	98.3	25.7	161.7	82.2	103
1950	32.4	100.5	42.9	66.3	31	47.2	136.6	112.3	138.1	79.9	70.6	57.2
1951	95.1	64.9	97.9	45.6	44.8	35.2	41.3	103.5	115.6	49.3	78.8	144.6
1952	112.9	21.9	28.4	49.2	96.6	56.3	40.7	73.9	53.8	131.4	51.5	74.8
1953	40.2	39.4	10.9	73.2	43.8	25.1	83.5	121.2	68.6	78.7	69.1	71
1954	54.8	103.7	59.7	30.4	101.5	62.1	90.5	104.4	124.3	125.9	99.7	97.3
1955	67.6	60.2	37.3	69.7	82.6	105	13.5	33.2	88	39.3	64.7	108.9
1956	74.6	21.7	50.2	22.3	33.8	59.6	116.3	128.6	119.4	61.4	48	107
1957	105.7	77.7	93	40.2	52.1	21	115.4	43.9	86.8	107.4	17.9	69.5
1958	95.6	86.9	39.5	37.5	101.2	85.1	100.2	153.3	101	46.1	51.6	88.7
1959	53.3	28.5	55.7	87.9	45.6	58.2	65.5	18.4	36.1	142.7	81.4	179.9
1960	84.7	44.6	42	59.3	68.9	78.7	145.4	112.5	130.1	67.1	151.7	127.6
1961	132.4	77.4	13.4	119.5	57.9	48.1	97.8	63.6	95.4	83.9	58.3	59.3
1962	87.1	32.8	54.8	49.5	68.6	36.4	52.8	115.4	147.2	32.4	76.9	76.4
1963	9.3	30.8	84.6	44	56.7	56.9	62.5	80.2	51.1	119.2	115.1	23.8
1964	43.6	24.8	76.3	73.6	70.3	52.1	72.8	101.2	48.1	76.3	57.7	137.5
1965	111.3	7.9	89.6	68.8	90.2	78.7	94.4	88.3	68.2	33.9	82.8	117.1
1966	72	75.5	42.9	94.3	77.8	113.3	44.4	99	68.5	137.8	45.4	84.9
1967	61.6	89.2	38.3	32.5	115.8	20	35.4	70.4	92.5	144.8	64.5	54.6
1968	106.1	13.8	62.5	51.9	73.8	57.3	24.6	85.2	109.8	82.9	102.4	126.4
1969	104.4	32.9	41.1	57.8	46.8	54.2	31.7	31.3	25.8	34.1	83.5	76.3
1970	47.4	88.5	37.7	98.5	30.2	40.9	75.9	51.7	91.8	70.7	134.7	34.1
1971	43.3	48	59.7	39.7	60	51.7	44.2	57.3	29.6	69.3	70.3	44
1972	81.6	44.4	63.7	62.6	88.6	53.4	64.1	48.5	10.8	44.1	104.4	73.1
1973	55.7	39.8	23.2	40.6	66.2	18	96.2	90.2	76.9	64.3	119	62.3
1974	144.4	55.8	28.7	29.8	59.8	46.6	98.1	89.1	119.9	50.5	59.5	76.7
1975	132.2	36.5	26.7	39.2	28.6	7.1	75.7	27.8	124	82	47	42.5
1976	70.4	42.7	56.2	26.4	69	29.5	54.4	6.2	80.3	129.7	62.1	56.4
1977	50.6	117.4	58.5	72.4	22.9	77	35.7	106.9	49.8	95.7	76.9	70.7
1978	73	51.7	77.7	49.8	14.8	50.1	66.7	61.1	41.9	45.7	79.5	111.1

1979	47.1	41.8	65.6	78.3	94.8	46.5	27	104.6	40.5	90.1	93.2	116
1980	54.7	68.1	80.6	36.1	27.7	48.7	103.2	70.8	98.9	91.7	68.8	87.6
1981	38.4	58.2	87.1	13.4	116	64.4	56.5	23.2	112.7	82.7	59.4	60.1
1982	66.7	64.4	84.9	23.8	51.6	85.7	14.9	110	62.2	115.6	106.9	92.2
1983	100.5	40	90.9	65.7	121	51.5	52	64.6	101.4	99.4	26.5	126.7
1984	128.6	55.7	58.9	35.6	18.3	26.9	36.3	98.6	81.5	78.6	94.4	85
1985	23.2	25.4	61.8	50.2	71.5	68.1	100.4	178	54.6	59.9	46.4	87.1
1986	80.3	2.4	88.1	55.4	102.1	101	55.4	139.5	2.3	100.5	94.1	127.1
1987	27.3	47.1	55.4	62.6	12.8	115.8	25.2	54.7	95	92	64.2	48.9
1988	123.1	60.3	100.4	11.6	77.5	47.3	96	87.9	54.7	84.8	43.1	37.4
1989	60	74.5	96.1	52.8	20.5	60	12.3	90	62.2	86.8	27.9	57.4
1990	104.8	168.9	15.2	48.3	24.1	62.2	55.4	43.8	20.5	142.5	62.3	97
1991	77.5	60.9	54.6	105.6	4.4	91.2	63.9	74.1	50.1	97.4	88.1	33.2
1992	65.4	41	86.8	75.7	50.2	32.5	65.1	116.2	85.5	49.1	84.3	68.5
1993	80.2	13.6	43	110.2	85.8	108.6	49.6	35.8	91.9	35.7	58.2	155
1994	107.7	79.5	96	100.4	57.9	42.2	64	64.4	84.7	54.5	59	139.2
1995	149.5	113.7	68.7	29.2	37.6	17.7	59	35	44.8	140.7	84.8	47.9
1996	78	90.2	100	61.9	54.8	26.2	52.2	96.7	28.1	138.1	85.5	26
1997	26.6	123.5	17.5	39	75.1	115.2	76.9	170.9	33.4	116.1	77.6	71.5
1998	101.2	26	84.9	88	25.3	164.8	79.1	50.8	62.5	130.5	98.4	91.6
1999	111.9	33.3	56.3	48.5	56	66.9	38.2	42.3	136.5	48	91.1	165.8
2000	54.3	97.3	31.3	46.5	56.7	40.8	63.7	67.7	99.8	137.6	131.8	75
2001	27.9	40.9	65.6	86	40	57.9	36.7	94.1	53.3	89.6	41.2	30.9
2002	113.1	125.1	42.6	72.6	109.6	101.2	65.8	51.6	23.5	123.8	130.2	77
2003	42.9	25.6	36.5	44.6	101.3	70.1	72.1	8.2	38.3	30.3	63.9	55.9
2004	81.1	27.7	57.9	50.7	29.9	50.1	41.9	71.5	70.8	145.1	56.9	78
2005	116.3	41	63.2	73.9	53.5	29.1	84.6	52.5	58	96.9	71.1	49.2
2006	32.3	37.3	120.7	45.9	85.1	26.6	65.7	115.7	107.7	133.4	101.7	120.8
2007	76.3	63.4	61.4	9.6	46.7	190	169.6	107.3	24.6	32.1	87.4	85.5
2008	186.2	33.8	82.7	13.6	13.7	54.8	123.7	204.8	107.1	108.8	53.2	59.8
2009	80.2	23.4	38.5	83.9	75	46.2	126.3	122.5	40.8	54.7	164.7	52.4
2010	75.9	58.7	71.1	36.9	32.4	44.9	148.3	44.4	131.7	62.8	145.1	12.4



The prevailing winds are from the W/SW directions. This means that the Wake will primarily be to the East/Northeast, which has a huge impact on the low-lying farmlands to the East. These include a lowering of the ground temperature by 3^0 Centigrade together with turbulent air that restricts flying birds. This barrier would interfere with foraging for food & would create massive displacement to the detriment of a range of at risk species & protected species.
This drop in temperature will have an effect on the food source for birds in association with an economic cost on all existing houses, with increased heating costs & colder enjoyment values.

Reference No 24 : Vestas Brochure data

Restricted
Document no.: 0098-0840 V03
2020-12-07

Performance Specification

EnVentus™

V162-6.0 MW 50/60 Hz

3.1 Climate and Site Conditions

The standard turbine is designed for the wind climate conditions listed below. Values refer to hub height.

Wind Climate	IEC S	IEC S	IEC S	IEC S
Power Rating	**6.0 MW**	**6.0 MW**	**6.0 MW**	**6.0 MW**
Hub Height	**119 m**	**125 m**	**149 m**	**166 m**
Average design parameters - IEC				
Wind Speed (10 min average), V_{ave}	7.4 m/s	8.5 m/s	7.9 m/s	7.9 m/s
Weibull Scale Factor, C	8.3 m/s	9.6 m/s	8.9 m/s	8.9 m/s
Weibull Shape Factor, k	2.48	2.3	2.48	2.48
I_{ref} acc. to IEC 61400-1	0.15	0.14	0.15	0.15
Turbulence Intensity acc. to IEC 61400-1, Including Wind Farm Turbulence (@15 m/s) I_{90} (90% quantile)	16.9%	15.7%	16.9 %	16.9 %
Wind Shear, α	0.30	0.20	0.30	0.30
Inflow Angle (vertical)	8°	8°	8°	8°
Extreme design parameters – IEC				
Extr. Wind Speed (10 min average), V_{50}	37.1 m/s	37.5 m/s	39.5 m/s	39.5 m/s
Survival Wind Speed (3 s gust), V_{e50}	51.9 m/s	52.5 m/s	55.3 m/s	55.3 m/s
Turbulence Intensity, I_{V50}	11%	11 %	11 %	11 %

Note Survival Wind Speed of 55.3m/s. Note maximum gust of 39.6m/s above & possibly at ground level. Note gust speeds for Birr Met Station above in excess of this survival speed.

3.4 Operational Envelope – Conditions for Power Curve and Ct Values (at Hub Height)

Please consult section 6 and subsequent, for power curves and C_t values.

Conditions for Power Curve and C_t Values (at Hub Height)	
Wind Shear, α	0.00-0.30 (10-minute average)
Turbulence Intensity, I	6-12% (10-minute average)
Blades	Clean
Rain	No
Ice/Snow on Blades	No
Leading Edge	No damage
Terrain	IEC 61400-12-1
Inflow Angle (Vertical)	0 ±2°
Grid Voltage	Nominal Voltage ±2.5%
Grid Frequency	Nominal Frequency ±0.5 Hz
Grid Active Power (LV-side)	Per tabulated values in Section 6 and following sections
Grid Reactive Power (LV-side)	Power Factor 1.0

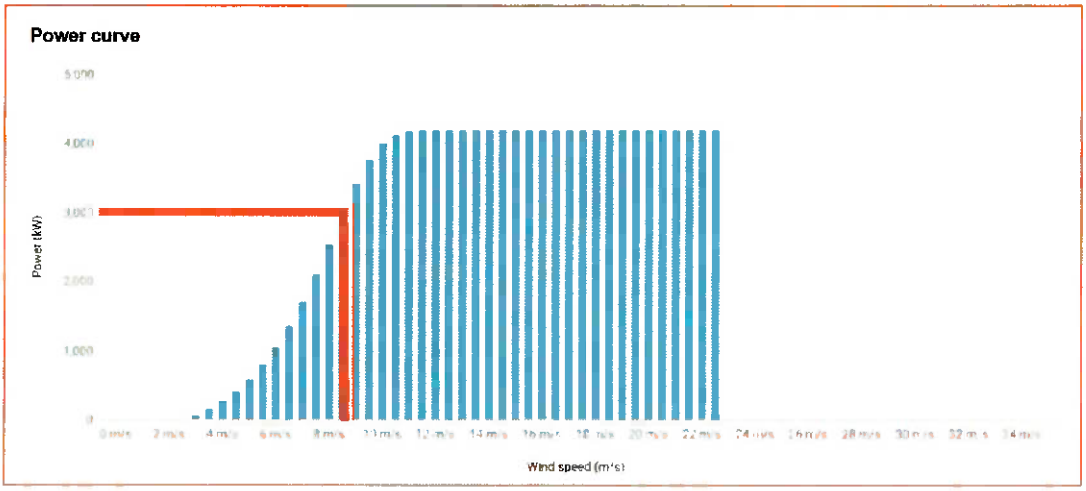
Note power curves based on turbulence 6-12%, clean blades, no rain, no ice/snow on blades, no damage to leading edge. All of these issues will lower power output.

6 Power Curves, Ct Values and Sound Curves, Mode PO6000/PO6000-0S

6.1 Power Curves, Mode PO6000/PO6000-0S

	Air density [kg/m³]													
Wind speed [m/s]	1.225	0.950	0.975	1.000	1.025	1.050	1.075	1.100	1.125	1.150	1.175	1.200	1.250	1.275
3.0	32	13	14	15	17	18	20	22	24	26	28	30	35	38
3.5	150	96	101	106	111	116	121	125	130	135	140	145	155	159
4.0	292	208	215	223	231	238	246	254	261	269	277	284	300	307
4.5	467	344	355	366	378	389	400	411	422	433	444	455	478	489
5.0	676	507	523	538	553	569	584	599	615	630	645	660	691	706
5.5	927	701	721	742	762	783	804	824	845	865	886	907	948	968
6.0	1229	934	961	988	1015	1042	1068	1095	1122	1148	1175	1202	1255	1282
6.5	1584	1211	1245	1279	1313	1347	1381	1415	1449	1483	1516	1550	1618	1651
7.0	2000	1535	1578	1620	1662	1705	1747	1789	1832	1874	1916	1958	2042	2084
7.5	2476	1907	1959	2010	2062	2114	2166	2218	2269	2321	2373	2424	2527	2578
8.0	3017	2330	2392	2455	2518	2581	2643	2706	2768	2831	2893	2955	3079	3141
8.5	3624	2807	2882	2957	3032	3107	3181	3255	3330	3404	3477	3551	3696	3769
9.0	4264	3337	3424	3511	3598	3685	3769	3853	3937	4022	4102	4183	4341	4419
9.5	4859	3882	3976	4070	4163	4257	4345	4433	4521	4609	4692	4776	4936	5014
10.0	5380	4415	4513	4611	4709	4808	4895	4983	5071	5159	5233	5306	5442	5504
10.5	5734	4939	5045	5149	5254	5299	5371	5443	5514	5585	5635	5684	5770	5807

Air Density at sea level is 1.225kg/m³. 8m/s is average annual wind speed. 3.017Mw is the output per turbine & 45.255Mw for 15 turbines & less than the 50Mw threshold for SID.



11.3.2.2 Physical environment: Wind and Storms

Future climate and weather predictions indicate a slight reduction in mid-century (2041 – 2060) average wind speeds around Ireland (-2.47% for RCP 8.5 high emissions scenario compared to the 1981 – 2000 baseline), with these decreases being more pronounced during the summer months. Predictions also point towards less frequent, but more intense storm activity around Ireland. However, there is uncertainty with regard to future predictions for storms, and it is expected that the trends observed in the frequency and intensity of storms will continue to be influenced by natural variability. Additionally, future trends are difficult to predict due to a low confidence in attributing historic trends in storms to climate change. However, ongoing changes in the climate may potentially affect storms with cumulative effects on wind.

Lemanaghan Wind Farm, Co. Offaly Planning Report: 5.2.1.1 Suitability of Lemanaghan Bog
Suitable Wind Speeds
The Irish Wind Atlas produced by Sustainable Energy Authority of Ireland (SEAI) shows average wind speeds for the country. A suitable wind regime and consistent wind speeds are required for the development of a wind energy project. **Wind speeds in the in the midlands bog groups are between 7 – 8 m/s.** While the wind resource of Ireland's midlands is lower than that of coastal and elevated regions, it is still very good in comparison with many parts of Europe. Onsite monitoring of the wind resource, which is ongoing, will further verify that with a sufficient turbine height and blade diameter, the wind resource of the site is commercially viable.

5.2.3 **Turbine Layout Design Process**
The selection of the number of turbines and layout of same also had regard to wind-take and the separation distance to be maintained between turbines, as well as landscape and visual, cultural heritage, noise and shadow flicker impacts.

Lemanaghan Wind Farm, Co. Offaly Planning Report

Table 7-1 International, National & Regional Policy Objective and Compliance Summary Table

Table 7-1 International, National & Regional Policy Objective and Compliance Summary Table Policy Document	Targets / Objectives	Compliance
Wind Energy Guidelines	• Acceptable noise thresholds and monitoring frameworks • Visual amenity setback and spacing • Control of shadow flicker • Compliance with Community consultation and dividend requirements • Consideration of the siting, route and design of the proposed grid connection as part of the whole project. #	**The Proposed Project complies with the requirements set out by the DoEHLG 2006 Guidelines, including noise, set back, shadow flicker, and community consultation guidelines.** **It is anticipated that the Proposed Project will be capable of adhering to the Draft DoHPLG 2019 Guidelines when finalised.**

Table 7-3 Local Policy Objective and Compliance Summary Table

Policy	Policy/ Objective	Compliance
Renewable Energy	CAEP-38 It is Council policy that in assessing planning applications for wind farms, the Council shall: • have regard to the provisions of the Wind Energy Development Guidelines 2006, the Interim Guidelines for Planning Authorities on Statutory Plans, Renewable Energy and Climate Change 2017 and the Draft revised Wind Energy Guidelines 2019 which are expected to be finalised in the near future;	Table 7-5 of this Report provides a compliance statement against the OCDP Wind Energy Development Management Standards (Development Management Standard 109), which include; the 2006 Guidelines and Draft 2019 Guidelines; the OCDP Wind Energy Strategy Designation Areas and all other development management standards in relation to wind energy as set out in Chapter 13 of the OCDP.

Reference No 26 : Separation distances. Should be 7x150 = 1,050m to comply with wind energy guidelines

Turbine	ITM X	Distance	Square	ITM Y	Distance	Square	Sum	Sq Root or Separation Distances between Turbines
1	614199			727374				
2	614482	283	80089	726940	-434	188356	268445	T1 to T2 = 518.1
3	614780	298	88804	726517	-423	178929	267733	T2 to T3 = 517.4
4	615314	534	285156	727112	595	354025	639181	T3 to T4 = 799.5
5	615979	665	442225	727580	468	219024	661249	T4 to T5 = 813.2
6	615647	-332	110224	727936	356	126736	236960	T5 to T6 = 486.8
7	614968	-679	461041	727550	-386	148996	610037	T6 to T7 = 781.0
8	615376	408	166464	728346	796	633616	800080	T7 to T8 = 894.5
9	616022	646	417316	728746	400	160000	577316	T8 to T9 = 759.8
10	615717	-305	93025	729399	653	426409	519434	T9 to T10 = 720.7
11	616380	663	439569	729350	-49	2401	441970	T10 to T11 = 664.8
12	616415	35	1225	728161	-1189	1413721	1414946	T11 to T12 = 1189.5
13	616995	580	336400	728609	448	200704	537104	T12 to T13 = 732.9
14	617357	362	131044	728184	-425	180625	311669	T13 to T14 = 558.3
15	617684	327	106929	728907	723	522729	629658	T14 to T15 = 793.5
1	614199			727374				
7	614968	769	591361	727550	176	30976	622337	T1 to T7 = 788.9
2	614482			726940				
4	615314	832	692224	727112	172	29584	721808	T2 to T4 = 849.6
2	614482			726940				
7	614968	486	236196	727550	610	372100	608296	T2 to T7 = 779.9
4	615314			727112				
6	615647	333	110889	727936	824	678976	789865	T4 to T6 = 888.7
5	615979			727580				
12	616415	436	190096	728161	581	337561	527657	T5 to T12 = 726.4
6	615647			727936				
12	616415	768	589824	728161	225	50625	640449	T6 to T12 = 800.3

9	616022			728746				
11	616380	358	128164	729350	604	364816	492980	T9 to T1 = 702.1
9	616022			728746				
12	616415	393	154449	728161	-585	342225	496674	T9 to T12 = 704.8
9	616022			728746				
13	616995	973	946729	728609	-137	18769	965498	T9 to T13 = 982.6
12	616415			728161				
14	617357	942	887364	728184	23	529	887893	T12 to T14 = 942.3
13	616995			728609				
15	617684	689	474721	728907	298	88804	563525	T13 to T15 = 750.7

Lemanaghan Wind turbine distances (yellow above) versus 7 times rotor diameter of 7x150 = 1050m (as required in both the 2006 Guidelines & the 2019 Draft Guidelines). Only one turbine distance complies with this 1050m separation distance & the application is thus non-compliant. The applicant is squeezing in way too many turbines in breach of the Wind Energy Guidelines, which will affect turbulence downwind & increase noise downwind. These turbine grid references [ITM X & ITM Y] are included in the Applicant's Non Technical Summary. This level of information is totally unacceptable for normal Citizens. Who can convert Grid coordinates to separation distances?

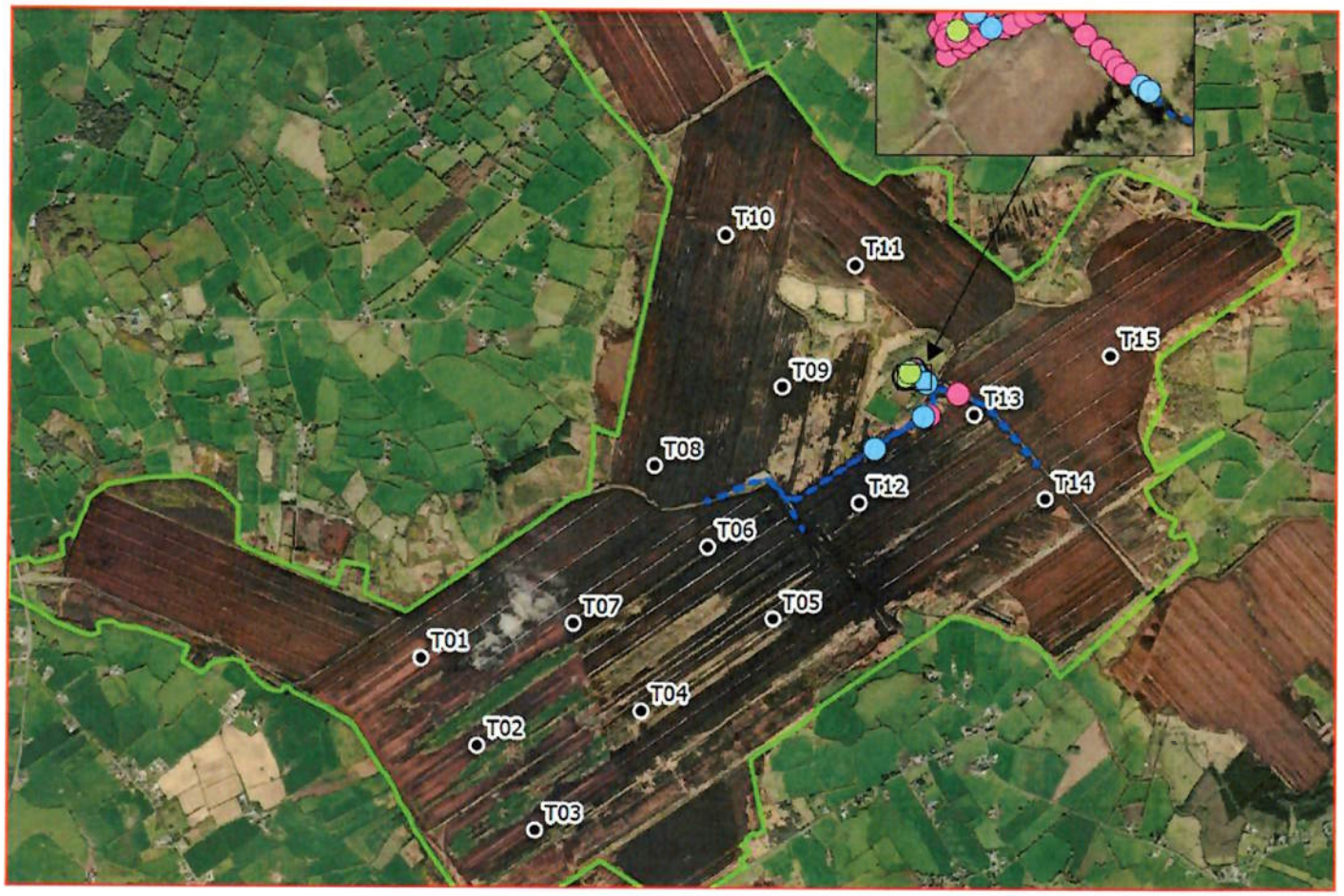
Table 1 Proposed Wind Turbine Locations and Elevations

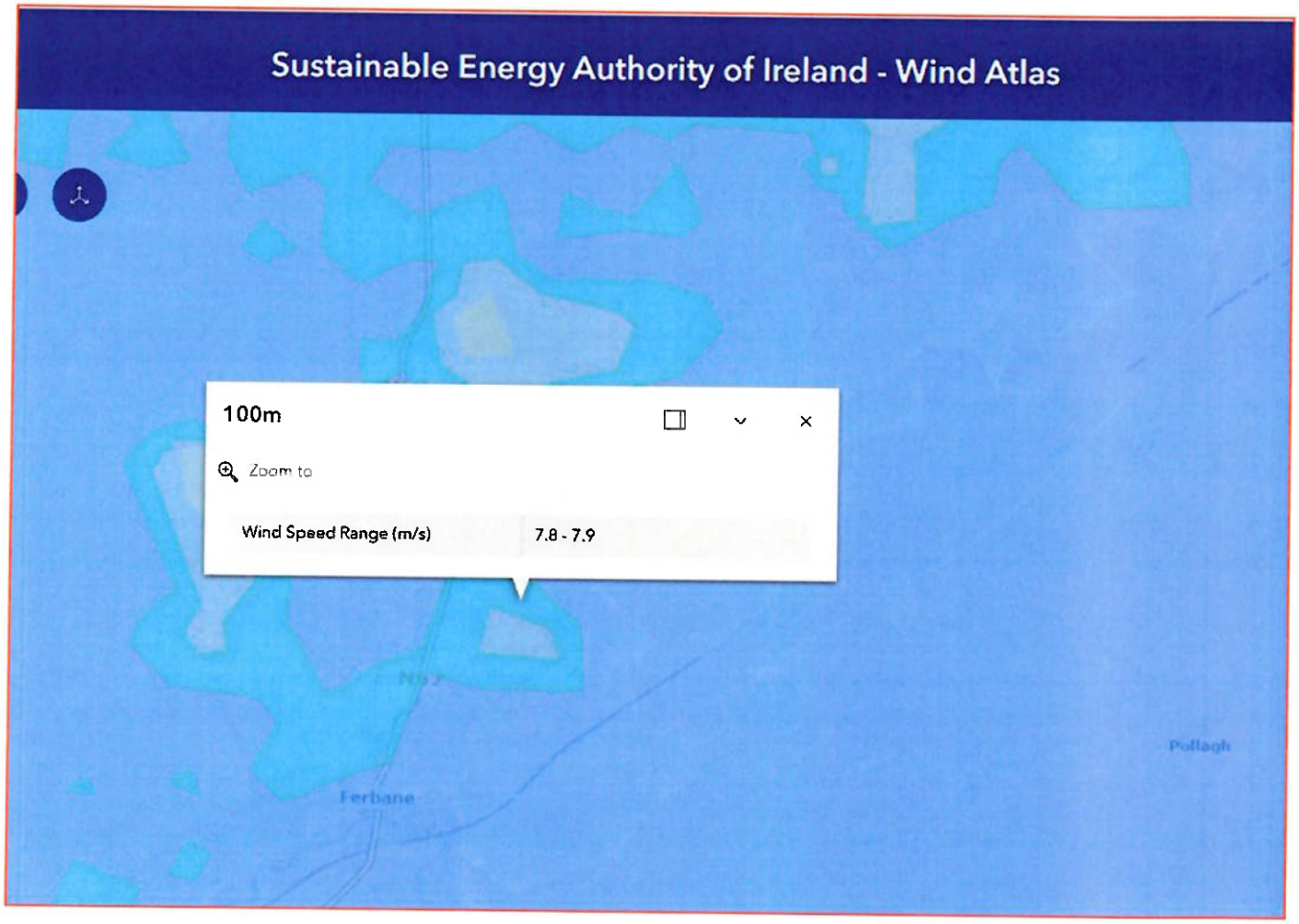
Turbine	ITM X	ITM Y	Top of Foundation Levels (mOD)
1	614199	727374	51.5
2	614482	726940	51.9
3	614780	726517	50.6
4	615314	727112	52.7
5	615979	727580	48.1
6	615647	727936	50.0
7	614968	727550	51.3
8	615376	728346	50.6
9	616022	728746	52.3
10	615717	729399	53.7
11	616380	729350	55.7
12	616415	728161	48.5
13	616995	728609	51.8
14	617357	728184	48.9
15	617684	728907	52.2

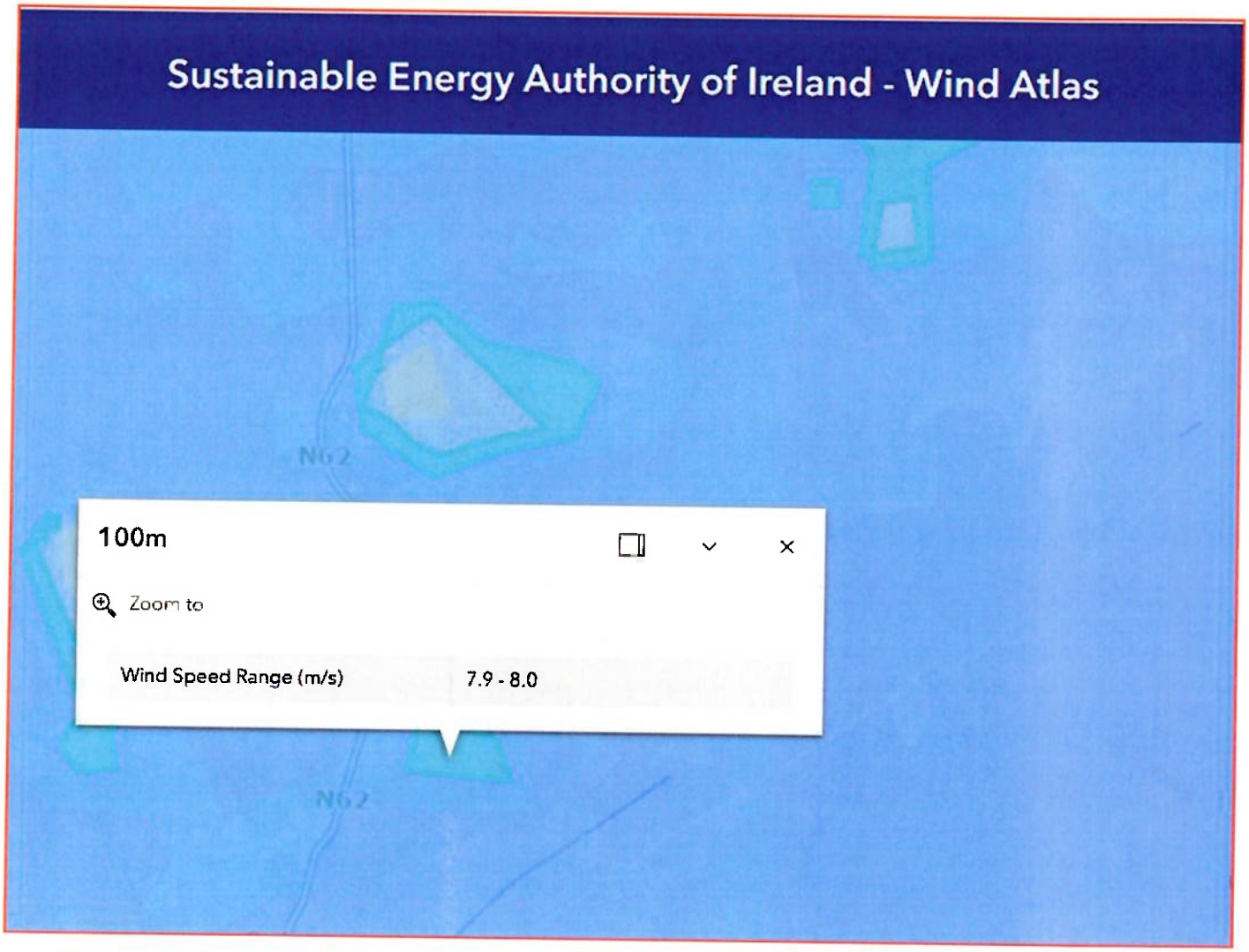
Reference Number 27 : Wind Turbine Separation Distances Matter, June 2014. Peter R Mitchell, AM, BChE "Evidence is that the manufacturer-recommended separation distances of 7 to 8 rotor diameters for turbines in line with the prevailing wind and 5 rotor diameters for turbines abreast, still allows turbulent air exiting one turbine to retain significant turbulence when entering the next; so the manufacturers' recommended spacings can be considered as an unfortunate compromise and inadequate to contain noise.

The most efficient turbine spacing, i.e., that which allows the turbines to economically extract the most energy from the wind, has been shown to be some 15 rotor diameters. Most efficient extraction of useful energy will approximately coincide with the least production of waste energy, namely sound and vibration.

The Waubra Foundation currently considers that for a block of turbines that is likely to be subject to changing wind directions, noise will be minimised if the turbine spacing in all directions approaches the most efficient spacing of about 15 rotor diameters.". http://waubrafoundation.org.au/resources/shepherd-khubbard-h-noise-radiation-characteristics-westinghouse-wwg-0600-wind-turbine-generator/



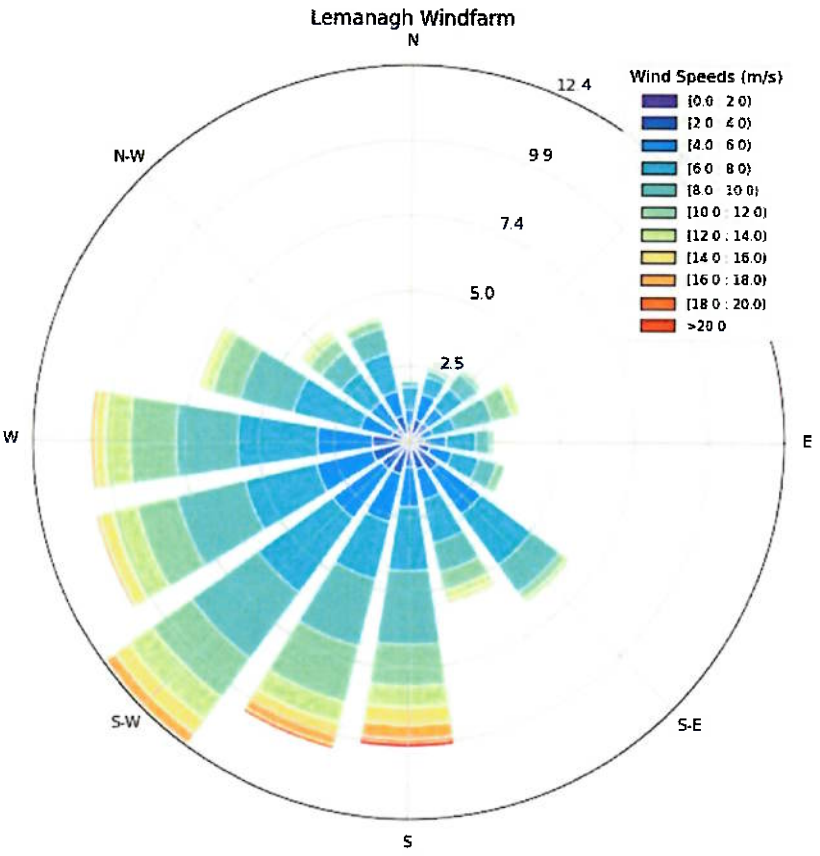

Sustainable Energy Authority of Ireland - Wind Atlas
100m
Zoom to
Wind Speed Range (m/s)
7.8 - 7.9
Ferbane
Pollagh



VESTAS WIND TURBINES

The power output for a Vestas 150 wind turbine based on c8m/s at 100m high (SEAI Wind Atlas) is a little over 3MW from above graph. For 15 Wind Turbines, the output is circa 45MW [3x15] & far less than the 50Mw threshold for SID & should not be submitted directly to ACP. This application should be submitted to OCC.

The Applicant & ACP are using brochure capacity to dodge the Offaly County Council Planning process and they are not using power output as outlined in the Act. They are denying our citizens the right of appeal. The only method for SID examination is through Judicial Review which is not an appeal process.



This Windrose indicates that the prevailing winds are from the South to West with the biggest amount from the South-West. All houses to the North to the East will suffer from downwind noise.

Reference No 28 : ACP Oriel Windfarm - 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 they are treated in the population estimates. The applicant should provide evidence-based justification for the method applied, which should comprise the most appropriate and precautionary method for estimating the breeding season populations to inform assessment conclusions.

The applicant is requested to clearly present the values and equations used to derive the population estimates, including their sources (e.g. a list of colonies or sites included within the reference populations), to allow validation of the methodology. The applicant should also address this issue in the Cumulative Impact Assessment.

Disturbance & Displacement

The rationale for decisions to screen out bird species for assessment of disturbance and displacement if determined to have a low sensitivity to disturbance and displacement or which were recorded in low numbers is not clear, giving rise to concerns regarding the robustness of the conclusions in the EIAR and NIS. The applicant is requested to provide justification for the approaches taken for screening out in such instances.

The Board notes the submission of Appendix 11- 07: Offshore Ornithology Apportioning Impacts to Individual Colonies of the EIAR which seeks to apportion predicted mortalities from displacement and collisions of the project to seabird colonies. In terms of disturbance and displacement, fours species have been identified as potentially at risk: Common Guillemot (*Uria aalge*);

Razorbill (*Alca torda*);

Great northern Diver (*Gavia immer*); and

Northern Gannet (*Morus bassanus);*

The Board notes that the applicant has assessed predicted annual mortalities for a number of species based on a single mortality rate, rather than the industry recommended range of mortality rates. Chapter 11 of the EIAR bases conclusions on a rate of 50% displacement and 1% mortality rate for auks1

1 The SNCB (2022) recommend a displacement rate of between 30% and 70% and a mortality rate of 1% and Nature Scot 60% and 1% respectively, 100% displacement and 0.5% mortality for GND and 60% to 80% displacement and 1% mortality rate for gannet during the operational phase of the project. Given the location of the site partially within the North-west Irish Sea SPA (and proximity to colonies at Rockabill SPA, Lambay Island SPA & Irelands Eye SPA) the applicant is requested to update the EIAR to adopt a range of relevant mortality rates in the estimates of predicted mortalities for relevant species, and that these be clearly presented in the EIAR.

Dundalk Bay is noted to be a very important foraging area for birds, likely linked to the prey resources known to exist there, including spawning habitat of the Atlantic Herring *Clupea harengus*. The rate of displacement does not appear to have been fully considered in the context of potential indirect and cumulative effects of the project on birds, such as Manx Shearwater, who forage in Dundalk Bay in large numbers, where a low rate of displacement may induce a population-scale impact. The applicant is requested to address potential changes in the distribution and abundance of important prey populations on birds.

Collision Risk

The Board notes the submission of Appendix 11-4 – Offshore Ornithology Collision Risk Modelling (CRM) which identifies five seabird species as potentially at risk due to their recorded abundance in the offshore wind farm area and their likelihood of flying at potential collision height (PCH) between the lowest and highest sweep of the WTG rotor blades above sea level: Northern Gannet (*Morus bassanus*);

Kittiwake (*Rissa tridactyla*);
Common gull (*Larus canus*);
Herring gull (*Larus argentatus*); and
Great black-backed gull (*Larus marinus*).

It is noted that the findings of the CRM rely on limited empirical data and avoidance rates for waterbirds which are not up to date. The level of confidence with regard to avoidance rates for a significant proportion of waterbirds is very low and this should be given due consideration when drawing conclusions on impacts. The use of the original Band (2012) model in its various forms may not be justified, and the Board is concerned that the conclusion of the applicants' assessment is not supported given the limitations identified. It is recommended that more appropriate methodologies are developed and implemented to gather relevant empirical data to support the assessment of effects, including updating all parameters using the most up to date empirical data, or if not appropriate, provide comprehensive justification for the methodology employed.

In terms of the estimated collisions for the above bird species, the Board notes that Natural England have accepted a 70% reduction in Northern Gannet collision mortality estimates to account for macro-avoidance at previous developments, such as Hornsea 4. However, this is applied where developments are much further from the coast and from Northern Gannet colonies. Given the proximity of the project to the coast and to the gannet colony at Ireland's Eye SPA and Lambay SPA, approximately 52km to the south of the project site and within the foraging range of this species, a more precautionary approach is recommended. The applicant is requested to consider the approach taken in relation to Northern Gannet collision estimates, so they are not reduced by 70% to account for macro-avoidance.

The Board notes that a number of species have been screened out as being vulnerable to collision risk, where abundances are noted to be high or very high due to their flight behaviours and responses, particularly, tending to fly below the sweep of the turbine blades. It is noted that those include species associated with nearby SPAs. The applicant is requested to provide further information on the rationale to exclude certain species in terms of the abundances identified and where, in certain conditions, they may fly higher than expected. Where a species is numerous, modelling of collision risk may produce fatality estimates that are concerning for particular populations, the Manx Shearwater *(Puffinus puffinus)* for example (a Qualifying Interest (QI) of the North-west Irish Sea SPA and the second most frequently recorded species within the Offshore Ornithological Study

Any potential specific mitigation measures to minimise the effects of the project on birds, such as painting of turbine blades, the use of curtailment systems in particular conditions or at particular times etc, if considered appropriate, should also be included and addressed in the application documentation.

Combined Disturbance and Displacement and Collision Risk:

Northern Gannet (*Morus bassanus*) - The Board notes that the overall impacts to species in terms of the predicted mortalities arising from displacement and/or collision events, are contextualised using the BDMPS as set out in Furness (2015). This area is significantly larger than the western Irish Sea and it is requested that the EIAR is revised to ensure that the assessment of predicted annual mortalities uses the western Irish Sea for context.

Red-throated diver (*Gavia stellata*) - Red-throated diver is identified as a QI for the Northwest Irish Sea SPA and a species known to be highly sensitive to offshore wind farm developments due to displacement effects. Recent empirical evidence indicates that the species avoids a larger area than the 4km buffer afforded in the EIAR and NIS, with a 10 km buffer being recommended as per UK Joint SNCB Interim Displacement Advice Note (2022). The EIAR indicates that the species was identified in low abundance (106 birds) in the north and west of the study area during the surveys. While noting the high sensitivity of the species to disturbance and displacement however, the low abundance recorded during site-specific surveys resulted in the species being screened out for EIA purposes. However, the 'Digital video aerial survey of birds in intertidal habitats of Gormanstown December 2018 to March 2019' (HiDef, 2019), commissioned by the Marine Institute, indicates the known extent of Red-throated Diver and their densities and shows the species concentrating in the shallow Dundalk Bay waters and in and around the proposed Oriel Project area. This survey data (HiDef, 2019) suggest that notable densities of the species may be present within km of the array area. In this regard, the Board is concerned that the EIAR does not set out the recorded density values for this species and scopes out red-throated diver for further consideration in terms of disturbance, displacement and mortality. The applicant is requested to include the HiDef surveys in the assessment of potential impacts on red-throated diver and other North-west Irish Sea SPA QI species sensitive to displacement during both construction and operational phases of the project (e.g. Great Northern Diver *Gavia immer*, Common Scoter *Melanitta nigra*), in terms of predicted mortalities based on a displacement buffer of 10km with regard to the North-west Irish Sea SPA and consider the significance of the effects on this species for all seasons, individually and combined.

Black-legged Kittiwake (*Rissa tridactyla*) - The Board note that Black-legged kittiwake, a species identified as being in decline, is a QI for North-west Irish Sea cSPA, as well as Lambay Island SPA and Ireland's Eye SPA, and that Black-legged Kittiwake has variable responses to offshore wind farms (OWFs). There is a colony in Northern Ireland which may also forage in this area. In this regard, the Board requests that the applicant include this species as a receptor of disturbance and displacement impacts during operation and maintenance. The scoping out of the species is considered to run contrary to the advice of NatureScot (2023) for species where both collision risk and displacement are considered. The applicant is requested to submit further information to identify and evaluate the impact of displacement of Black-legged Kittiwake in conjunction with collision risk. The application documentation should be revised to fully address the potential for significant impacts on this species.

Great Northern Diver (*Gavia immer*) – The Board note that the application area is important for wintering Great Northern Divers, a species known to be vulnerable to disturbance, including from construction activities and associated vessel movements as well as during the operational phase of the project. Bird Watch Ireland raise concerns about this Annex I species who consider that the international importance. A 'no mitigation' approach as proposed, particularly during the construction and operational phases is not considered appropriate. The applicant is requested to address these concerns, particularly in terms of the cumulative unknowns identified in the EIAR.

Colonies at Rockabill – the applicant is requested to provide additional information on the movement of auks (Guillemots *(Uria aalge)* and Razorbills (*Alca torda*)) from Lambay to show that there is no significant impact on the Rockabill, Lambay and Irelands Eye populations, given their range of foraging grounds, including the area of the project.

Other - The waters in and adjacent to the proposed Oriel Wind Farm are an important resource for the western Irish Seas marine bird populations. The passage of marine birds through the development area does not appear to have been fully characterised because of the data regime adopted. It is requested that the EIAR adopt a range of relevant mortality rates in the estimates of predicted mortalities for relevant species and that the EIAR is revised to ensure that the assessment of predicted annual mortalities uses the western Irish Sea for context. It is recommended that the developer cross reference to NPWS Article 12 reports which provide information on the current status, pressures and future prospects for sea birds.

The applicant is requested to provide further analysis of the potential effects of the proposed development in relation to predicted mortalities from both collision and displacement impacts for relevant species. This should, at a minimum, incorporate the relevant available data including for example, HiDef (2019) and ObSERVE Phase II data where appropriate. Graphical representation Population Variability Analysis (PVA) results are considered to be of assistance to interpret model outputs where appropriate.

Light-bellied Brent Goose (*Branta bernicla hrota*) - The Board notes the results of the vantage point surveys undertaken to establish the migratory movements of Light-Bellied Brent Geese across Dundalk Bay during the spring -3: Migratory Geese Survey Report). The observed movements of birds, low and close to the shoreline, likely reflect commuting movements of flocks aligned to tidal cycles and movement between established foraging areas in Dundalk Bay and Carlingford Lough, while the significant migratory move of the 14/15th April would coincide with the northern migration of light-bellied brent geese. Autumn movements are noted to be different to the spring movements, particularly in terms of the volume of birds and sites being used from Strangford Lough and south towards Dublin and Wexford. The Board note the primary survey method of coastal vantage point surveys by human observers, at a distance of between 6-12km from the project site, and which the DAU have considered to be insufficient, with concerns that this methodology could discount the potential for the geese, and other species, to fly through the proposed array area. Reliance on published literature does not provide detailed or precise data movements, and as many of these movements occur overnight, the routes taken are not known. Therefore, and based on known flight heights and potential flightlines between the major concentrations in Strangford Lough and sites along the East Coast of Ireland, there is potential for there to be a significant potential for large numbers of Brent geese flying through the proposed array area during both day and night, over very short timescales, and particularly in autumn. The potential impact of siting wind turbines on a migratory route for this species without appropriate mitigation during such short-term events could be potentially catastrophic for Light-Bellied Brent Geese populations, the vast majority of which winter in Ireland. The applicant is requested to address these concerns in relation potential effects of the project on migrating geese. Any potential specific adaptive mitigation measures to minimise the effects of the project, particularly during the Spring and Autumn migrations and which identify the timings of the migrations, depletion of food supply etc, should also be included and addressed in the EIAR.

Migratory Species – Non seabirds

The Board notes the international importance of Ireland, including Dundalk Bay SPA, for a range of waterbird species. The AA screening report does not detail the potential impacts upon and interactions of the proposed project with migratory waterbirds, with a focus on foraging and breeding birds only. It is noted that all migrating birds have been scoped in for further assessment, which is welcome, but the applicant is requested to update the AA to include a reference to potential impacts and interactions with regard to migratory waterbirds which are SCIs of SPAs. A review of the screened-out Natura 2000 sites and water bodies is required to be undertaken to

ensure that the NIS has considered all relevant pathways appropriately, as well as migratory or normal flight paths of avian species.

The applicant is further requested to clearly address the potential for ex situ impacts upon species listed for Dundalk Bay SPA that occur outside the red-line boundary.

The Board has concerns regarding the methodologies employed with regard to the survey and monitoring of the movement of migratory waterbirds at key migration times. The primary survey method of coastal vantage point surveys by human observers, at a distance of between 6-12km from the project site, and which appear to primarily focus on geese, is considered to be insufficient and inappropriate to assess the migratory movements of birds through the array area, and the potential impacts on these species. In addition, the reliance on literature to fill knowledge gaps, while useful, does not provide adequate data to ensure a comprehensive assessment of potential effects on birds. The applicant is requested, having regard to the comments above, to address the purported existing data gap to enable the assessment of potential impacts of the proposed development on migratory birds. Radar (horizontal and vertical surveys) or similar at the Array Area during peak migration periods might be utilised to provide site-specific data, which could be used to support the applicant's current assessment and provide quantitative information on passage of birds to feed into collision modelling. Should radar not be conducted and an alternative survey methodology utilised, comprehensive justification for the alternative should be provided. Peak migration periods during which data are to be collected can be further informed through review of existing data and makes reference to the key migration times being spring and autumn, the Board considers that migration information during the winter months would also be of assistance to the assessment (e.g. irruptive cold weather movements from the continent and UK). The applicant is invited consider this aspect for inclusion also.
In terms of the findings of the Migratory Non-Seabirds Collision Risk Modelling (Appendix 11-06 of the EIAR), and noting the comments in the DAU submission, the conclusions arrived at in this regard, may rely on limited empirical data and the avoidance rates applied in the model for waterbirds are not up to date. The level of confidence with regard to avoidance rates for a significant proportion of waterbirds is very low and as such, the validity of the conclusions arrived at are potentially understated. It appears therefore, that the conclusion of the NIS may not be fully supported given the limitations identified. The applicant is requested to address these concerns, having regard to the DAU submission.
The applicant is requested to justify the screening out for further assessment of all passerines (Table 11-15 of the EIAR), which considers the risks to migrating passerines as negligible 'due to the relative size of the project and the behaviour of the birds (e.g. passage movements restricted to twice annual events, large population sizes and flight heights typically above risk height)'. It is noted that many hundreds of thousands of migrants come to Ireland for the winter, moving west as autumn progresses and returning north and east as spring advances. The applicant is requested to provide more information and assessment with regard to these species and to consider the potential effects of the development at the project level as well as cumulatively.

Terrestrial Bird Species:
Chapter 19 of the EIAR considers the potential effects of the project on onshore birds and intertidal birds and includes Appendix 19-02: Intertidal Bird Survey and Onshore Bird Survey Reports. The DAU note that the focus of data collection to support the application has been on marine-dwelling avifauna as opposed to land-based avifauna, with knowledge gaps with respect to transboundary and migratory movements of land-based avifauna in Irish waters and beyond. As such, it is noted that no new empirical data have been collected for land-based migratory birds as part of the monitoring programme, to detect and assess the
This would provide a better understanding of the potential impact and cumulative impacts of the project, and other ORE developments in terms of the Irish Sea. The applicant is requested to address these concerns, including those raised in the DAU submission on the project.
The CRM identifies 3 terrestrial bird species as being vulnerable to wind turbines, including Corncrake (*Crex crex*), Merlin (*Falco columbarius*) and Hen Harrier (*Circus cyaneus*). However, the predictive power of the model employed is low, particularly for species that are not foraging in the offshore area. As such, the use of SOSS2
2 Strategic Ornithological Support Services
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.
Response from MLavelle: The maps included for Bird counts in this application refer to different sites & not this windfarm site.

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 Number 29 : Biodiversity biases in research and practice: Lessons from the Irish onshore wind sector. Emma King, Courtney E. Gorman, Jane C. Stout, Yvonne M. Buckley, Ian Donohue. *Ecol Solut Evid.* 2025;6:e70147. | 1 of 12 https://doi.org/10.1002/2688-8319.70147.
wileyonlinelibrary.com/journal/eso3

3 | RESULTS
Our global literature search identified 124 scientific articles relating to the impacts of onshore windfarms on biota from 2000 to 2021 (Table S1). There were no geographical search restrictions, and published literature was found across five continents (Figure 1a), with most from Europe (48%, 59/124 papers; Figure 1b). Eighteen papers (15%) incorporated results from multiple countries. A full list of studies and their geographical locations is provided in Table S1.
Within the scientific research identified in our survey, seven general categories of impact were described across our focal taxonomic groups: collision with wind turbines, habitat alteration and loss, proliferation of invasive species, increased stress (via, e.g. increased levels of stress hormone cortisol, or corticosterone), reduced reproductive output, alterations to food webs (e.g. species impacted due to a change in food web or a cascading impact across the food web) and behavioural changes. Early studies (2000–2007) of potential windfarm impacts accounted for just under 10% of the total number of papers in our survey, with studies focusing primarily on collision impacts on birds and invertebrates, and behavioural change in mammals. Collision was the most recorded type of impact in our review overall (52% of studies, 64/124 papers) and research grew notably in this area from 2008 onwards (Figure 2a).

This is reflected in a surge in the literature on impacts on volant taxonomic groups, such as birds and bats, from 2008. Habitat alteration was also a common impact category studied in the literature from 2008 onwards (32% of studies, 36/112 papers from 2008 to 2021). This focused largely on birds, but there were also some studies on mammals and vegetation. More recently, a wider variety of impacts were studied across a greater range of taxa (Figure 2a). From 2016, all six of our focal taxonomic groups were consistently represented in the literature. Moreover, these studies also incorporated a broader diversity of impacts. Though studies of collision impacts remained a priority in studies from 2016 to 2021 (49% of studies, 36/73 papers), focusing primarily on bats (56% of studies of collision impacts, 20/36 papers), research into all five of the other categories of impact together made up the remainder of these more recent studies (51%, 37/73 papers).

Our survey identified 336 granted windfarm applications, of which 138 (41%) provided an EIAR with an uploaded and accessible ecology chapter. A total of 622 surveys were reported in those applications, with substantial variation among them in the taxa prioritised (Figure 2b). The reasoning for surveying vegetation provided in most EIARs was to provide context on the landscape of the proposed development, in the absence of an Irish national land cover map prior to 2023. Field-based surveys were the most common methodologies used (57% of reports, 354/622 surveys), followed by opportunistic (33%, 205/622 surveys) and scoping (10%, 63/622 surveys) methods.

Early EIARs had an uneven distribution of survey methods across taxa but this distribution is changing and becoming more even over time. Recent EIARs are implementing field-based Surveys more widely and equitably across groups, with field-based Methods accounting for 47% (20/43) of surveys from 2000 to 2003 but 81% (17/21 surveys) by 2020–2021.

Birds were surveyed in all EIAR chapters reviewed predominantly using field-based methodologies (86%, 119/138 surveys).

Field-based surveys were dominated by a focus on vegetation and birds with occasional inclusion of other groups until 2010, when all six of our focal taxonomic groups started to become more represented in EIARs.

Herpetofauna were the taxonomic group surveyed most using opportunistic methods (88%, 71/88 herpetofauna surveys), in addition to mammals (65%, 87/134 mammal surveys). There were 49 surveys of invertebrates and the majority of these were also done using opportunistic methods (67%, 33/49 invertebrate surveys). Although invertebrates were originally further categorised into volant, above-ground and below-ground groups, there were insufficient studies and papers to analyse each group separately, and some surveys did not specify which group was included. Scoping surveys were the most inconsistent methodology used in EIARs, and from 2017 onwards, no scoping surveys were reported. Bats were the taxonomic group surveyed most frequently using scoping methodologies in Irish EIARs (30/55 bat surveys).

The taxonomic focus of both the scientific literature and EIARs has changed considerably over time (Figure 3a,b). From 2000, the taxonomic coverage of both scientific literature and environmental impact assessment has increased notably, with consistent and more evenly distributed taxonomic coverage in EIARs relative to scientific research, while the latter also shows notable year-to- year variation in focus (Figure 3). The taxonomic diversity included in both the scientific literature and in EIARs has increased significantly over time ($t = 3.4$, $p = 0.001$; Table S2). However, the rate of this increase differs between these data sources (interaction between Data Source and Year: $t = 4.47$, $p < 0.001$; Table S2; Figure S1), with taxonomic diversity increasing more steeply over time in the scientific literature compared to the EIARs, though from a lower baseline (Figure 3c).

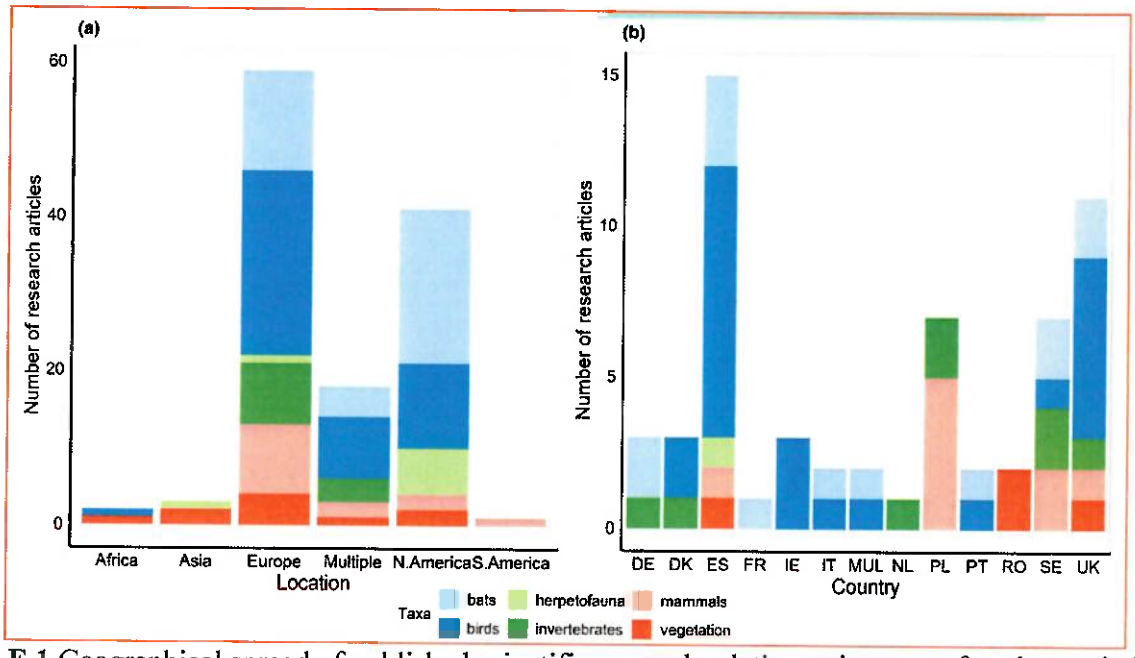


FIGURE 1 Geographical spread of published scientific research relating to impacts of onshore windfarms on biota from 2000 to 2021 across continents (a) and countries in Europe (b). Multiple (MUL) refers to research that includes results across multiple countries or regions: DE—Germany; DK—Denmark; ES—Spain; FR—France; IE—Ireland; IT—Italy; NL—Netherlands; PL—Poland; PT—Portugal; RO—Romania; SE— Sweden; and UK—United Kingdom. We highlight results for Europe as this is the region in which our case study on EIARs is from. Ireland had only three scientific research publications identified in our survey relating to onshore wind impacts on biodiversity, all of which focused on birds.

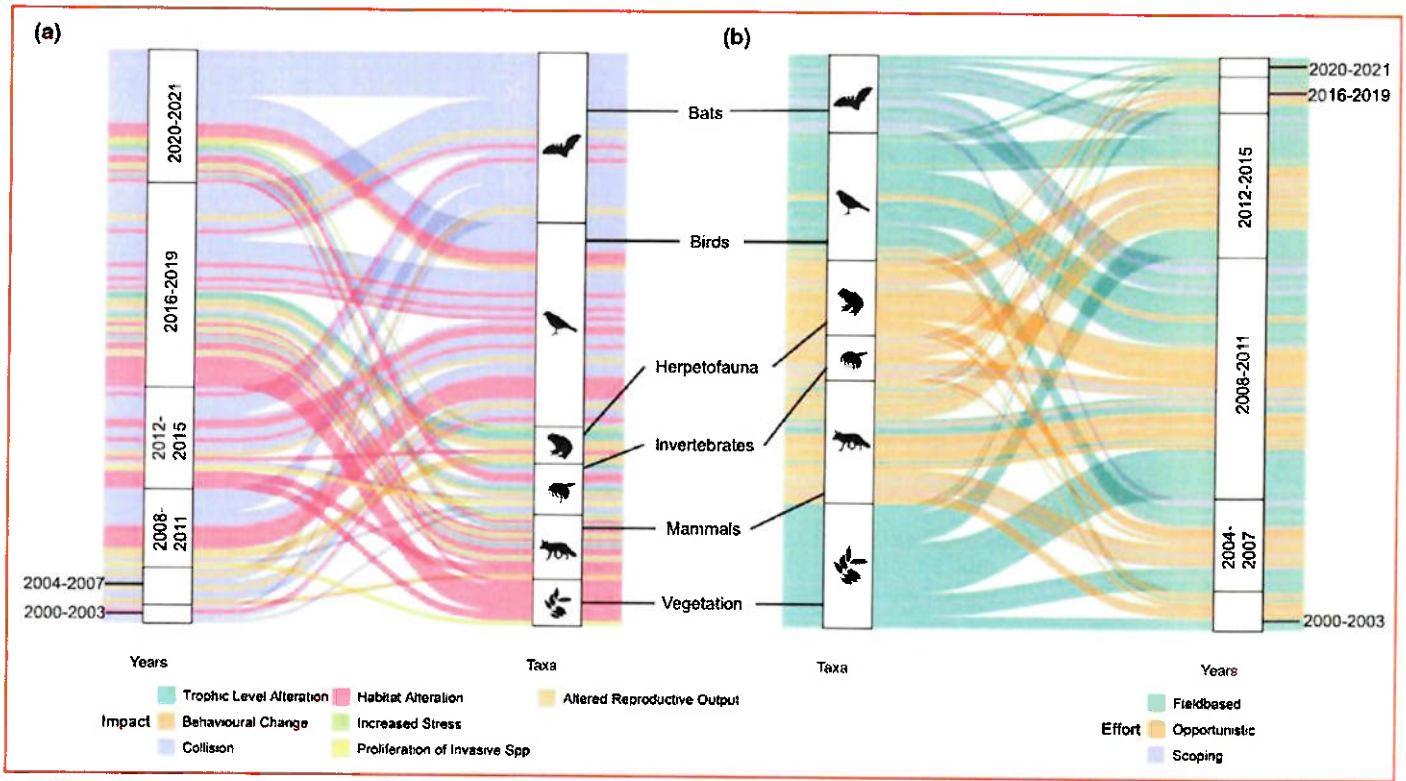


FIGURE 2 Variation over time (2000–2021) in studied taxa and impacts of onshore windfarms on biodiversity from the global scientific literature (a) and the taxa targeted in Irish EIARs through different survey methods (b). Segments on the vertical axes represent categories (years and taxonomic groups) and are proportional in size to the number of published studies ($n = 124$) or surveys ($n = 622$). In both plots, the number of research articles and EIARs has increased through time. In the scientific literature (a) the number of research articles focusing on birds and bats is greater than that of other taxonomic groups, while in EIARs (b), the number of surveys is more consistent across the taxonomic groups.

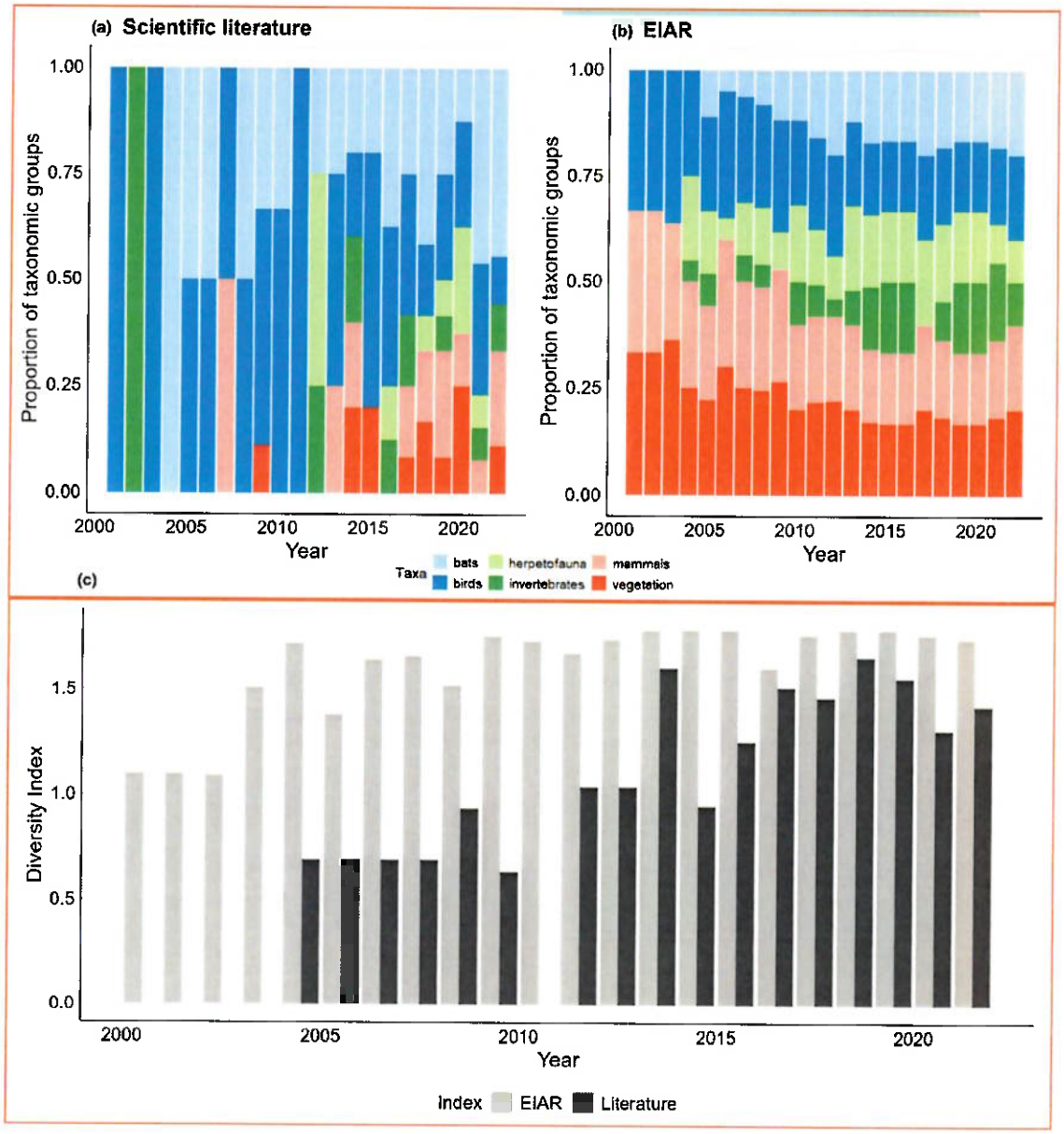
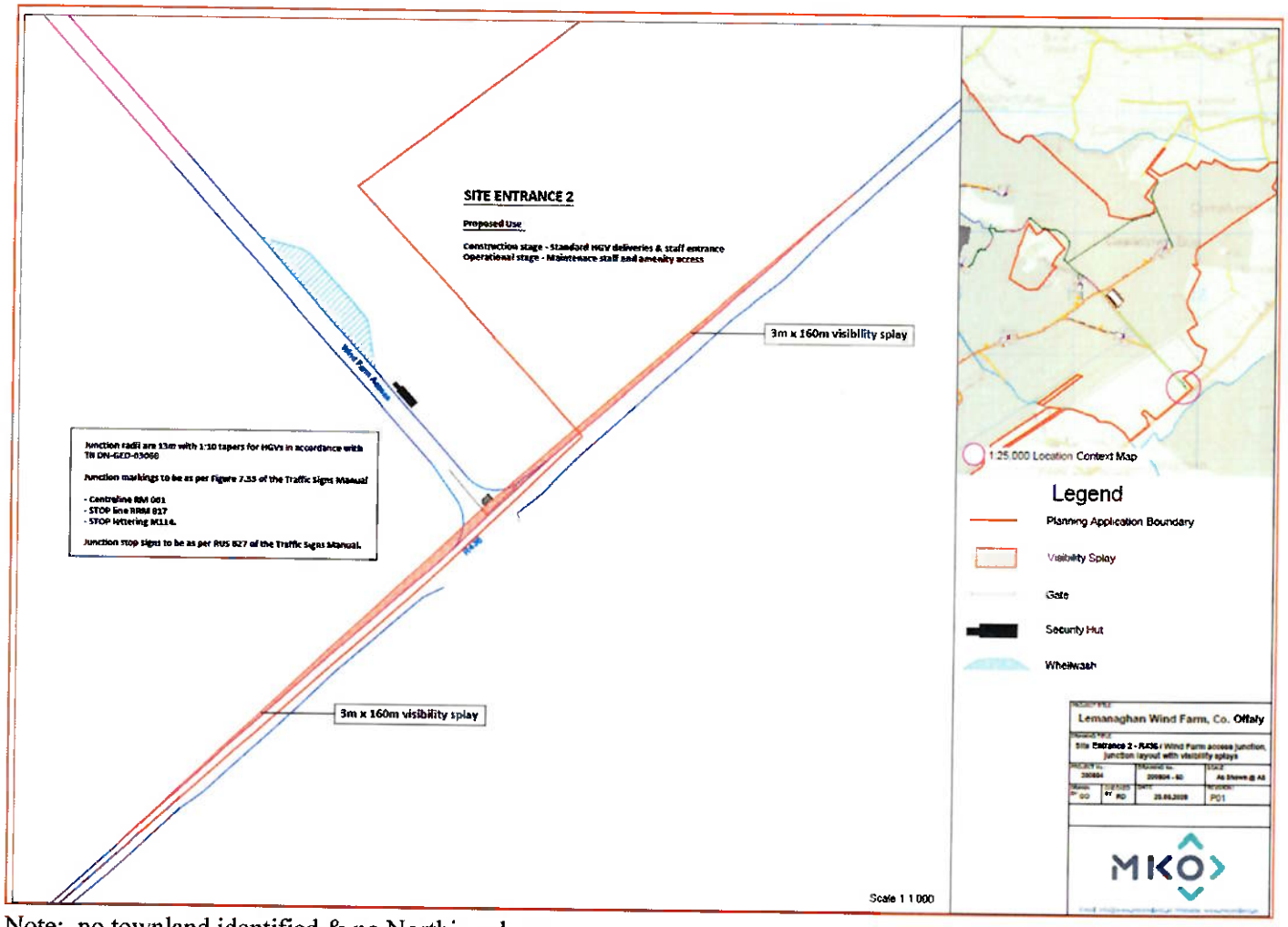
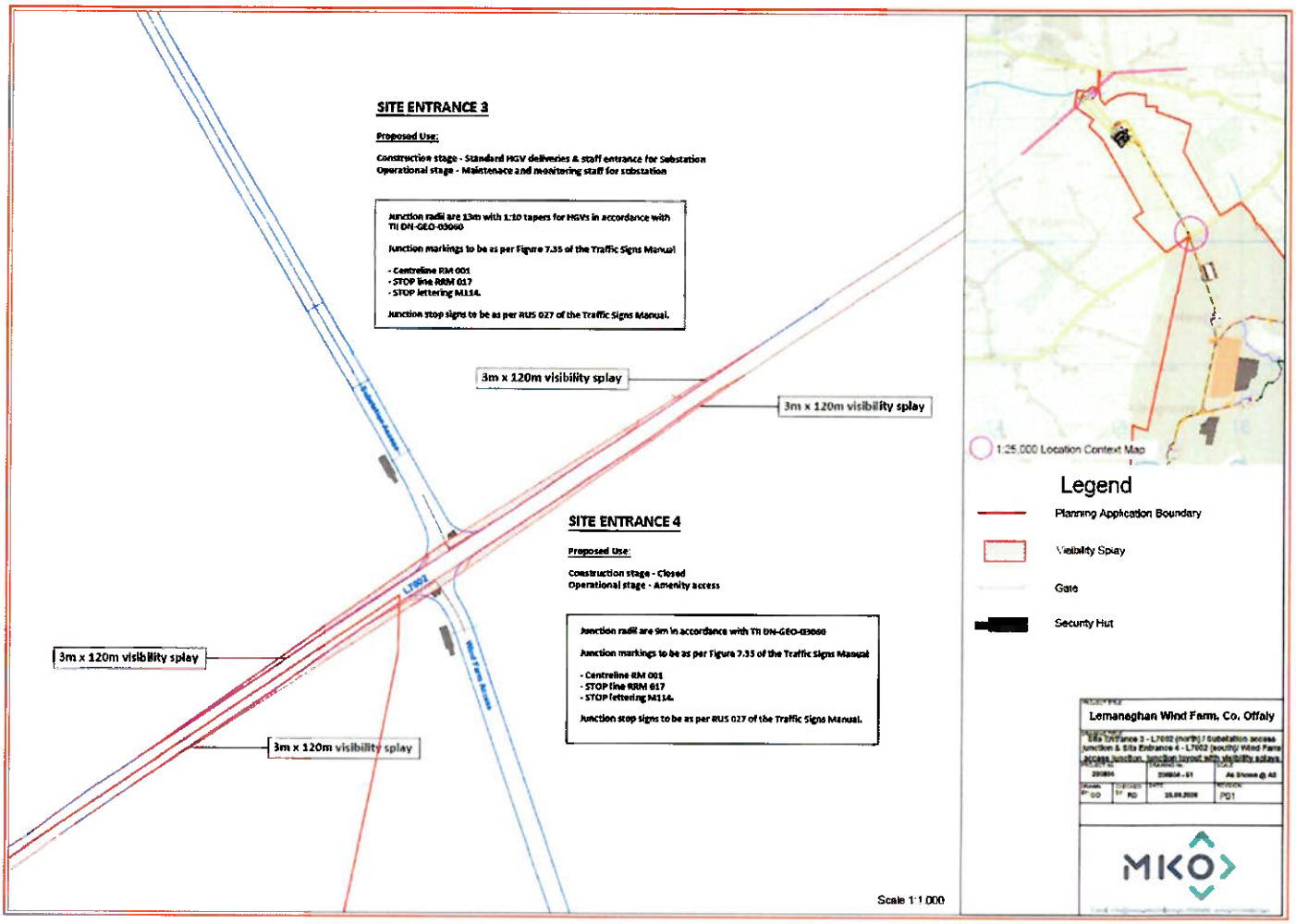


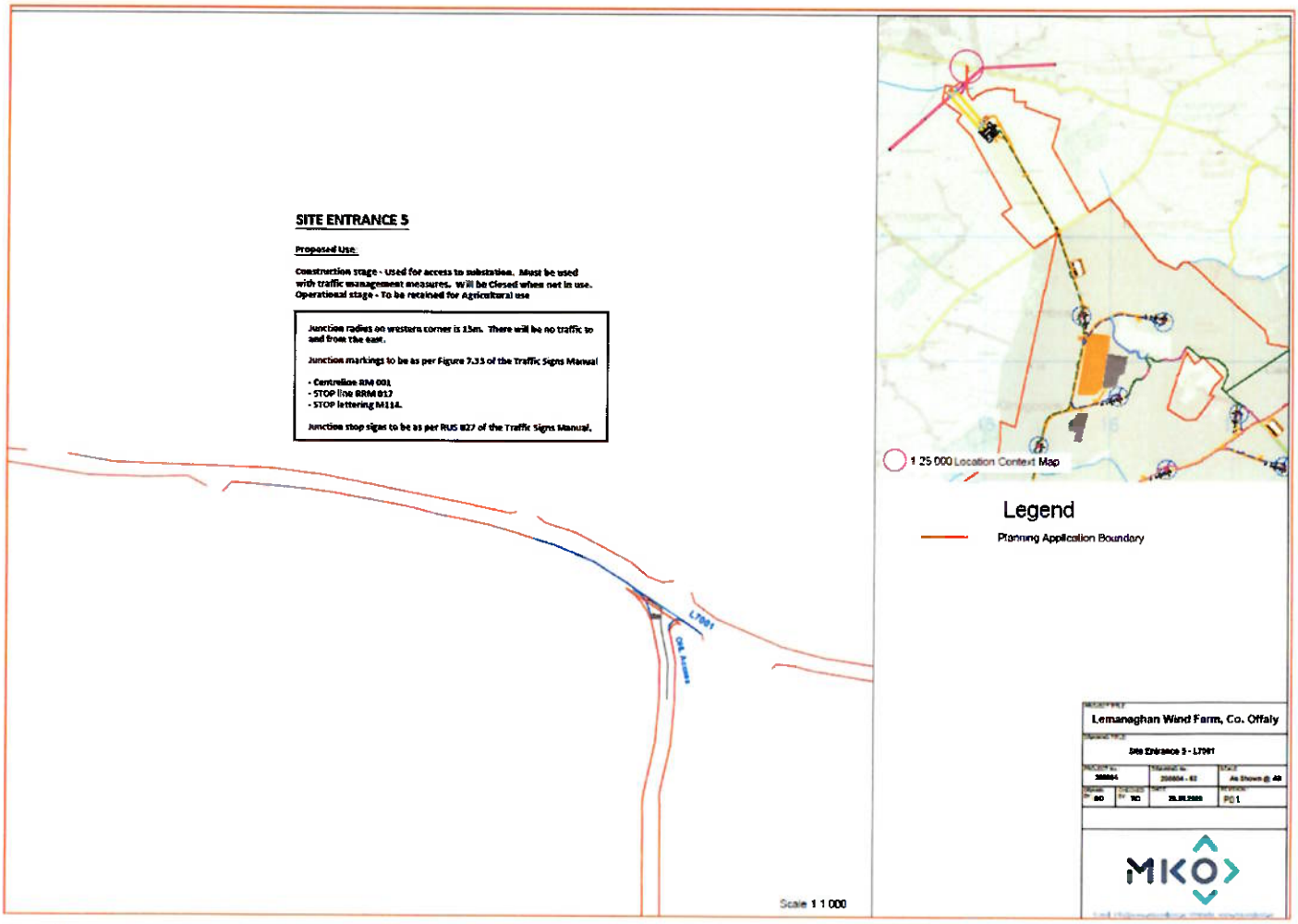
FIGURE 3 Relative taxonomic focus of scientific literature (a) and EIARs (b) over time (2000–2021), and the (Shannon) diversity of the taxonomic focus in the scientific literature and EIARs (c). Only one taxonomic group was found to have been studied in our literature survey for the years 2001, 2002 and 2010, and thus diversity was zero in those years.



Note: no townland identified & no Northing shown.



Note: no townland identified & no Northing shown.



Note: no townland identified & no Northing shown.

1.5.3 **Competitiveness of Wind Energy**

While Ireland has a range of renewable resources, as the Energy White Paper states that "[Onshore Wind] is a proven technology and Ireland's abundant wind resource means that a wind generator in Ireland generates more electricity than similar installations in other countries. This results in a lower cost of support".

In fact, the cost of support is more than offset by the fact that adding large quantities of wind to the wholesale market drives down auction prices in any half-hour trading period when the wind is blowing, i.e., for 80% of the hours of the year. Wind has a capacity factor of approx. 35%, which is its average output throughout the year relative to its maximum output. However, wind is generating power at some level for 80% of the hours of the year. A Pöyry study from 2015 showed that reaching our targets in 2020 would reduce wholesale prices by more than costs of new grid infrastructure, backup and the subsidies paid to wind, resulting in a net saving of €43m per year in 2020. The EU has noted that Ireland has one of the lowest costs of supporting renewables mainly because onshore wind is on a par with the cost of power from conventional generation when a full cost-benefit analysis is undertaken.

10.3.3.4 Human Health

Whilst the operational phases of the Proposed Project will give rise to minor increases in dust and vehicle emissions, the implementation of the mitigation measures discussed above, and good management practices can prevent or minimise potential effects off-site. Good management practice consists of adopting appropriate working methods, choosing the right equipment and ensuring that the workforce understands the company's responsibilities and is familiar with good working practice and dust suppression techniques. The potential for health effects is considered negligible as the potential for both exhaust and dust emissions will be limited and controlled through mitigation measures (please see Section 10.3.2 and Section 10.3.3 above for detailed mitigation measures).

Exposure to chemicals such as SO2 and NOx, Pb, benzene and O3 are thought to be harmful to human health. The production of clean renewable energy from the Proposed Project will offset the emission of these harmful chemicals produced by fossil fuel powered sources of electricity and, therefore, will have a long term, moderate, positive impact on human health. Further information on the impact of the Proposed Project on Human Health is contained in Chapter 5: Population and Human Health.

10.3.5.2 **Operational Phase**

Exhaust emissions of carbon dioxide (CO2), oxides of nitrogen (NOx), sulphur dioxide (SO2) or dust emissions during the operational phase of the Proposed Project will be minimal, relating to the use of operation and maintenance vehicles onsite, and therefore there will be no measurable negative cumulative effect with other developments on air quality.

As established above in Section 10.3.2, there will be a long-term, imperceptible, negative effect on air quality from:

- Exhaust emissions from maintenance LGV vehicles visiting the Proposed Project site 1-2 times per day and on occasion more frequent LGV and HGV visits during component or substation infrastructure replacement;
- Exhaust emissions from approx. 20 amenity user LGV vehicles visiting the Proposed Project site per day;
- Dust emissions from maintenance LGV vehicles visiting the Proposed Project site 1-2 times per day and on occasion more frequent LGV and HGV visits during component or substation infrastructure replacement;
- Dust emissions from approx. 20 amenity user LGV vehicles visiting the Proposed Project site per day.

As established above in section 10.3.2, post-mitigation, there will be an overall long-term, moderate, positive effect on Air Quality from:

- The provision of an alternative to electricity derived from coal, oil or gas-fired power stations. The Proposed Project will result in emission savings of CO2, oxides of nitrogen (NOx), and sulphur dioxide (SO2). The production of renewable energy from the Proposed Project will have a long-term moderate positive impact on air quality due to the offsetting of approximately 56,375 tonnes of CO2 per annum. Please see Chapter 11 Climate for further details on carbon displacement calculations.

Therefore, it is considered there will be no measurable negative cumulative effects on air quality should other proposed or consented plans within the surrounding landscape be operational in parallel with the Proposed Project. However, once the Proposed Project is operational, there will be a long-term, moderate, positive impact on air quality.

In addition to the above, the Proposed Project site will continue to be used for minimal turbary peat cutting activities from private landowners and therefore, vehicles required for access to these areas will continue to utilise the site as required. During the operational phase, there will be a short term, imperceptible, negative cumulative effect on air quality due to vehicle exhaust emissions.

Table 10-20 Impact Assessment Classification Summary Topic	Pre-Mitigation Effect	Mitigation Section Reference	Residual Effect	Significance
Construction Phase				
Exhaust Emissions	Short-Term, Slight, Negative	Section 10.3.2.1	Short-Term, Imperceptible, Negative	Not Significant
Dust Emissions	Short-Term, Moderate, Negative	Section 10.3.2.2	Short-Term, Slight, Negative	Not Significant
Operational Phase				
Exhaust Emissions	Long-Term, Imperceptible, Negative	Section 10.3.3.1	Long-Term, Imperceptible, Negative	Not Significant
Dust Emissions	Long-Term, Imperceptible, Negative	Section 10.3.3.2	Long-Term, Imperceptible, Negative	Not Significant
Air Quality	Long-term, Moderate, Positive	N/A	Long-term, Moderate, Positive	Not Significant
Human Health [This relates to site workers & not nearby residents]	Long-term, Moderate, Positive	N/A	Long-term, Moderate, Positive	Not Significant

4 Description of the Proposed Project

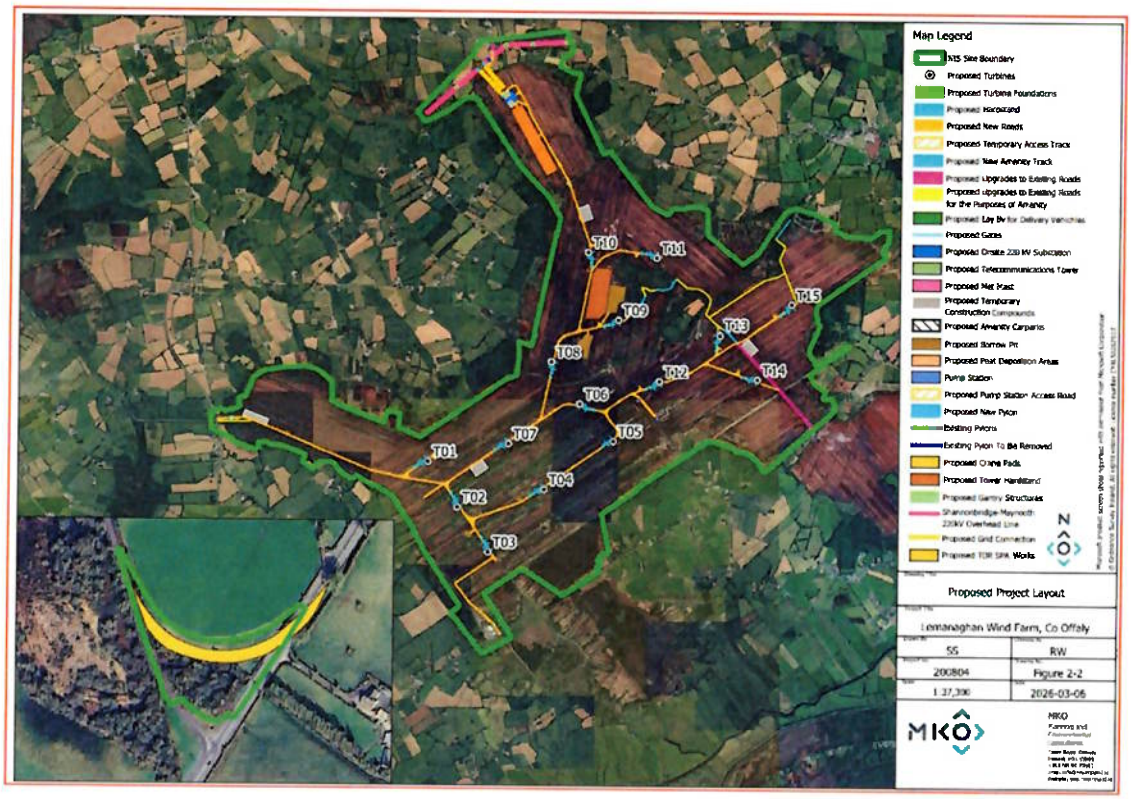
Chapter 4: Description of the Proposed Project describes the Proposed Project and its component parts which is the subject of a proposed application for planning permission to An Coimisiún Pleanála (ACP) in accordance with Section 37E of the Planning and Development Act 2000 (as amended). Construction methodologies for the main infrastructural components of the development are also included in this chapter (or its associated appendices) of the EIAR. The development description for the current planning application as appears in the public notices is included in Section 1 above.

The overall layout of the Proposed Project encompasses the Proposed Wind Farm and the Proposed Grid Connection. The Proposed Project has been designed to minimise potential environmental effects, while at the same time maximising the energy yield from the Proposed Wind Farm. Detailed site layout drawings of the Proposed Project are included in Appendix 4-1 to the EIAR.

The proposed wind turbine layout has been optimised using wind farm design software (a combination of WAsP [wind resource assessment software] and WindPro [Computational Fluid Dynamics and WindFarmer]) to maximise the energy yield from the Proposed Project site, while maintaining sufficient distances between the proposed turbines to ensure turbulence and wake effects do not compromise turbine performance and maintain the minimum setbacks from neighbouring properties as set out in the 'Wind Energy Development Guidelines for Planning Authorities' (DoEHLG, 2006) (hereafter referred to as the 'DoEHLG 2006 Guidelines') and the Draft Wind Energy Development Guidelines (December 2019) (hereafter referred to as the 'Draft DoHPLG 2019 Guidelines). The Irish Transverse Mercator (ITM) Grid Reference coordinates of the proposed turbine locations are listed in Table 1 below.

Table 1 Proposed Wind Turbine Locations and Elevations

Turbine	ITM X	ITM Y	Top of Foundation Levels (mOD)
1	614199	727374	51.5
2	614482	726940	51.9
3	614780	726517	50.6
4	615314	727112	52.7
5	615979	727580	48.1
6	615647	727936	50.0
7	614968	727550	51.3
8	615376	728346	50.6
9	616022	728746	52.3
10	615717	729399	53.7
11	616380	729350	55.7
12	616415	728161	48.5
13	616995	728609	51.8
14	617357	728184	48.9
15	617684	728907	52.2



The proposed wind turbines to be installed for the Proposed Wind Farm have the following dimensions:

- Turbine Tip Height – 220 metres
- Hub Height – 145 metres
- Blade Rotor Diameter – 150 metres

Turbines from the main turbine manufacturers share common appearance and other major characteristics, with minor cosmetic differences differentiating one from another. The wind turbines that will be installed on the Proposed Wind Farm will be conventional three-blade turbines, that will be geared to ensure the rotors of all turbines always rotate in the same direction. For the purposes of this EIAR, a rated output of 6MW has been chosen to calculate the power output of the proposed 15-turbine renewable energy development, which would result in an estimated installed capacity of 90MW.

The Proposed Project makes use of the existing road network insofar as possible. To provide internal access within the Proposed Project site, connecting the wind turbines, proposed onsite 220kV substation, and associated infrastructure, approximately 17.1 kilometres of new internal roads will need to be constructed and 1.14km of existing road will be upgraded. It is proposed to construct passing bays along the proposed site roads in order to allow construction traffic to safely pass each other while travelling in opposite directions. Areas such as wide junctions and proposed hardstands will also be used as passing bays throughout the construction phase of the Proposed Wind Farm.

One meteorological (met) mast is proposed as part of the Proposed Wind Farm. The met mast will be equipped with wind monitoring equipment at various heights.

Each turbine will be connected to the proposed onsite 220kV electricity substation via underground 20kV or 33kV (kilovolt) electricity cabling. Fibre-optic cables will also connect each wind turbine and the met mast to the proposed onsite 220kV substation (i.e., to the turbine control system within the Independent Power Producer (IPP) Control Building). The electrical and fibre-optic cabling connecting the proposed turbines to the proposed onsite 220kV substation compound will be run in cable ducts adjacent to the proposed internal roads and buried directly alongside the internal roads at depths of approximately 1.2m below ground level to the top of the duct.

It is proposed to manage any excess overburden generated through construction activities within the Proposed Project site, in 2 no. peat deposition areas, in linear berms along access roads where appropriate, and landscaping.

As part of the Proposed Project, no commercial forestry felling will occur. However, the removal of immature woodland (hereafter referred to as vegetation removal) will be required within and around development footprint to allow for the construction of the site entrances, access roads, underground cabling, and other ancillary infrastructure.

A Biodiversity Management and Enhancement Plan (BMEP) has been prepared for the Proposed Project and is included as Appendix 6-5 of the EIAR. This plan has been developed to offset the loss of habitats identified within the Proposed Project site and further enhance the biodiversity of the site and its environs.

The Proposed Project site is currently served by a number of existing tracks and access roads due to its previous use of industrial peat extraction. The Proposed Project will upgrade 3 no. existing entrances and facilitate 2 no. new site entrances. The main site entrance is located on the N62 and consists of the upgrade to an existing entrance to facilitate abnormal load delivery; all other site entrances are located on local and regional roads which surround the Proposed Project site.

It is intended to obtain significant volumes of crushed stone that will be required for the construction of the Proposed Project from 4 no. proposed onsite borrow pits. In addition to the gravel, cobbles and boulder material to be extracted from the proposed borrow pits, it is anticipated that engineering fill and higher-quality, surfacing granular fill and sand will be sourced from local, authorised quarries.

A 220kV connection between the Proposed Wind Farm and the national electricity grid will be necessary to export electricity from the Proposed Wind Farm. It is proposed to construct a 220kV electricity substation within the northern section of the site, in the townland of Cooldorragh, with close proximity to the existing Shannonbridge-Maynooth 220kV OHL located approximately 0.4km north of the proposed onsite 220kV substation at its closest point.

Current activities onsite include site management and environmental monitoring as required under Integrated Pollution Control (IPC) Licence P0500-011 from the Environmental Protection Agency (EPA). Industrial scale peat extraction was permanently ceased by BnM in Lemanaghan Bog in June 2020. From June 2020 until the end of 2024, all remaining stockpiled peat was systematically removed from Lemanaghan Bog. BnM's statutory duties to discharge the conditions of its Integrated Pollution Control Licence (IPC) Licence (Ref. P0500-01; hereafter "IPC Licence"), from the Environmental Protection Agency (EPA) for the Boora Bog Group, which encompasses Lemanaghan Bog also remain ongoing. These ongoing duties, such as environmental monitoring, do not facilitate the continuation of peat extraction, but rather ensure compliance with BnM's extant IPC Licence. It is also a requirement of 'Condition 10 Cutaway Bog Rehabilitation' of the IPC Licence that following the decommissioning of use of all or part of their bogs, BnM, prepares (to the satisfaction of the EPA) and implements a Cutaway Bog Rehabilitation Plan. BnM have produced a Draft Rehabilitation Plan for Lemanaghan Bog, and it is the intention of BnM to rehabilitate the bog in a phased approach under IPC Licence. Irrespective of the consenting or construction of the Proposed Project, the measures outlined in the Draft Cutaway Bog Decommissioning and Rehabilitation Plan (Draft Rehabilitation Plan) (Appendix 2-4 to the EIAR) will be implemented by BnM in agreement with the EPA, per the BnM's IPC Licence Obligations.

An important part of a renewable energy development, which the Applicant has been at the forefront of developing, is its Community Fund. The Applicant is endeavouring to develop new ways to direct increased gain towards the local community with particular focus on those living closest to the Proposed Wind Farm. Community gain from significant development proposals, including wind farms, whilst a relatively recent approach, is now a common consideration for developers and, indeed, planning authorities. This approach recognises that, with any significant wind farm proposal, the locality in which the Proposed Wind Farm is situated is making a significant contribution towards helping achieve national renewable energy and climate change targets, and the local community should derive some benefit from accommodating such a development in their locality.

The construction phase is estimated to take approximately 24 to 30 months, and the works can be broken down into three main overlapping phases, 1) civil engineering works: 18 months, 2) electrical works: 18 months, and 3) turbine erection and commissioning: 9 months.

The Proposed Wind Farm is expected to have a lifespan of approximately 35 years. As part of the Proposed Wind Farm planning application, permission is being sought for the full operational life of the Proposed Project. During the operational period, on a day-to-day basis the wind turbines will operate automatically, responding by means of meteorological equipment and control systems to changes in wind speed and direction.

Following the end of their useful life, the equipment may be replaced with a new technology, subject to planning permission being obtained, or the Proposed Wind Farm may be decommissioned fully. The Proposed Grid Connection and proposed onsite 220kV substation will remain in place as it will be under the ownership and control of the ESB Networks and/or EirGrid and will form a permanent part of the national electricity grid. The Decommissioning Plan for the Proposed Project is further detailed in Appendix 4-8 to the EIAR.

1 Integrated Pollution Control License PO-500-01 issued by the EPA for the Boora Bog Group. Available at: https://epawebapp.epa.ie/terminalfour/ippc/ippc-view.jsp?regno=P0500-01

5 Population and Human Health (See previous reference for HSE & Infrasound)

One of the principal concerns during the development process is that human beings, as individuals or communities, should experience no significant diminution of their quality of life from the direct, indirect or cumulative effects arising from the construction, operation and decommissioning of a development. Ultimately, all the effects of a development impinge on human beings, directly and indirectly, positively and negatively. The key issues examined in Chapter 5 of the EIAR include population, human health, employment and economic activity, land use, residential amenity (including visual amenity, shadow flicker and noise), community facilities and services, tourism, property values, traffic and health and safety.

The Proposed Wind Farm is located 3 km northeast of Ferbane and approximately 2.5 km southwest of the village of Ballycumber in Co. Offaly, from the nearest proposed turbines (T03 and T15, respectively). The Proposed Grid Connection, located in the north of the Proposed Project site, is in the townland of Cooldorragh, Co. Offaly. The land uses within the Proposed Project site are a mixture of natural recolonisation of degraded bog and peat cutting in very small areas of active turbary. The primary surrounding land use within the population study area comprises a mix of agriculture, peat cutting, and low-density residential.

The design, construction, operation and decommissioning of the Proposed Project will provide employment for technical consultants, contractors and maintenance staff. Up to approximately 100-120 jobs are likely to be created during the construction phase of the Proposed Project. The construction phase of the Proposed Project will last between approximately 24-30 months, and the decommissioning phase will likely last approximately 12 months. The majority of construction/decommissioning phase staff will be sourced locally, thereby helping to sustain employment in the construction trade. Where appropriate, engineering fill and higher quality, surfacing granular fill and sand will be sourced from local, authorised quarries.

There is currently no published credible scientific evidence to positively link wind turbines with adverse health effects. The main publications supporting the view that there is no evidence of any direct link between wind turbines and health are summarised in Chapter 5. Similarly, there is insufficient evidence from the scientific literature discussed in Chapter 5 to credibly determine that there is the potential for a significant effect on property values, as a result of the Proposed Project.

Shadow flicker is an effect that occurs when rotating wind turbine blades cast shadows over a window in a nearby property. Shadow flicker is an indoor phenomenon, which may be experienced by an occupant sitting in an enclosed room when sunlight reaching the window is momentarily interrupted by a shadow of a wind turbine's blade. Shadow flicker lasts only for a short period of time and occurs only during certain specific combined circumstances. The DoEHLG 2006 Guidelines recommend that shadow flicker at neighbouring dwellings within 500 metres of a proposed turbine location should not exceed a total of 30 hours per year or 30 minutes per day. It is further noted that at distances greater than 10 rotor diameters from a turbine, the potential for shadow flicker is very low, and therefore the shadow flicker study area is set at 1.50km (10 x 150m rotor diameter). In total, there are 157 properties identified within 1.5 km of the proposed turbines.

WindPRO computer software was used to model the predicted daily and annual shadow flicker levels in significant detail, identifying the predicted daily start and end times, maximum daily duration and the individual turbines predicted to give rise to shadow flicker.

Response from MLavelle: The failure to provide the inputs & outputs from this computer software is not acceptable. Note ACP opinion for Oriel Windfarm.

ACP Response to Oriel Windfarm:
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.

The shadow flicker model assumes that daylight hours consist of 100% sunshine. This is a conservative assumption which represents theoretical precautionary conditions. Following the detail provided above on sunshine hours, a sunshine factor of 26.46% has been applied. The predicted shadow flicker levels have been modelled for all 157 no. sensitive receptors located within the shadow flicker study area. The predicted shadow flicker model results indicate:

- 29 sensitive receptors are theoretically predicted to experience zero shadow flicker;
- 128 sensitive receptors are theoretically predicted to experience some shadow flicker; Of the 128 sensitive receptors, 58 sensitive receptors are theoretically predicted to experience shadow flicker that exceeds the DoEHLG 2006 Guidelines thresholds for daily shadow flicker. Please see Table 5-9 in Chapter 5 for details.

No sensitive receptors are theoretically predicted to experience shadow flicker that exceeds the DoEHLG 2006 Guidelines thresholds for annual shadow flicker.

Where daily shadow flicker exceedances have been predicted at buildings by the modelling software, a site visit will be undertaken firstly to determine the level of occurrence, existing screening and window orientation. This will determine if the receptor has an actual line of sight to any turbine and actual potential for shadow flicker to occur. Once this exercise is completed and all the potentially affected properties, the following measures will be employed. If it is not possible to mitigate any identified shadow flicker limit exceedance locally using the measures detailed above, wind turbine control measures will be implemented.
It is also noted that the Proposed Project could be brought in line with the requirements of the Draft DoHPLG 2019 Guidelines should they come into force during the planning application process for this development.
For the assessment of cumulative impacts, any other existing, permitted or proposed developments (wind energy or otherwise) have been considered. The potential cumulative effects of the Proposed Wind Farm, Proposed Grid Connection (together forming the Proposed Project) and other relevant developments has been carried out with the purpose of identifying what influence the Proposed Project will have on the surrounding environment when considered cumulatively with regards to employment and economic activity, tourism and amenity, traffic, air (dust), health and safety, property values, shadow flicker, and residential amenity.
Impacts on human beings during the construction, operational and decommissioning phases of the Proposed Project are described in Chapter 5 in terms of health and safety, employment and investment, population, land-use, noise, dust, traffic, tourism, residential amenity, renewable energy production and reduction in greenhouse gas emissions, shadow flicker and interference with communication systems. Where a negative impact is identified, appropriate mitigation measures will be put in place to ensure that there will be no significant health effects on sensitive receptors in the surrounding area. Overall, the construction, operation and decommissioning of the Proposed Project will not have any significant adverse effects on population and human health, following the implementation of the appropriate mitigation measures.

6 Biodiversity

Chapter 6: Biodiversity of the EIAR assesses the likely significant effects (both alone and cumulatively with other projects) that the Proposed Project may have on Biodiversity (excluding birds, which are assessed separately in Chapter 7 of the EIAR). The chapter also sets out the mitigation measures proposed to avoid, reduce or offset any potential significant effects identified.

To inform the assessment, a comprehensive desk study, NPWS consultation and a suite of field surveys were undertaken. Desk studies included a review of available ecological records and information in relation to designated sites within the surrounding area. Field surveys were undertaken between 2021 and 2025 and included multidisciplinary walkover surveys, habitat mapping, and dedicated surveys for protected species including bats, otter, badger and marsh fritillary. Aquatic ecology surveys were also undertaken, including fisheries and aquatic macroinvertebrate surveys, to assess the ecological status of watercourses within and downstream of the site.

The surveys were carried out in accordance with TII Guidelines on Ecological Surveying Techniques for Protected Flora and Fauna on National Road Schemes (TII, 2008)2. The habitats within the Proposed Project site were subject to detailed survey and habitat mapping, undertaken following the classification system set out in 'A Guide to Habitats in Ireland' (Fossitt, 2000)3. Cutover peatland habitats have been categorised according to the guidance set out in Irish Wildlife Manual No. 1284. Surveys also included a search for Invasive Alien Species listed under the Third Schedule of the European Communities (Birds and Natural Habitats) Regulations 2011.

The Proposed Project is dominated by cutover peatland habitats, predominantly by large areas of bare cutover bog and smaller areas of revegetating bog supporting a mosaic of pioneer heath, poor fen and scrub vegetation. Areas of agricultural grassland are present in the northern and central areas of the Proposed Project site, with treeline and hedgerow field boundaries. Areas of immature woodland are also present within the Proposed Project site. The Lemanaghan Stream passes through the site and ultimately drains to the River Shannon.

As outlined in Section 1 above, the Proposed Project site encompasses an area of 1,268ha. The construction of the Proposed Project will result predominantly in the loss of bare cutover bog habitat, which has been heavily modified through historical industrial peat extraction and drainage. Approximately 60.8 ha of habitat will be lost, the majority of which (approximately 50.6 ha) comprises bare cutover bog of low ecological value. Additional habitat loss includes approximately:

- 3.27 ha of revegetating bog habitat;
- 1.02 ha of immature woodland;
- 0.64ha of scrub;
- 2.45ha of building and artificial surfaces;
- 1.05ha improved agricultural grassland;
- 0.98ha cutover bog / scrub mosaic;
- 0.46ha dry meadows and grassy verges / scrub mosaic;
- 0.29ha dry meadows and grassy verges; and
- 0.017ha of raised bog.

These habitats represent a small proportion of the similar habitats present within the wider site and surrounding landscape and there is no potential for significant effects as a result of habitat loss.

2 TII (2008) Guidelines on Ecological Surveying Techniques for Protected Flora and Fauna on National Road Schemes. Dublin: National Roads Authority.

3 (Fossitt, 2000) A Guide to Habitats in Ireland.

4 Smith, G.F. & Crowley, W. (2020) The habitats of cutover raised bog. Irish Wildlife Manuals, No. 128. National Parks and Wildlife Service, Department of Housing, Local Government and Heritage, Ireland.

Small areas of degraded uncut raised bog habitat occur at the peripheries of the Proposed Project site. The Proposed Project has been designed to avoid these areas; however, a small area (approximately 0.017 ha) of degraded uncut raised bog will be affected by upgrades to an existing track associated with proposed amenity tracks. This represents a very small proportion of the raised bog habitat present within the site and wider landscape and is not considered significant. There will be no significant hydrological impacts to remnant raised bog habitats within or adjacent to the Proposed Project site.

A Biodiversity Management and Enhancement Plan (BMEP) is proposed as part of the Proposed Project (see Appendix 6-5). The plan includes measures to enhance biodiversity within the site through the planting of approximately 7.8 ha of native woodland, the establishment of approximately 6.5 km of native hedgerow and management measures to enhance suitable marsh fritillary habitat in an area of 6.7ha. These measures are intended to provide long-term biodiversity enhancement within the site.

Bat species composition and activity recorded during detailed bat surveys were typical of the habitats present within the site and surrounding landscape. No bat roosts were identified within the footprint of the Proposed Project. A small soprano pipistrelle bat roost was recorded in an existing structure located more than 340 m from the nearest proposed turbine (T13), and it will be retained and avoided as part of the Proposed Project. With regard to construction impacts, no significant effects are anticipated in relation to the loss of commuting or foraging habitat, the loss or disturbance of roosts, or displacement of bat populations. During operation, there is potential for collision risk with turbine blades. A range of mitigation measures will be implemented including habitat buffers around turbines, turbine blade feathering at low wind speeds, and a post-construction monitoring programme. With these measures in place, no significant residual effects on bat populations are predicted.
No otter holts or resting sites were identified within the Proposed Project site. There are 2 no. new clear-span water crossing structures proposed within the Proposed Project site and no instream works will occur. Pre-construction surveys will be undertaken to confirm the status of otters within the site. No significant effects on otter are anticipated.
One badger sett was recorded within the Proposed Project site, located over 300 m from any proposed infrastructure. The Proposed Project has been designed to avoid this sett. Pre-construction surveys will be undertaken to confirm the status of badgers within the site and appropriate protection measures will be implemented during construction. No significant effects on badger are anticipated.
Evidence of marsh fritillary was recorded within the Proposed Project site in the form of one inactive larval web. The Proposed Project has been designed to avoid areas of suitable marsh fritillary habitat, and no marsh fritillary habitat will be lost as part of the Proposed Project. As a result, there is no potential for significant effects on marsh fritillary populations. The BMEP also includes measures to enhance marsh fritillary habitat within the Proposed Project site.
Aquatic ecology surveys found that the drains and streams within the site are of relatively low ecological value, with limited habitat for fish or other sensitive aquatic species. The main potential impact pathway relates to deterioration in water quality during construction, operation, or decommissioning. A range of best-practice pollution prevention and drainage design measures will be implemented to protect surface water and groundwater quality, and a full hydrological assessment of the Proposed Project is provided in Chapter 9 of this EIAR. With these measures in place, no significant effects on rivers, streams or associated aquatic habitats and species are anticipated.
The Proposed Project is not located within any European Sites or nationally designated sites. The Ferbane Bog SAC, Mongan Bog SPA, River Shannon Callows SAC and Middle Shannon Callows SPA have been fully assessed within the Appropriate Assessment Screening and NIS that accompanies this planning application. This report has been prepared to provide the competent authorities with the information necessary to complete an Appropriate Assessment screening and an Appropriate Assessment for the Proposed Project in compliance with Article 6(3) of the Habitats Directive. The NIS concludes that the Proposed Project, individually or in-combination with other plans or projects, will not adversely affect the integrity of any European Site.

A cumulative assessment was undertaken to consider the potential for the Proposed Project to interact with other plans and projects in the surrounding area, including other wind farms and large-scale developments. Following this assessment, no significant cumulative effects on biodiversity have been identified.
It is therefore judged that, provided the Proposed Project is constructed and operated in accordance with the design, best practice and mitigation measures described within this application, significant individual or cumulative effects on biodiversity are not anticipated at international, national, county or local scales or on any of the identified Key Ecological Receptors.

Reference 30 : Balancing nature and economic interests in the European Union: On the concept of mitigation under the Habitats Directive. Lorenzo Squintani. c 2019 The Author. ***Review of European, Comparative & International Environmental Law*** **Published by John Wiley & Sons Ltd. wileyonlinelibrary.com/journal/reel. DOI: 10.1111/reel.12292**

"THE FOUR CRITERIA TO ESTABLISH A MITIGATION MEASURE"

3.1 | Mitigation measures in context

Article 6 of the Habitats Directive gives teeth to the Directive by establishing proactive, preventive and procedural requirements for the conservation of Natura 2000 sites. This provision refers to three kinds of measures: conservation, preventive and compensatory measures. It does not refer to mitigation measures. Before discussing what the latter measures are, it is important to briefly explain what the former three measures are, in order to distinguish between them.

Conservation measures *are covered by Article 6(1) of the Directive. These measures focus on positive and proactive interventions to maintain and improve the status of conservation of a Natura 2000 site. Any measure leading to deterioration therefore falls outside the realm of this concept.*

Preventive measures *are envisaged under Article 6(2) of the Directive and aim at avoiding deterioration, similarly to conservation measures. Yet these kind of measures do not need to take the form of positive action, as in the context of Article 6(1). Non-action is also a form of preventive measure, if it prevents damage from occurring. What matters under this provision is avoiding disturbance that is likely to affect the objectives of the Directive significantly, particularly its conservation objectives in relation to Natura 2000 sites.*

Compensation measures are mentioned in Article 6(4) of the Directive, which establishes an exception to the obligation contained in Article 6(3). Together, Articles 6(3) and 6(4) describe a two-step – or, in case the derogation clause is used, a three-step – procedure for granting development consent to plans or projects likely to have a significant effect on a Natura 2000 site, based on a 'first come, first serve' approach. The concepts of 'plan' (such as land-use plans, sectoral plans, etc.) and 'projects' (such as construction works or other interventions in the natural environment) have to be interpreted broadly, and ***include also developments outside a Natura 2000 site****, which are likely to have a significant effect on it (the so-called 'external effect'). **In light of the precautionary principle, the assessment of the effects of plans of projects inside or outside Natura 2000 sites – either individually or in combination with other plans or projects (so-called cumulative impacts) – is based on the likelihood of effects, not on their certainty**. If the screening phase indicates **the presence of a potentially significant negative effect, an appropriate assessment needs to be performed, in light of the site's ecological functions and conservation objectives. A negative outcome should lead to the refusal of authorization.***

Yet, Article 6(4) of the Directive specifies that if, in spite of a negative assessment of the implications for the site and in the absence of alternative solutions, a plan or project must nevertheless be carried out for imperative reasons of overriding public interest, a Member State must take all compensatory measures necessary to ensure that the overall coherence of a Natura 2000 site is guaranteed. All the constitutive elements of this derogation clause have to be interpreted restrictively, for balancing environmental protection and economic development. In particular, the concept of compensation measures entails, typically, the designation of like-for-like replacement habitat. In the view of the European Commission, what matters is that the function performed by the affected site is successfully recreated elsewhere.

Adequate implementation and enforcement of Article 6 of the Directive strengthens nature conservation. Yet the complex relationship between Articles 6(3) and 6(4) has led to uncertainty as to what 'adequately implemented and enforced' means, and where 'gold-plating' starts. In particular, in certain Member States questions have arisen on the extent to which measures adopted to avoid damage can be taken into account in concluding that no significant adverse effect will occur.

It is here that the concept of mitigation measures enters into the legal discussion under Article 6 of the Directive, creating much uncertainty, and potential abuses.

Thanks to the judgments in the Waddenzee, Sweetman, Briels and Orleans cases, it can confidently be established that ***mitigation measures are allowed under the Habitats Directive only if four cumulative requirements are met:***

(i) the measure aims at preventing the damage caused by a specific plan/project (functional linkage criterion);
(ii) the measure must ensure that this damage (specificity criterion);
(iii) will be prevented (prevention criterion); and
(iv) that there is no doubt about this preventive effect (no-doubts criterion).

In Sweetman, the Court clarified that the specificity criterion refers to each individual conservation objective, justifying the designation of that site in the list of Sites of Community Importance (SCIs) in accordance with the Directive. Similarly, from Briels it is clear that, under the prevention criterion, measures provided to replace a damaged area with another cannot be taken into account in the assessment of the implications of a project provided for in Article 6(3). In the judgment under review, the Court confirmed both criteria by stating: the case-law relating to Article 6 of the Habitats Directive requires a distinction to be drawn between protective measures forming part of the plan or project at issue and intended to avoid or reduce any direct adverse effects caused by it, in order to ensure that that plan or project does not adversely affect the integrity of the sites concerned, which are covered by Article 6(3),

and measures which, in accordance with Article 6(4), are aimed at compensating for the negative effects of the plan or project on that site and cannot be taken into account in the assessment of the implications of that plan or project on that site ...

Moreover, according to the Court's case-law, it is only when it is sufficiently certain that a measure will make an effective contribution to avoiding harm to the integrity of the site concerned, by guaranteeing beyond all reasonable doubt that the plan or project at issue will not adversely affect the integrity of that site, that such a measure may be taken into consideration in the 'appropriate assessment" within the meaning of Article 6(3) of the Habitats Directive

The use of the adverb 'likely' in Article 6(3) of the Directive was clearly linked to the precautionary principle by the Court of Justice already in the Waddenzee case. Since then, the requirement that there should be no scientific doubt about the ability to prevent the specific damage of a specific project has gained clarity. The Court of Justice made clear that there are two ways of complying with this criterion.

First, a proposed measure can qualify as a mitigation measure under Article 6(3) of the Directive if, at the moment of the authorization of the plan or project, 'the procedures needed to accomplish the alleged mitigation measures have already been carried out'. *Clearly, the implementation of a mitigation measure makes it easier to analyse whether the significant negative effects of a plan or project have been avoided or not.*

The concept of 'project' must be interpreted broadly. The PAS (Dutch Programma Aanpak Stikstof 2015–2021, PAS) judgment clarifies that this concept is probably even broader than originally thought. Indeed, not only the Court of Justice defines this concept without linking it to that used in the EIA Directive, that is, by covering activities not covered by the EIA Directive. Most importantly, the Court defines it by linking its meaning to the effects of the activities on the protected site. Indeed, the Court states that it is important to examine whether such activities are likely to have a significant effect on a protected site. This is an effects-based test, which is capable of covering any kind of activity, even the spreading of fertilizers.

In the context of the establishment of mitigation measures, following Briels, it remained unclear whether mitigation measures have to be 'functionally' linked to a project development, that is, whether the proposed measures are part of the scrutinized project or of a mitigation scheme or restoration programme that does not take into account the specific project under scrutiny. Following Orleans, the present judgment confirms that a proposed mitigation measure must aim at avoiding the damage caused by the plan or project under scrutiny specifically. Management plans and generic restoration measures taken under Articles 6(1) and 6(2) of the Habitats Directive can be taken into account under the concept of mitigation measures when scrutinizing a specific project only if they specifically address the negative effects of that project.

What matters is that there is no reasonable scientific doubt as to the absence of adverse effects of each plan or project on the integrity of the site concerned. Therefore, there is no de-linking effect, meaning that the conservation goals of the Directive can be used to review the appropriateness of the assessment of a specific plan, differently than in other fields of EU environmental law, such as under the Nitrates Directive

The approach to the no-doubts criterion is a very stringent one. It stems from the Orleans case, in which the Court of Justice ruled that only those measures which are completed at the moment of the appropriate assessment can be taken into account as mitigation measures. Orleans concerned the development of a large part of the port of Antwerp (Belgium), affecting a Natura 2000 site. The Court found that the Belgian Regional Development Implementation Plan allowing the project only did so after the sustainable establishment of habitats and habitats of species in core ecological areas. Second, the Court ruled that a decision would have to declare that habitats in the nature reserves had in fact been sustainably created, and the application for a planning permit relating to implementing the intended use of the area concerned would also have had to include that decision. Accordingly, the negative effects would have taken place only after that certainty regarding the effectiveness of the positive effects had been proven.

Yet, the Court ruled that such certainty would have been acquired only after the plan had been adopted, and thus that the proposed measures could not qualify as mitigation measures under Article 6(3) of the Directive.

The second way in which a measure could qualify as a mitigation measure under Article 6(3) of the Directive is when there is no scientific doubt about the effectiveness of the proposed measure.

This means that, even when a measure has not been carried out yet, it is still possible to speak of a mitigation measure. What matters is that there is scientific certainty about the effectiveness of such a measure, thus avoiding the significant damage that would otherwise occur. This criterion is clearly less demanding than the previous one. Still, the question is when scientific certainty exists about the effectiveness of a measure. This criterion could therefore be more difficult to fulfil in practice than it seems. It is still unclear what burden of proof the Court would consider to be sufficient under this approach. In the present judgment, the Court left this matter to the national court to decide, in an exercise of judicial subsidiarity. Yet, it cannot be discounted that the Court of Justice will formulate some guidance in future case law if called upon to clarify this issue

Reference No: 31 : Environmental Impact of Wind Farms. Bošnjakovi´c, M.; Hrka´c, F.; Stoi´c, M.; Hradovi, I. Environments 2024, 11, 257. https://doi.org/ 10.3390/environments11110257

Toxicity

The toxicity of substances to humans can be expressed in different ways and is often expressed in CTUh (Comparative toxic unit for human). Onshore wind farms have an average of around 3.9 CTUh/TWh.

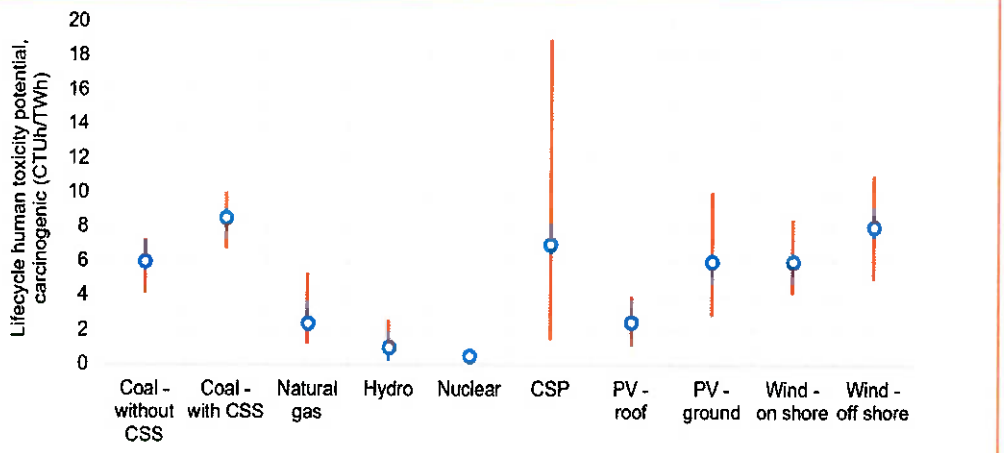


Figure 4. Lifecycle human toxicity potential, carcinogenic. The red line represents the range and the circle represents the median.

Danger of Ice Flying off the Blades

Ice build-up on the rotor blades of wind turbines can pose a serious threat to people and objects in the immediate vicinity. It is, therefore, important to assess the dangers associated with ice shards falling and flying from the rotor blades. Icing can also lead to the failure of wind turbines because the structural integrity is impaired. The hazard posed by ice depends on the severity of the icing, the type of icing, the wind, the rotor speed and other environmental conditions. ***A piece of ice with a weight of 0.2 kg and a density of 500 kg/m3 falling from a height of 30 to 50 m is considered fatal if the impact has a kinetic energy of more than 40 J.***

Danger of Blade Parts Flying Off

A "blade failure" can have a number of causes and can result in either whole blades or parts of blades being thrown from the turbine. ***A total of 537 separate incidents have been recorded. It has been documented that parts of the blades have travelled up to 1.6 km.*** *In Germany, parts of the blade penetrated the roofs and walls of nearby buildings. For this reason, a law was passed in Germany (Bavaria) in 2016 requiring a minimum of two kilometers to be kept between dwellings or workplaces and wind turbines, and Ireland is considering a similar measure.*

Impact on Radio Waves and Air Traffic

Offshore wind turbines can interfere with radar systems on board ships and on land as well as radars used to monitor air traffic. Wind farms located near weather radars can cause false echoes that can be misinterpreted as weather phenomena such as precipitation or thunderstorms. The reason for the interference lies in the structure of the turbines, the height of the turbines and the displacement of the rotors, which can reflect radar signals. In addition, telecommunication and data transmission signals can be weakened when wind turbines are in the line of sight (LOS) for radio communications. In general, two types of effects of wind farms on radar systems can occur:
Formation of radar shadows behind wind turbines, which can result in lower targets being poorly recognised or not recognised at all. The relatively high frequencies used by the radar are attenuated when the signal passes through the wind farm, i.e., they shorten the range of the radar.
Reflection of the radar beams from the wind turbines can lead to false radar targets (false echoes).

Radar systems work by recognising weak reflections that are often in motion. In addition, the rotor blades of wind turbines produce false reflections in the direction of the receivers, causing the radar to misinterpret the signals. While the wind farm industry is growing rapidly, they are causing serious interference problems in critical civil and military radio systems, degrading radar detection range and increasing the complexity of air surveillance and navigation missions.

Habitat Destruction

Based on 84 studies of onshore wind farms in 22 countries, (Tolvanen et al). presented data on the average distance of habitat displacement from the edge of wind farms. The predominant height of wind towers in the studies was 50–99 m.

For birds, bats and mammals, habitat displacement accounted for 63%, 72% and 67% of cases, respectively. Cranes, owls and semi-wild reindeer showed consistent habitat displacements of up to 5 km on average. Gallinaceus birds showed movements of up to 5 km on average, but "no movement" was reported in 40 cases. Bats were displaced by an average of up to 1 km in most cases. Waders, birds of prey, sparrows and black-winged stilts moved their habitats by up to 500 m on average.

Furthermore, human-caused forest landscape fragmentation may lead to a rise in the number of predators (Pasanen-Mortensen and Elmhagen, 2015). For instance, infrastructure like buildings and maintenance roads could attract fox activity (Hradsky et al. 2017), so the risk of predation may be higher near wind farms. Grouse are known to be sensitive to human disturbance (Coppes et al 2017). Many grouse species are site-loyal and therefore highly vulnerable if their habitat overlaps with areas that are suitable for wind turbine installation, particularly in the absence of another suitable habitat (Braunisch et al. 2015).

Collision with a Wind Farm

For some bat species, the installation of wind turbines creates new habitats because there are more insects to feed on in the vicinity of the wind turbines. ***Direct causes of bat death at wind turbines are well recognised and include barotrauma (Rollins et al. 2012) and collisions with rotating blades (Horn et al. 2008) or a combination of both.***
The potential threats of wind farms to birds are well documented in the literature, for example. Research suggests that mortality rates (although they may be relatively high in certain areas) are highly variable and depend on a number of factors such as the bird species, the size and the location of the wind farm and others. (Barclay et al. 2007) reported a mortality rate of 0.00–9.33 birds per year per turbine and a mortality rate of 0.00–42.7 for bats.
The selective shutdown of wind farms along the bird migration route using radar is very effective in reducing collision rates (Tomé et al 2017).

Noise Onshore Wind Farm

Noise pollution has a negative impact on wildlife as it disrupts mechanisms that are crucial for their survival. According to studies, noise can result in the following:
Result in physiological trouble, such as genuine hearing loss or persistently elevated stress hormone levels.
Be viewed as a direct danger, which would lead to an increase in predatory behaviour at the expense of foraging or the departure of the afflicted region, which would result in the loss of habitat.
Distract attention during foraging and reduce foraging efficiency.
Interfere with animal communication by reducing the distance from which the signal can be perceived and lowering the quantity of information that can be taken out of the signal, such as the sound of a predator or approaching potential prey.
Influence the reproductive process. Taubmann et al. reported that noise disturbs grouse up to a distance of 865m. Increasing turbine noise, turbine visibility, and turbine shadow during the breeding season reduced the likelihood of selecting a breeding site.

The roles that these processes play in determining the effects of noise pollution on different species are not mutually exclusive. Different species respond differently to noise as they have different sensitivities to noise. In general, noise pollution alters animal communities. The effects of noise can contribute to the reduction in biodiversity and also threaten the sustainability of local ecosystems.

The Effects of Vibrations from Wind Turbines on the Ecological System

The impact of vibrations is one of the aspects to be considered when analysing the impact of wind turbines on the environment. Vibrations are mechanical oscillations that can be caused by the operation of the wind farm and its

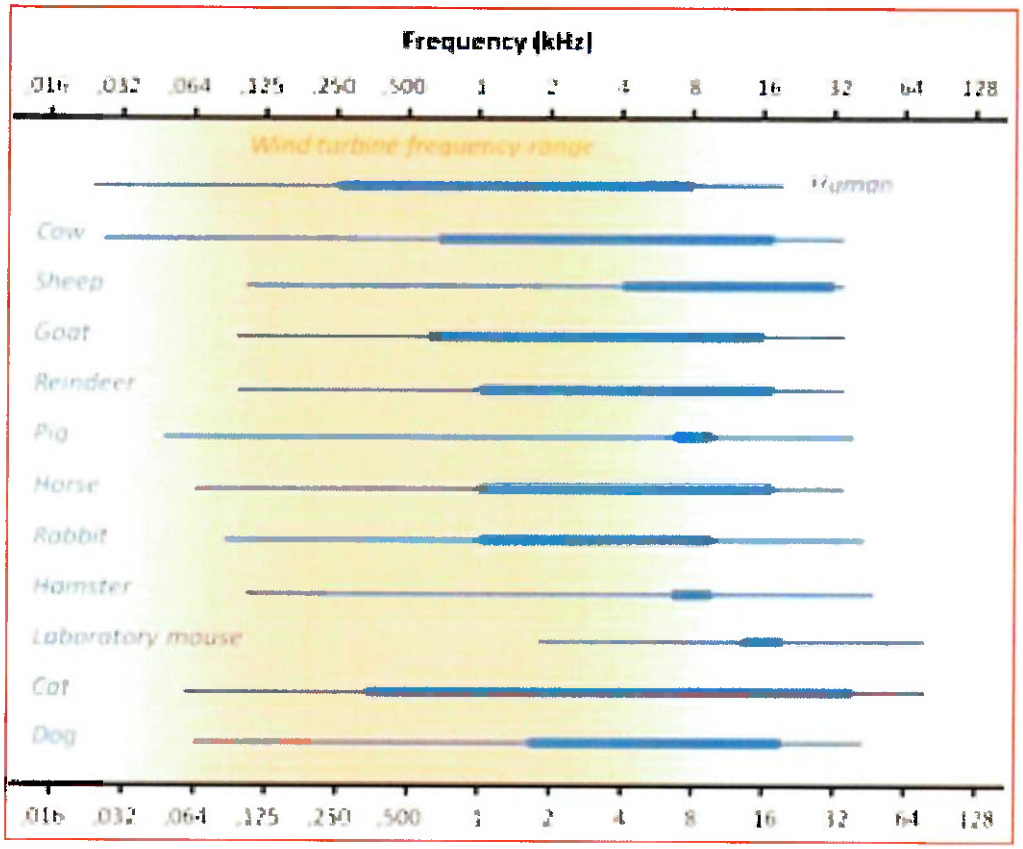
components. In this chapter, the effects of vibrations on the environment are analysed, taking into account the possible consequences for living beings, structures and the surrounding space.
The source of vibrations in wind farms is the rotating parts of the turbines, such as rotor blades and generators. The rotation of these parts generates periodic vibrations that are transmitted to the ground via the foundations of the wind farm. These vibrations can have a negative impact on the animals in the surrounding area, especially on their sensitive acoustic perception. A study by Estefania Velilla and colleagues from 2021 shows how vibrations from wind farms affect the abundance of earthworms in the soil. The relative intensity of vibrations in the soil was measured and the results showed a decrease in the number of earthworms near the wind turbines, which is considered a negative impact on soil organisms. A decrease in earthworms was found in a radius of about 200 m around the wind turbines, where the noise level decreased by an average of 23 ± 7dB. Earthworms are considered important engineers of the ecosystem, and interference with their abundance, survival and reproduction can indirectly affect important processes such as water filtration, nutrient cycling and carbon sequestration. In addition, the vibrational noise generated by the wind turbine can mask the vibrational signs of approaching moles, making earthworms in noisy areas more vulnerable to predation (Dominoni et al. 2020).

Wind farms generate noise that can have harmful effects on humans and animals, especially in the vicinity of the wind farm. Problems noted in humans include insomnia, headaches and the like. For animals, there is a wide range of potential impacts: from possible hearing damage to interference in foraging, predator marking, habitat abandonment and more. The moving rotor blades of the wind farm can pose a risk of collision and death for birds and bats.

Reference Number 32 : 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.


Frequency (kHz)
.016
.032
.064
.125
.250
.500
1
2
4
8
16
32
64
128
Wind turbine frequency range
Human
Cow
Sheep
Goat
Reindeer
Pig
Horse
Rabbit
Hamster
Laboratory mouse
Cat
Dog

7 Birds

Reference No 33: The recent EU **Court of Justice** decision on the **Scope of Birds Directive** applies to this site.

The Court of Justice delivered an important judgment clarifying the scope of protection for wild bird species in the EU under the Birds Directive (Directive 2009/147) in case **C-784/23 - OÜ Voore Mets and AS Lemeks Põlva**

The Court confirmed that all wild birds, regardless of the population status, are protected from deliberate killing or capture and their nest and eggs are protected from deliberate destruction. This includes not only intentional acts but also activities where the possibility of harm is accepted, such as forestry, construction and farming activities. On the other hand deliberate disturbance is only prohibited where it would be significant at a population level.
This will have significant implications for consents involving activities such as tree felling and hedgerow clearance both in terms of the level of characteristation needed and whether the competent authority will need to grant derogations under the strict conditions of Article 9 of the Birds Directive.

The Court's analysis focused on several key aspects of the Birds Directive's interpretation.

First, regarding the concept of "deliberate" actions under Article 5, the Court held that this encompasses not only intentional acts but also situations where the actor accepts the possibility of protected birds being killed or disturbed, or their nests damaged. This interpretation aligns with the Court's previous interpretation of similar provisions in the Habitats Directive.

The Court emphasised that the Birds Directive's protections apply to all wild bird species, not merely endangered ones. This broad application reflects the directive's fundamental purpose of protecting all naturally occurring wild birds in EU territory.
A significant distinction was drawn between different prohibitions within Article 5.

The Court held that Article 5(d), concerning deliberate disturbance, only applies where such disturbance would significantly affect the objective of maintaining bird populations at satisfactory levels. However, the prohibitions in Article 5(a) and (b), regarding killing and nest destruction, apply regardless of population impact.

The Court confirmed that scientific data and field observations provide a sufficient basis for establishing bird presence and applying protective measures, consistent with the precautionary principle enshrined in EU law. The fact that no endangered species were present does not affect the application of these protections.

Chapter 7: Birds assesses the likely significant effects that the Proposed Project may have on bird species. Firstly, a brief description of the Proposed Project is provided. This is followed by a comprehensive description of the methodologies that were followed in order to obtain the information necessary to complete a thorough assessment of the potential effects of the Proposed Project on bird species. The survey data are presented in full in the Environmental Impact Assessment Report (EIAR) appendices, with a summary of the information presented within this chapter. An analysis of the results is then provided, which discusses the ecological significance of the birds recorded within the study area. The potential effects of the Proposed Project are then described in terms of the construction, operation and decommissioning phases of the development. An accurate prediction of the effects is derived following a thorough understanding of the nature of the Proposed Project along with a comprehensive knowledge of bird activity within the study area. The identification of Key Ornithological Receptors (KORs) and the assessment of effects follow a precautionary approach.

The following KORs were identified: golden plover, whooper swan, crane, hen harrier, kingfisher, merlin, peregrine, barn owl, kestrel, lapwing, snipe, woodcock, buzzard, and sparrowhawk.

The potential for effects on designated sites is comprehensively described in the NIS that accompanies this application. The NIS concluded that where the potential for any adverse effect on any European Site has been identified, the pathway by which any such effect may occur has been robustly blocked through the use of avoidance, appropriate design and mitigation measures as set out within this report and its appendices. The measures ensure that the construction, operation and decommissioning of the site will not adversely affect the integrity of any European sites.

Based on the detailed assessment, it is considered that the potential effects of the Proposed Project upon birds will not be significant. Effects associated with habitat loss, disturbance displacement, barrier effect, collision risk and cumulative effects have been assessed to be no greater than long-term slight negative effect (EPA, 2017) and low effect significance (Percival, 2003). The only exceptions are kingfisher, wintering whooper swan and breeding lapwing for which moderate habitat loss effects were predicted in the absence of mitigation.

Consequently, a robust mitigation and enhancement plan has been proposed to reduce the magnitude of the effects, proposals are outlined in the BMEP (Appendix 6-5). Significant residual effects, following the implementation of measures outlined within the BMEP, on the KORs with regard to direct habitat loss, disturbance/displacement, barrier effect or collision mortality are not anticipated.

An assessment of potential cumulative effects was also undertaken, taking into consideration other extant planning applications and existing and proposed wind farms within 25km. No residual additive, antagonistic or synergistic effects have been identified with regards to habitat loss, displacement, of collision mortality for any of the identified KORs. No significant cumulative impacts are predicted.

Following consideration of the residual effects (post-mitigation), it is concluded that the Proposed Project will not result in any significant effects on any of the identified KORs. No significant effects on receptors of International, National or County Importance were identified. Provided that the Proposed Project is constructed, operated and decommissioned in accordance with the design, best practice mitigation and enhancement measures that are described within this application, significant individual or cumulative effects on the identified KORs are not anticipated.

Reference No 34 : 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 birds1–3. 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 wheatear2.

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 not3.
- 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 sites5.
- Total bird densities 0.3-1.3 birds/ha lower at wind farm sites compared to reference areas1.

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 information1,6–8.

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 impacts9,10.

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 collision11.

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 construction10.

Turbine characteristics

1. Greater rotor blade width and lower clearance to the ground both increase the likelihood of collision12. 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 colour13 or pattern14 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 occur15.

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 species16.

We are fully supportive of renewable energy solutions, and wind power is an important component of the UK's energy mix, but it is important to fully understand the biodiversity impacts of these developments. We believe that wind power can coexist with successful local bird populations when turbines are well designed and carefully sited.

However, turbines located inappropriately, especially on sensitive moorlands can cause significant habitat displacement for ground-nesting birds and potential collision risks for raptors.

References

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3. Pearce-Higgins, J. W., Stephen, L., Douse, A. & Langston, R. H. W. Greater impacts of wind farms on bird populations during construction than subsequent operation: results of a multi-site and multi-species analysis. *Journal of Applied Ecology* 49, 386–394 (2012).

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5. Pearce-Higgins, J. W., Stephen, L., Langston, R. H. W. & Bright, J. A. Assessing the cumulative impacts of wind farms on peatland birds: a case study of golden plover Pluvialis apricaria in Scotland. *Mires and Peat* 4, 01 (2008).

6. Fernández-Bellon, D., Irwin, S., Wilson, M. & O'Halloran, M. Reproductive output of Hen Harriers Circus cyaneus in relation to wind turbine proximity. *Irish Birds* 10, 143–150 (2015).

7. Wilson, M. W., Fernandez-Bellon, D., Irwin, S. & O'Halloran, J. *The Interactions between Hen Harriers and Wind Turbines. WINDHARRIER Final Project Report.* https://www.ucc.ie/en/media/research/planforbio/forestecology/WINDHARRIERFinalProjectReport.pdf (2015).

8. Wilson, M. W., Fernández-Bellon, D., Irwin, S. & O'Halloran, J. Hen Harrier Circus cyaneus population trends in relation to wind farms. *Bird Study* 64, 20–29 (2017).

9. Bright, J. A. *et al.* Spatial overlap of wind farms on peatland with sensitive areas for birds. *Mires and Peat* 4, 07 (2008).

10. Drewitt, A. L. & Langston, R. H. W. Assessing the impacts of wind farms on birds. *Ibis* 148, 29–42 (2006).

11. Péron, G. *et al.* The energy landscape predicts flight height and wind turbine collision hazard in three species of large soaring raptor. *Journal of Applied Ecology* 54, 1895–1906 (2017).

12. Škrábal, J. *et al.* Red kite (*Milvus milvus*) collision risk is higher at wind turbines with larger rotors and lower clearance, evidenced by GPS tracking. *Biological Conservation* 312, 111482 (2025).

13. May, R. *et al.* Paint it black: Efficacy of increased wind turbine rotor blade visibility to reduce avian fatalities. *Ecology and Evolution* 10, 8927–8935 (2020).

14. Hancock, G. R. *et al.* Biologically inspired warning patterns deter birds from wind turbines. *bioRxiv* 2025–04 (2025).

15. Gémard, C., Duriez, O., Chappe, O., Duclos, G. & Besnard, A. Towards a better understanding of avian collision in wind energy facilities using automatic detection systems. *Journal of Applied Ecology* 62, 1437–1448 (2025).

16. Schippers, P. *et al.* Mortality limits used in wind energy impact assessment underestimate impacts of wind farms on bird populations. *Ecology and Evolution* 10, 6274–6287 (2020).

3.1.2.2 : Bird survey results were reviewed for species relevant to the assessment of potential impacts on SPAs within the potential Zone of Influence of the Proposed Project site (included in Table 4-1). Only bird species listed as SCIs of these SPAs are described below. These species are:

• Golden Plover	• Black-tailed Godwit	• Teal
• Whooper Swan	• Shoveler	• Pintail
• Lapwing	• Coot	• Cormorant
• Black-headed Gull	• Tufted Duck	• Mallard

• Common Tern	• Wigeon	• Little Grebe

From the lists below they only reviewed: Golden Plover, Whooper Swan, Lapwing & Black Headed Gull. Reference the ACP Oriel Windfarm bird details above.

The target species listed below were only recorded during waterbird distribution and abundance surveys, greater than 1.5km, and up to 8km, from the Proposed Project site. There were no observations of these species within or near the Proposed Project site over the 4.5 years of surveying.

- Common Tern (closet record = 7.7km distant from Proposed Project site).
- Black-tailed Godwit (closet record = 6.0km distant from Proposed Project site).
- Shoveler (closet record = 3.6km distant from Proposed Project site).
- Coot (closet record = 5.8km distant from Proposed Project site).
- Teal (closet record = 1.8km distant from Proposed Project site).
- Tufted Duck (closet record = 5.8km distant from Proposed Project site).

The following species were recorded during ornithological surveys, however, the distances between the Proposed Project site and the respective SPAs are significantly greater than the foraging ranges of these species.

- Wigeon – SCI of Middle Shannon Callows SPA situated approx. 8.9km from Proposed Project site – core foraging range of wigeon is 2.5 – 2.8km (Johnston et al., 2013).
- Mallard – SCI of Lough Ree SPA situated approx. 11.4km from Proposed Project site – core foraging range of mallard is 0.5 – 1.3km (Johnston et al., 2013).
- Little Grebe – SCI of Lough Ree SPA situated approx. 11.4km from Proposed Project site.
- Pintail – SCI of River Little Brosna Callows SPA situated approx. 5.4km from the Proposed Project site (20.6km from the Proposed Wind Farm) – core foraging range of pintail is 1.3km (Johnston et al., 2013).
- Cormorant – SCI of 18.2km from the Proposed Project site (33.6km from the Proposed Wind Farm) – core foraging range of cormorant is 5.2km (Thaxter et al., 2012)

The following species are SCI species of SPAs included in Table 4-1 and were not recorded during any ornithological surveys:

- Greenland White-Fronted Goose
- Corncrake
- Common Scoter
- Goldeneye

8.2.1.1 **Other Wind Farm Projects**

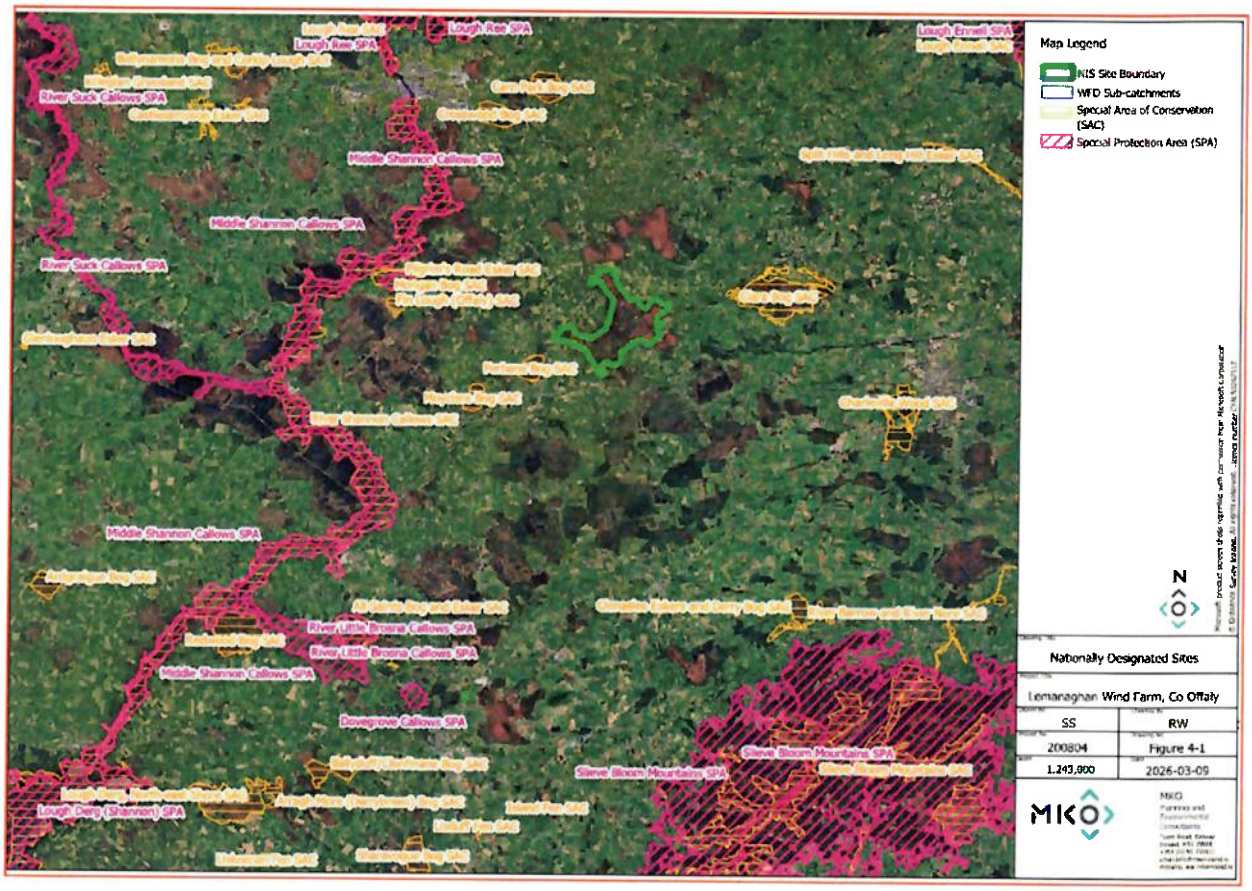
On a precautionary basis a 25km zone of influence was used to identify wind farm developments in the wider area. In total, 9 no. applications relating to wind energy were identified within 25km of the Proposed Project site. Each identified wind energy project is considered in further detail in the sections below.

Table 8-2 Wind farm projects within 25km of the Proposed Project

Wind Farm	Planning Ref.	Planning Status	No. of Turbines	Distance (turbine to turbine)	County
Bellair Wind Farm	N/A	Proposed	N/A	2.73km*	Offaly
Leabeg Wind Farm	10130	Existing	2	6.25km	Offaly
Lea Mor Single Turbine	OCC24/60326; ACP 321244	Permitted	1	6.75km	Offaly
Derrinlough Wind Farm	19.306706	Existing	21	10.68km	Offaly
Cloghan Wind Farm	14188, 19404	Existing	9	10.79km	Offaly
Umma More Wind Farm	25M.321595	Proposed	9	16.28km	Westmeath
Kilbeggan Turbine	22537	Permitted	1	17.08km	Westmeath
Cush Wind Farm	19.318816	Permitted	8	17.43km	Offaly
James Nally Single Turbine	114099	Existing	1	18.84km	Westmeath

Table 8-3 Available predicted collisions per annum from existing, permitted or proposed wind farms within 25km of the Proposed Project site

Wind Farm	Golden Plover[41]	Lapwing
Proposed Project	10.665	2.007
Proposed Bellair Wind Farm	N/A	N/A
Existing Leabeg Wind Farm	-	-
Existing Derrinlough Wind Farm	2.84*	3.55
Permitted Cush Wind Farm	1.55*	4.98
Proposed Umma More Wind Farm	10.842	19.562
Permitted Lea More Single Turbine	0.377	7.641
Cumulative Predicted Collisions	26.274	37.65





Note: Bird counts not relevant to Lemanaghan Windfarm site

Appendix 7 Survey Data NIS Appendices - F - 2026.03.19 – 200804
Observations of Golden Plover form Waterbird Distribution and Abundance Surveys have been further divided across the following Figures in order to improve readability:

Figure 1-4a – Golden Plover Waterbird and Distribution Survey Data Winter Season 2020/21
Figure 1-4b – Golden Plover Waterbird and Distribution Survey Data Winter Season 2022/22
Figure 1-4c – Golden Plover Waterbird and Distribution Survey Data Winter Season 2022/23
Figure 1-4d – Golden Plover Waterbird and Distribution Survey Data Winter Season 2023/24
Figure 1-4e – Golden Plover Waterbird and Distribution Survey Data Winter Season 2024/25



Note: Bird counts not relevant to Lemanaghan Windfarm site



Note: Bird counts not relevant to Lemanaghan Windfarm site



Note: Bird counts not relevant to Lemanaghan Windfarm site



Note: Bird counts not relevant to Lemanaghan Windfarm site



Response from MLavelle: These Figures refer to a site south of Lemanaghan Windfarm site and not relevant to this application.

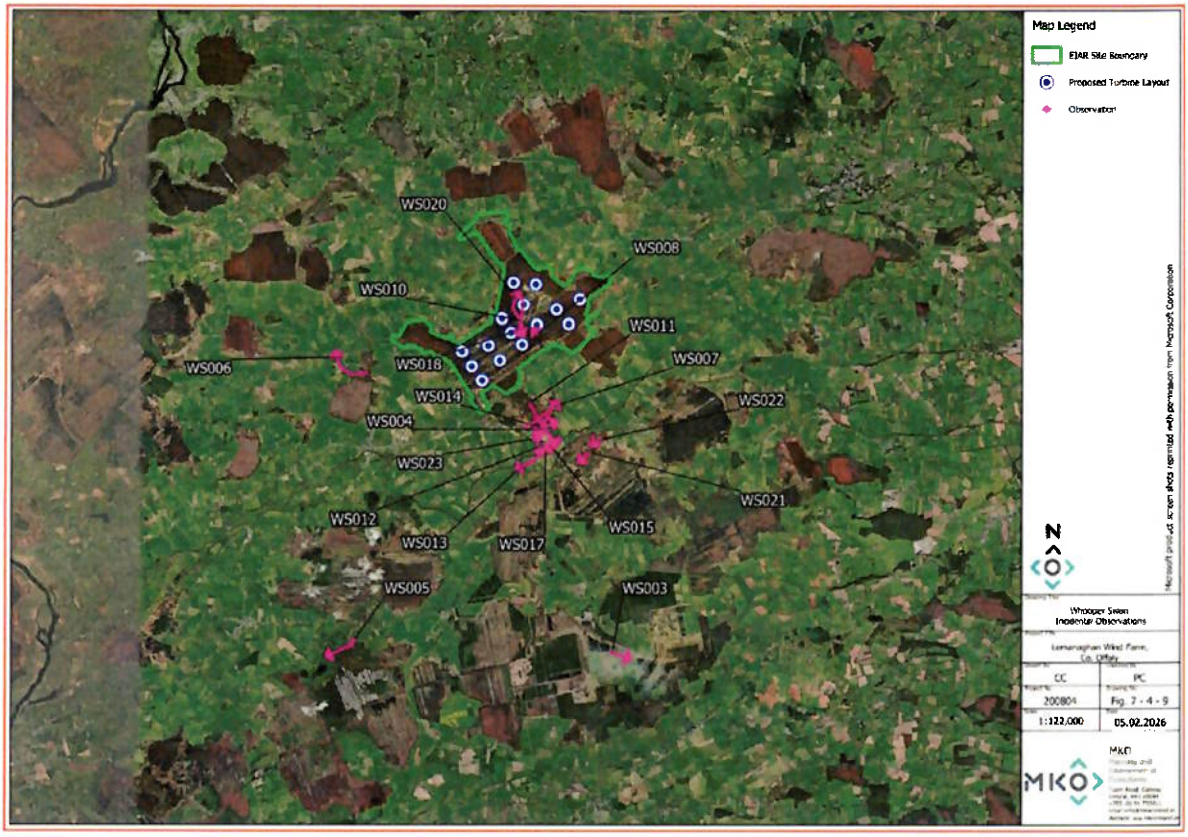
Observations of Whooper Swan form Waterbird Distribution and Abundance Surveys have been further divided by season in the following Figures for clarity purposes:
Figure 2-3a – Whooper Swan Waterbird and Distribution Survey Data Winter Season 2020/21
Figure 2-3b – Whooper Swan Waterbird and Distribution Survey Data Winter Season 2022/22
Figure 2-3c – Whooper Swan Waterbird and Distribution Survey Data Winter Season 2022/23
Figure 2-3d – Whooper Swan Waterbird and Distribution Survey Data Winter Season 2023/24
Figure 2-3e – Whooper Swan Waterbird and Distribution Survey Data Winter Season 2024/25



Note: Bird counts not relevant to Lemanaghan Windfarm site



Note: Bird counts not relevant to Lemanaghan Windfarm site


Map Legend
EIAR Site Boundary
Proposed Turbine Layout
Observation
WS020
WS008
WS010
WS011
WS007
WS006
WS018
WS014
WS022
WS004
WS023
WS021
WS012
WS013
WS017
WS015
WS005
WS003
N
Whooper Swan
Incidental Observations
CC
PC
200804
Fig. 7 - 4 - 9
1:122,000
05.02.2026
MKO

Hen Harrier



Note: Bird counts not relevant to Lemanaghan Windfarm site

KINGFISHER



Note: Bird counts not relevant to Lemanaghan Windfarm site

LITTLE EGRET



Note: Bird counts not relevant to Lemanaghan Windfarm site

Observations of Little Egret form Waterbird Distribution and Abundance Surveys have been further divided across the following Figures in order to improve readability:

Figure 6-3a – Little Egret Waterbird and Distribution Survey Data Winter Season 2020/21

Figure 6-3b – Little Egret Waterbird and Distribution Survey Data Winter Season 2022/22

Figure 6-3c – Little Egret Waterbird and Distribution Survey Data Winter Season 2022/23

Figure 6-3d – Little Egret Waterbird and Distribution Survey Data Winter Season 2023/24

Figure 6-3e – Little Egret Waterbird and Distribution Survey Data Winter Season 2024/25



Note: Bird counts not relevant to Lemanaghan Windfarm site



Note: Bird counts not relevant to Lemanaghan Windfarm site



Note: Bird counts not relevant to Lemanaghan Windfarm site



Note: Bird counts not relevant to Lemanaghan Windfarm site



Note: Bird counts not relevant to Lemanaghan Windfarm site

MERLIN



Note: Bird counts not relevant to Lemanaghan Windfarm site

LAPWING



Note: Bird counts not relevant to Lemanaghan Windfarm site

Observations of Lapwing form Waterbird Distribution and Abundance Surveys have been further divided across the following Figures in order to improve readability:

Figure 9-4a – Lapwing Waterbird and Distribution Survey Data - Winter Season 2020/21
Figure 9-4b – Lapwing Waterbird and Distribution Survey Data - Breeding Season 2021 (April & May)
Figure 9-4c – Lapwing Waterbird and Distribution Survey Data - Winter Season 2022/22
Figure 9-4d – Lapwing Waterbird and Distribution Survey Data - Breeding Season 2022 (April & May)
Figure 9-4e – Lapwing Waterbird and Distribution Survey Data - Winter Season 2022/23
Figure 9-4f – Lapwing Waterbird and Distribution Survey Data - Breeding Season 2023 (April & May)
Figure 9-4g – Lapwing Waterbird and Distribution Survey Data - Winter Season 2023/24
Figure 9-4h – Lapwing Waterbird and Distribution Survey Data - Breeding Season 2024 (April & May)
Figure 9-4i – Lapwing Waterbird and Distribution Survey Data - Winter Season 2024/25



Note: Bird counts not relevant to Lemanaghan Windfarm site



Note: Bird counts not relevant to Lemanaghan Windfarm site



Note: Bird counts not relevant to Lemanaghan Windfarm site



Note: Bird counts not relevant to Lemanaghan Windfarm site



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Note: Bird counts not relevant to Lemanaghan Windfarm site



Note: Bird counts not relevant to Lemanaghan Windfarm site

BLACK HEADED GULL



Note: Bird counts not relevant to Lemanaghan Windfarm site

Observations of Black-headed Gull form Waterbird Distribution and Abundance Surveys have been further divided across the following Figures in order to improve readability:

Figure 10-3a – Black-headed Gull Waterbird and Distribution Survey Data - Winter Season 2020/21

Figure 10-3b – Black-headed Gull Waterbird and Distribution Survey Data - April & May 2021
Figure 10-3c – Black-headed Gull Waterbird and Distribution Survey Data - Winter Season 2021/22
Figure 10-3d – Black-headed Gull Waterbird and Distribution Survey Data - April & May 2022
Figure 10-3e – Black-headed Gull Waterbird and Distribution Survey Data - Winter Season 2022/23
Figure 10-3f – Black-headed Gull Waterbird and Distribution Survey Data - Winter Season 2023/24
Figure 10-3g – Black-headed Gull Waterbird and Distribution Survey Data - Winter Season 2024/25



Note: Bird counts not relevant to Lemanaghan Windfarm site



Note: Bird counts not relevant to Lemanaghan Windfarm site



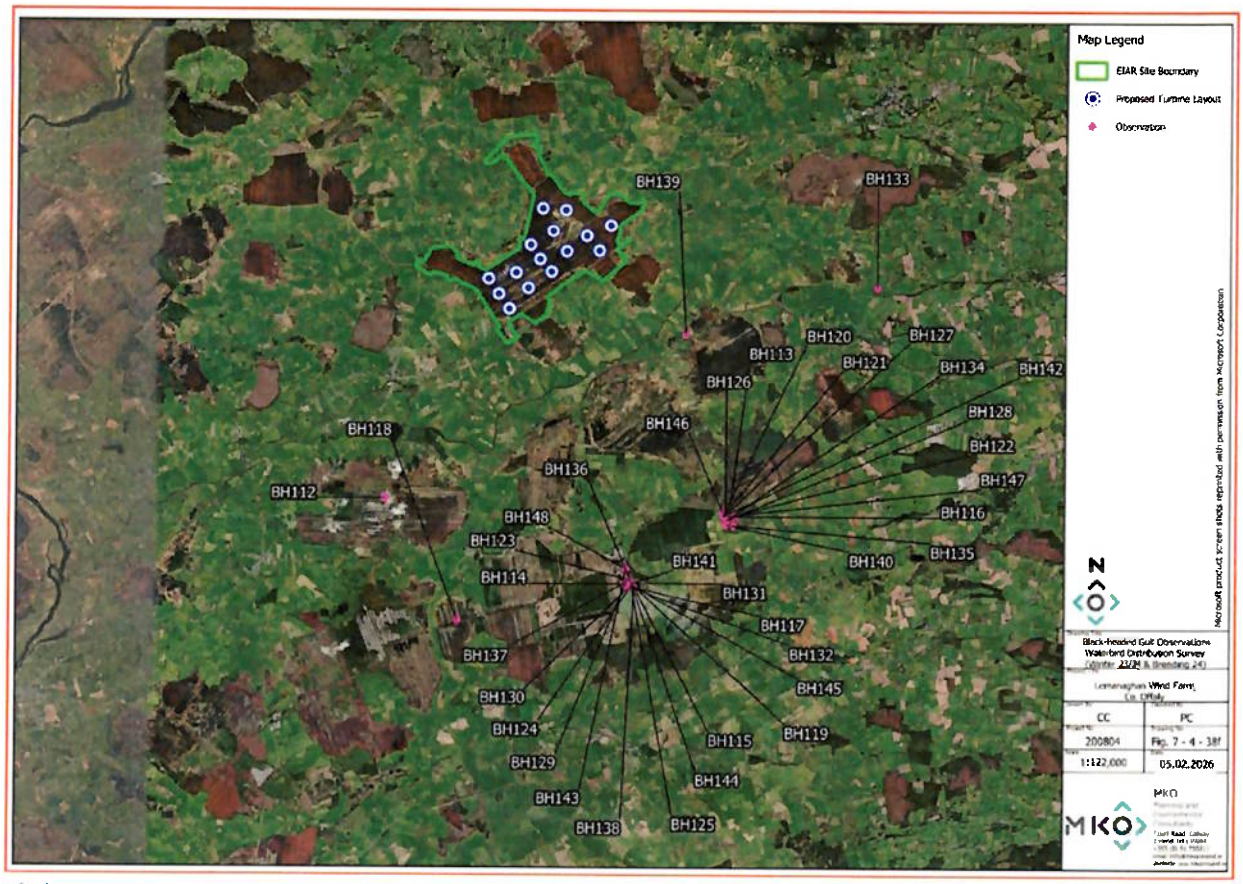
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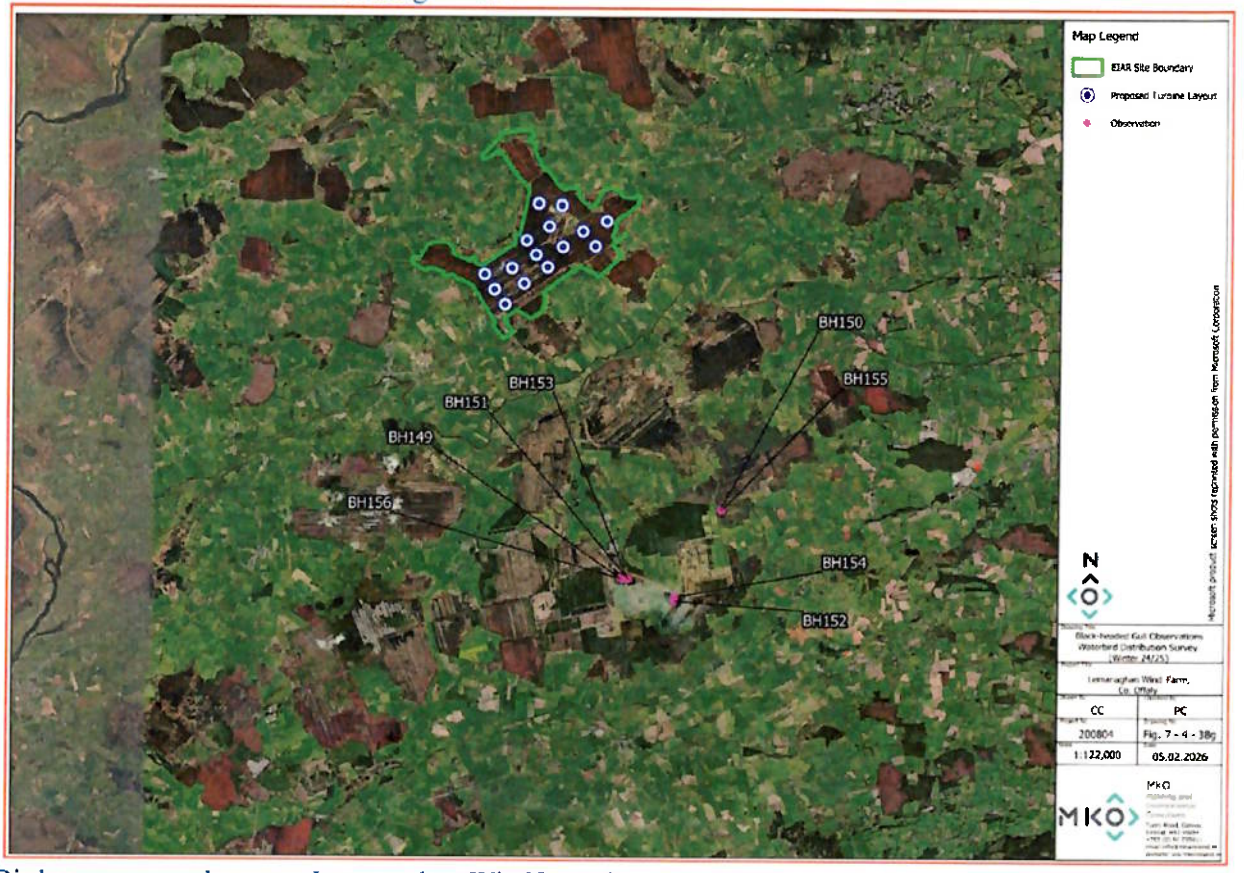
Note: Bird counts not relevant to Lemanaghan Windfarm site



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Note: Bird counts not relevant to Lemanaghan Windfarm site



Note: Bird counts not relevant to Lemanaghan Windfarm site

CURLEW



Note: Bird counts not relevant to Lemanaghan Windfarm site

Observations of Curlew form Waterbird Distribution and Abundance Surveys have been further divided across the following Figures in order to improve readability:

Figure 12-3a – Curlew Waterbird and Distribution Survey Data - Winter Season 2020/21

Figure 12-3b – Curlew Waterbird and Distribution Survey Data - Winter Season 2021/22

Figure 12-3c – Curlew Waterbird and Distribution Survey Data - Winter Season 2022/23

Figure 12-3d – Curlew Waterbird and Distribution Survey Data - Winter Season 2023/24
Figure 12-3e – Curlew Waterbird and Distribution Survey Data - Winter Season 2024/25



Note: Bird counts not relevant to Lemanaghan Windfarm site



Note: Bird counts not relevant to Lemanaghan Windfarm site



Note: Bird counts not relevant to Lemanaghan Windfarm site



Note: Bird counts not relevant to Lemanaghan Windfarm site

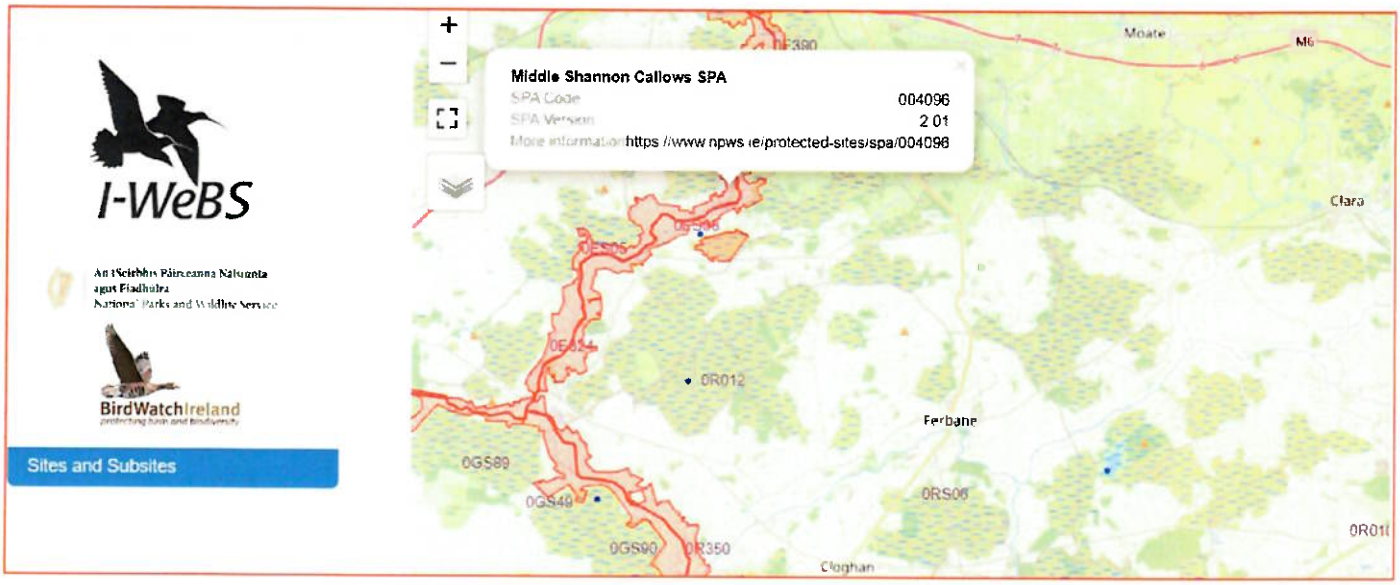


Note: Bird counts not relevant to Lemanaghan Windfarm site

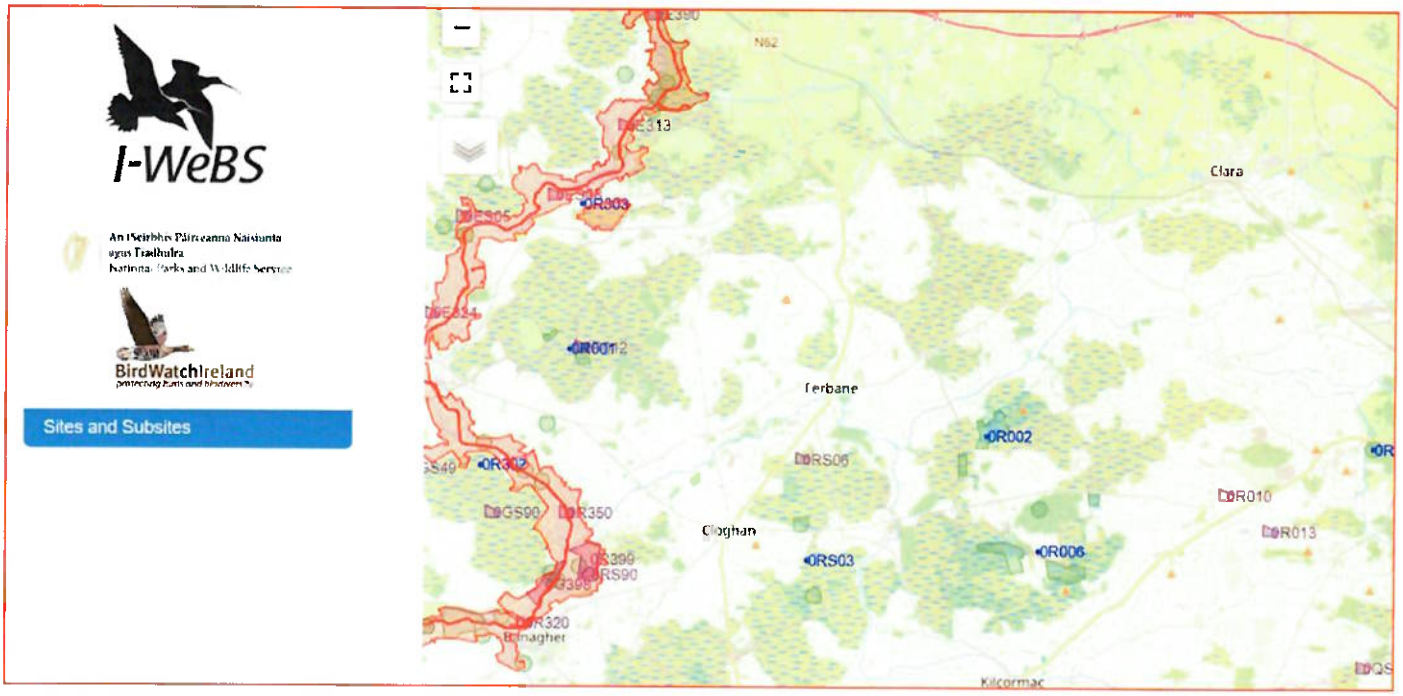
Table 7 - 7 - 1 Key ornithological receptors identified during surveys

Species	Scientific Name	Conservation Status
Crane	*Grus grus*	Annex I EU Birds Directive
Golden Plover	*Pluvialis apricaria*	Annex I EU Birds Directive; BoCCI Red Listed (Breeding & Wintering Populations); SCI of Middle Shannon Callows SPA & Lough Ree SPA
Hen Harrier	*Circus cyaneus*	Annex I EU Birds Directive
Kingfisher	*Alcedo atthis*	Annex I EU Birds Directive
Merlin	*Falco columbarius*	Annex I EU Birds Directive
Peregrine	*Falco peregrinus*	Annex I EU Birds Directive
Whooper Swan	*Cygnus cygnus*	Annex I EU Birds Directive; SCI of Middle Shannon Callows SPA & Lough Ree SPA
Barn Owl	*Tyto alba*	BoCCI Red-list
Kestrel	*Falco tinnunculus*	BoCCI Red-list

Species	Scientific Name	Conservation Status
Lapwing	*Vanellus vanellus*	BoCCI Red Listed (Breeding & Wintering Populations; SCI of Middle Shannon Callows SPA & Lough Ree SPA;
Snipe	*Gallinago gallinago*	BoCCI Red Listed (Breeding & Wintering Populations)
Woodcock	*Scolopax rusticola*	BoCCI Red-Listed Species (Breeding Populations)
Buzzard	*Buteo buteo*	Species sensitive to wind farm developments (Raptor Species)
Sparrowhawk	*Accipiter nisus*	Species sensitive to wind farm developments (Raptor Species)


I-WeBS
An tSeirbhís Páirceanna Náisiúnta agus Fiadhúlra
National Parks and Wildlife Service
BirdWatchIreland
Sites and Subsites
Middle Shannon Callows SPA
SPA Code 004096
SPA Version 2.01
More information https://www.npws.ie/protected-sites/spa/004096
Moate
M6
Clara
0R012
Ferbane
0GS89
0GS49
0RS06
0GS90
0R350
Cloghan


I-WeBS
An tSeirbhís Páirceanna Náisiúnta agus Fiadhúlra
National Parks and Wildlife Service
BirdWatchIreland
Sites and Subsites
Ferbane
Turraun Nature Reserve
Site Code 0R002
Current TRUE
Belmont
N62
0RS06


I-WeBS
An tSeirbhís Páirceanna Náisiúnta agus Fiadhúlra
National Parks and Wildlife Service
BirdWatchIreland
Sites and Subsites
N62
Clara
0R303
0R012
Ferbane
0R002
0RS06
0R010
0R013
0R302
0GS90
0R350
Cloghan
0RS03
0R006
0R320
Kilcormac

Reference No 35 : IRISH BIRDING –

Table 1 - OFFALY BIRD SPECIES – by species

Date	Common Name	Number	Location
19-Oct-25	American Golden Plover	1	Shannon Harbour
15-Oct-25	American Golden Plover	1	Shannon Harbour
14-Oct-25	American Golden Plover	1	Shannon Harbour
28-May-23	Barn Owl	1	Tullamore
07-Apr-23	Barn Owl	1	Blueball
14-Dec-22	Barn Owl	1	Tullamore
24-Jan-22	Barn Owl	1	M6
12-Jan-22	Barn Owl	1	Kilcormac
19-Jun-21	Barn Owl	2	Lough Boora Discovery Park
03-Nov-20	Barn Owl	1	Ballinagar
15-Apr-20	Barn Owl	1	Cavemount Bog
09-Apr-23	Blackcap	4	Pollagh
31-Aug-24	Black-tailed Godwit	5	Drinagh Wetlands
09-Jan-26	Brambling	2	Lough Boora Discovery Park
29-Dec-25	Brambling	1	Lough Boora Discovery Park
26-Dec-25	Brambling	2	Lough Boora Discovery Park
25-Dec-25	Brambling	2	Lough Boora Discovery Park
04-Feb-22	Brambling	1	Lough Boora Discovery Park
27-Dec-21	Brambling	1	Undisclosed Location
18-Dec-21	Brambling	1	Ballyduff
28-Nov-21	Brambling	1	Garryhinch
22-Feb-21	Brambling	2	Geashill
21-Feb-21	Brambling	2	Walsh Island
29-Sept-25	Buzzard	3	Lough Boora Discovery Park
01-Jun-25	Buzzard	3	Lough Boora Discovery Park
14-Oct-24	Buzzard	1	Lough Boora Discovery Park
06-Sept-24	Buzzard	1	Lough Boora Discovery Park
23-May-24	Buzzard	2	Moneygall
08-Oct-23	Buzzard	7	Lough Boora Discovery Park
13-Aug-23	Buzzard	4	Lough Boora Discovery Park
16-Apr-23	Buzzard	5	M7
09-Apr-23	Buzzard	2	Lough Boora Discovery Park
22-Feb-23	Buzzard	2	Lough Boora Discovery Park
13-Nov-22	Buzzard	2	Lough Boora Discovery Park
05-Nov-22	Buzzard	1	Lough Boora Discovery Park
07-Aug-22	Buzzard	1	Moneygall
23-Mar-22	Buzzard	18	Lough Boora Discovery Park
23-Mar-22	Buzzard	15	Lough Boora Discovery Park
15-Mar-22	Buzzard	3	Lough Boora Discovery Park
06-Mar-22	Buzzard	4	Lough Boora Discovery Park
06-Feb-22	Buzzard	3	Lough Boora Discovery Park
05-Feb-22	Buzzard	2	Lough Boora Discovery Park
30-Jan-22	Buzzard	5	Lough Boora Discovery Park
29-Jan-22	Buzzard	2	Lough Boora Discovery Park
27-Jan-22	Buzzard	1	Charleville Castle

27-Jan-22	Buzzard	1	Birr Castle Demesne
05-Jan-22	Buzzard	4	Lough Boora Discovery Park
16-Dec-21	Buzzard	1	Birr
25-Nov-21	Buzzard	3	Lough Boora Discovery Park
23-Nov-21	Buzzard	4	Lough Boora Discovery Park
23-Nov-21	Buzzard	4	Lough Boora Discovery Park
21-Nov-21	Buzzard	1	Tullamore
13-Nov-21	Buzzard	4	Lough Boora Discovery Park
12-Nov-21	Buzzard	4	Lough Boora Discovery Park
22-Sept-21	Buzzard	1	Lough Boora Discovery Park
06-Sept-21	Buzzard	6	Lough Boora Discovery Park
15-Aug-21	Buzzard	1	Moneygall
10-Aug-21	Buzzard	1	Dunkerrin
30-Jul-21	Buzzard	5	Lough Boora Discovery Park
17-Jul-21	Buzzard	2	Birr
04-Jun-21	Buzzard	1	N52
29-May-21	Buzzard	5	Lough Boora Discovery Park
26-May-21	Buzzard	2	Lough Boora Discovery Park
12-May-21	Buzzard	1	Lough Boora Discovery Park
14-Sept-20	Buzzard	5	Lough Boora Discovery Park
13-Sept-20	Buzzard	4	Lough Boora Discovery Park
06-Sept-20	Buzzard	5	Lough Boora Discovery Park
30-Aug-20	Buzzard	5	Lough Boora Discovery Park
09-Jul-20	Buzzard	1	Birr
23-Jan-20	Buzzard	1	Lough Boora Discovery Park
16-Nov-19	Buzzard	1	Lough Boora Discovery Park
28-Oct-19	Buzzard	2	Lough Boora Discovery Park
20-Mar-22	Chiffchaff	4	Lough Boora Discovery Park
18-Mar-22	Chiffchaff	1	Undisclosed Location
18-Mar-22	Chiffchaff	1	Tullamore
21-Mar-21	Chiffchaff	1	Tullamore
27-Mar-20	Chiffchaff	2	Raheenmore Bog
23-Nov-19	Chiffchaff	1	Lough Boora Discovery Park
02-Jun-24	Crane	2	Turan wetlands
26-Aug-23	Crane	3	Little Brosna Callows / Calaí na Brosnaí Bige
22-May-22	Crane	1	Undisclosed Location
18-Mar-22	Crane	1	Undisclosed Location
14-Mar-22	Crane	2	Lough Boora Discovery Park
16-May-21	Crane	2	Lough Boora Discovery Park
03-Feb-24	Crossbill	2	Lough Boora Discovery Park
29-May-22	Crossbill	3	Lough Boora Discovery Park
20-May-25	Cuckoo	1	Killeigh
06-May-25	Cuckoo	1	Slieve Bloom Mountains
01-May-25	Cuckoo	1	Lough Boora Discovery Park
14-Apr-25	Cuckoo	1	Clara Bog
02-Jun-24	Cuckoo	3	Turan wetlands
14-May-24	Cuckoo	1	Lackagh More
05-Jun-23	Cuckoo	1	Birr
02-May-23	Cuckoo	1	Ballycumber

12-Jun-22	Cuckoo	1	Cultree
29-May-22	Cuckoo	4	Slieve Bloom Mountains
29-May-22	Cuckoo	1	Lough Boora Discovery Park
12-May-22	Cuckoo	1	Banagher / Beannchar na Sionna
02-May-22	Cuckoo	1	Sharavogue
19-Apr-22	Cuckoo	1	Cloghan
07-Jun-21	Cuckoo	2	Lough Boora Discovery Park
30-May-21	Cuckoo	1	Cadamstown
29-May-21	Cuckoo	2	Lough Boora Discovery Park
18-May-21	Cuckoo	1	Ballycon Bog
12-May-21	Cuckoo	1	Lough Boora Discovery Park
02-May-21	Cuckoo	1	Slieve Bloom Mountains
29-Apr-21	Cuckoo	1	Derryounce Bog
25-Apr-21	Cuckoo	1	Daingean
17-Apr-21	Cuckoo	1	Clonmacnoise
12-May-20	Cuckoo	1	Tullamore
08-Oct-23	Curlew	100	Lough Boora Discovery Park
10-Sept-23	Curlew	20	Lough Boora Discovery Park
13-Aug-23	Curlew	15	Lough Boora Discovery Park
19-Jun-22	Curlew	2	Lough Boora Discovery Park
12-May-22	Curlew	1	Undisclosed Location
25-Nov-21	Curlew	28	Lough Boora Discovery Park
09-Jan-21	Curlew	2	Tullamore
15-Apr-20	Curlew	2	Undisclosed Location
16-Nov-19	Curlew	40	Lough Boora Discovery Park
27-Oct-23	Fieldfare	1	Little Brosna Callows / Calaí na Brosnaí Bige
13-Nov-21	Fieldfare	10	Lough Boora Discovery Park
03-Aug-20	Garden Warbler	1	Lough Boora Discovery Park
23-Jan-26	Glossy Ibis	1	Clonmacnoise
09-Sept-25	Glossy Ibis	1	Lough Boora Discovery Park
09-Apr-23	Golden Plover	100	Lough Boora Discovery Park
05-Nov-22	Golden Plover	100	Lough Boora Discovery Park
25-Nov-21	Golden Plover	100	Lough Boora Discovery Park
12-Nov-21	Golden Plover	100	Lough Boora Discovery Park
01-Jun-25	Grasshopper Warbler	1	Turraun
18-Jul-22	Grasshopper Warbler	1	Lough Boora Discovery Park
24-May-25	Great Spotted Woodpecker	1	Lough Boora Discovery Park
06-Mar-25	Great Spotted Woodpecker	1	Ballybeg
24-Sept-24	Great Spotted Woodpecker	1	Shannon Harbour
13-Jul-24	Great Spotted Woodpecker	1	Little Brosna Callows
13-Feb-24	Great Spotted Woodpecker	1	Lough Boora Discovery Park
25-Jan-24	Great Spotted Woodpecker	1	Ballincor
02-Apr-23	Great Spotted Woodpecker	1	Kinnity
05-Dec-21	Great Spotted Woodpecker	1	Garryhinch
31-Dec-20	Great Spotted Woodpecker	1	Tullamore
27-May-20	Great Spotted Woodpecker	1	Knocknamase or Golden Grove Wood
04-May-20	Great Spotted Woodpecker	1	Knocknamase or Golden Grove Wood
02-May-20	Great Spotted Woodpecker	1	Knocknamase or Golden Grove Wood
29-Apr-20	Great Spotted Woodpecker	1	Knocknamase or Golden Grove Wood

27-Nov-25	Great White Egret	1	Turraun Wetland
05-May-25	Great White Egret	1	Lough Boora Discovery Park
27-Dec-24	Great White Egret	1	Shannon Bridge
16-Dec-24	Great White Egret	1	Raheen Lough
11-Dec-24	Great White Egret	2	Ferbane
01-Nov-24	Great White Egret	1	Raheen Lough
23-Oct-24	Great White Egret	1	Tullamore
21-Oct-24	Great White Egret	1	Clurraghbee
22-Oct-22	Great White Egret	1	Lough Boora Discovery Park
26-Apr-21	Great White Egret	1	Clonmacnoise
09-Sept-25	Green Sandpiper	1	Shannon Harbour
14-Aug-25	Green Sandpiper	1	Lough Boora Discovery Park
22-Mar-23	Green Sandpiper	1	Raheen Lough
29-Aug-22	Green Sandpiper	5	Raheen Lough
29-Jul-22	Green Sandpiper	3	Raheen Lough
02-Jul-22	Green Sandpiper	3	Ragheen Lake
22-Feb-22	Green Sandpiper	3	Ragheen Lough
12-Nov-21	Green Sandpiper	2	Sullane Delta
25-Apr-21	Green Sandpiper	1	Lough Boora Discovery Park
05-May-23	Greenshank	2	Raheen Lough
13-Apr-26	Grey Partridge	1	Lough Boora Discovery Park
19-Dec-25	Grey Partridge	4	Lough Boora Discovery Park
24-May-25	Grey Partridge	2	Lough Boora Discovery Park
14-May-25	Grey Partridge	1	Lough Boora Discovery Park
22-Apr-25	Grey Partridge	2	Lough Boora Discovery Park
02-Jun-24	Grey Partridge	3	Lough Boora Discovery Park
18-May-24	Grey Partridge	3	Lough Boora Discovery Park
01-May-23	Grey Partridge	2	Lough Boora Discovery Park
29-Apr-23	Grey Partridge	2	Lough Boora Discovery Park
09-Apr-23	Grey Partridge	2	Lough Boora Discovery Park
18-Jul-22	Grey Partridge	2	Lough Boora Discovery Park
01-Jun-22	Grey Partridge	18	Lough Boora Discovery Park
25-May-22	Grey Partridge	2	Lough Boora Discovery Park
16-Apr-22	Grey Partridge	4	Lough Boora Discovery Park
31-Mar-22	Grey Partridge	2	Lough Boora Discovery Park
29-Mar-22	Grey Partridge	2	Lough Boora Discovery Park
15-Mar-22	Grey Partridge	2	Lough Boora Discovery Park
12-Mar-22	Grey Partridge	2	Lough Boora Discovery Park
04-Mar-22	Grey Partridge	6	Lough Boora Discovery Park
29-Jan-22	Grey Partridge	2	Lough Boora Discovery Park
23-Nov-21	Grey Partridge	6	Lough Boora Discovery Park
13-Nov-21	Grey Partridge	1	Lough Boora Discovery Park
07-Jun-21	Grey Partridge	2	Lough Boora Discovery Park
30-Aug-20	Grey Partridge	20	Lough Boora Discovery Park
26-Aug-20	Grey Partridge	8	Lough Boora Discovery Park
03-Aug-20	Grey Partridge	14	Lough Boora Discovery Park
28-Oct-19	Grey Partridge	25	Lough Boora Discovery Park
17-Mar-22	Greylag Goose	23	Lough Boora Discovery Park
30-Jan-22	Greylag Goose	18	Lough Boora Discovery Park

23-Oct-25	Hen Harrier	2	Lough Boora Discovery Park
26-Dec-24	Hen Harrier	1	Lough Boora Discovery Park
14-Feb-24	Hen Harrier	1	Lough Boora Discovery Park
25-Jan-24	Hen Harrier	1	Ballincor
28-Dec-23	Hen Harrier	1	Lough Boora Discovery Park
22-Feb-23	Hen Harrier	2	Lough Boora Discovery Park
18-Feb-23	Hen Harrier	1	Lough Boora Discovery Park
06-Feb-23	Hen Harrier	1	Lough Boora Discovery Park
13-Nov-22	Hen Harrier	2	Lough Boora Discovery Park
03-Nov-22	Hen Harrier	1	Lough Boora Discovery Park
10-Sept-22	Hen Harrier	2	Lough Boora Discovery Park
23-Mar-22	Hen Harrier	1	Lough Boora Discovery Park
20-Mar-22	Hen Harrier	1	Lough Boora Discovery Park
17-Mar-22	Hen Harrier	1	Lough Boora Discovery Park
15-Mar-22	Hen Harrier	3	Lough Boora Discovery Park
14-Mar-22	Hen Harrier	2	Lough Boora Discovery Park
12-Mar-22	Hen Harrier	1	Lough Boora Discovery Park
04-Mar-22	Hen Harrier	1	Lough Boora Discovery Park
25-Feb-22	Hen Harrier	1	Lough Boora Discovery Park
06-Feb-22	Hen Harrier	1	Lough Boora Discovery Park
05-Feb-22	Hen Harrier	1	Lough Boora Discovery Park
04-Feb-22	Hen Harrier	2	Lough Boora Discovery Park
30-Jan-22	Hen Harrier	3	Lough Boora Discovery Park
29-Jan-22	Hen Harrier	2	Lough Boora Discovery Park
21-Jan-22	Hen Harrier	2	Lough Boora Discovery Park
05-Jan-22	Hen Harrier	3	Lough Boora Discovery Park
01-Jan-22	Hen Harrier	3	Lough Boora Discovery Park
30-Dec-21	Hen Harrier	2	Lough Boora Discovery Park
25-Nov-21	Hen Harrier	2	Lough Boora Discovery Park
23-Nov-21	Hen Harrier	2	Lough Boora Discovery Park
22-Sept-21	Hen Harrier	1	Lough Boora Discovery Park
06-Sept-21	Hen Harrier	1	Lough Boora Discovery Park
30-Jul-21	Hen Harrier	2	Lough Boora Discovery Park
26-May-21	Hen Harrier	1	Lough Boora Discovery Park
14-Sept-20	Hen Harrier	1	Lough Boora Discovery Park
13-Sept-20	Hen Harrier	2	Lough Boora Discovery Park
06-Sept-20	Hen Harrier	4	Lough Boora Discovery Park
26-Aug-20	Hen Harrier	1	Lough Boora Discovery Park
03-Aug-20	Hen Harrier	1	Lough Boora Discovery Park
04-Mar-20	Hen Harrier	2	Lough Boora Discovery Park
17-Nov-19	Hen Harrier	2	Lough Boora Discovery Park
16-Nov-19	Hen Harrier	1	Lough Boora Discovery Park
28-Oct-19	Hen Harrier	1	Lough Boora Discovery Park
26-Oct-19	Hen Harrier	1	Lough Boora Discovery Park
22-Oct-19	Hen Harrier	1	Lough Boora Discovery Park
09-Jan-26	Jack Snipe	1	Lough Boora Discovery Park
26-Jan-24	Jack Snipe	9	Ballincor
17-Apr-21	Jack Snipe	1	Clonmacnoise
29-Sept-25	Kestrel	1	Lough Boora Discovery Park

16-Apr-23	Kestrel	2	M7
13-Nov-22	Kestrel	1	Lough Boora Discovery Park
05-Nov-22	Kestrel	1	Lough Boora Discovery Park
06-Feb-22	Kestrel	1	Lough Boora Discovery Park
29-Jan-22	Kestrel	1	Lough Boora Discovery Park
05-Jan-22	Kestrel	1	Lough Boora Discovery Park
25-Nov-21	Kestrel	2	Lough Boora Discovery Park
23-Nov-21	Kestrel	1	Lough Boora Discovery Park
21-Nov-21	Kestrel	1	Tullamore
12-Nov-21	Kestrel	1	Lough Boora Discovery Park
06-Sept-21	Kestrel	1	Lough Boora Discovery Park
14-Sept-20	Kestrel	2	Lough Boora Discovery Park
13-Sept-20	Kestrel	2	Lough Boora Discovery Park
06-Sept-20	Kestrel	3	Lough Boora Discovery Park
30-Aug-20	Kestrel	3	Lough Boora Discovery Park
04-Mar-20	Kestrel	2	Lough Boora Discovery Park
27-Dec-25	Kingfisher	1	Ballycommon
10-Sept-23	Kingfisher	1	Lough Boora Discovery Park
21-Oct-22	Kingfisher	1	Clonmaenoise
27-Jan-22	Kingfisher	1	Birr Castle Demesne
18-Jul-21	Kingfisher	1	Lough Boora Discovery Park
03-Nov-20	Kingfisher	1	Daingean
13-Apr-20	Lesser Redpoll	1	Cavemount Bog
29-Sept-25	Little Egret	1	Lough Boora Discovery Park
01-Jun-22	Long-eared Owl	1	Cloneyhurke
23-Aug-20	Long-eared Owl	3	Cor More
01-Jul-20	Long-eared Owl	4	Geashill
29-Dec-25	Marsh Harrier	1	Lough Boora Discovery Park
29-Sept-25	Marsh Harrier	1	Lough Boora Discovery Park
22-Sept-25	Marsh Harrier	1	Lough Boora Discovery Park
16-Mar-25	Marsh Harrier	1	Lough Boora Discovery Park
17-Oct-24	Marsh Harrier	1	Lough Boora Discovery Park
18-Feb-23	Marsh Harrier	1	Lough Boora Discovery Park
23-Mar-22	Marsh Harrier	1	Lough Boora Discovery Park
26-May-21	Marsh Harrier	1	Lough Boora Discovery Park
10-Sept-20	Marsh Harrier	1	Lough Boora Discovery Park
06-Sept-20	Marsh Harrier	1	Lough Boora Discovery Park
30-Aug-20	Marsh Harrier	1	Lough Boora Discovery Park
23-Nov-19	Marsh Harrier	1	Lough Boora Discovery Park
29-May-21	Meadow Pipit	4	Lough Boora Discovery Park
27-Dec-25	Merlin	1	Lough Boora Discovery Park
26-Dec-25	Merlin	1	Lough Boora Discovery Park
19-Dec-25	Merlin	1	Lough Boora Discovery Park
08-Nov-25	Merlin	1	Ballycommon
16-Mar-25	Merlin	1	Lough Boora Discovery Park
08-Mar-25	Merlin	1	Shannon Callows
25-Jan-24	Merlin	2	Ballincor
22-Feb-23	Merlin	1	Lough Boora Discovery Park
05-Nov-22	Merlin	1	Lough Boora Discovery Park

23-Mar-22	Merlin	1	Lough Boora Discovery Park
15-Mar-22	Merlin	1	Lough Boora Discovery Park
05-Feb-22	Merlin	1	Lough Boora Discovery Park
04-Feb-22	Merlin	1	Lough Boora Discovery Park
30-Jan-22	Merlin	1	Lough Boora Discovery Park
01-Jan-22	Merlin	2	Lough Boora Discovery Park
23-Nov-21	Merlin	2	Lough Boora Discovery Park
13-Nov-21	Merlin	2	Lough Boora Discovery Park
18-Oct-21	Merlin	1	Lough Boora Discovery Park
04-Mar-20	Merlin	1	Lough Boora Discovery Park
20-Feb-20	Merlin	1	Lough Boora Discovery Park
27-Oct-19	Merlin	1	Lough Boora Discovery Park
21-Oct-22	Mistle Thrush	50	Clonmacnoise
23-Mar-22	Northern Harrier	1	Lough Boora Discovery Park
17-Mar-22	Northern Harrier	1	Lough Boora Discovery Park
15-Mar-22	Northern Harrier	1	Lough Boora Discovery Park
14-Mar-22	Northern Harrier	1	Lough Boora Discovery Park
12-Mar-22	Northern Harrier	1	Lough Boora Discovery Park
06-Mar-22	Northern Harrier	1	Lough Boora Discovery Park
04-Mar-22	Northern Harrier	1	Lough Boora Discovery Park
02-Mar-22	Northern Harrier	1	Lough Boora Discovery Park
27-Feb-22	Northern Harrier	1	Lough Boora Discovery Park
26-Feb-22	Northern Harrier	1	Lough Boora Discovery Park
25-Feb-22	Northern Harrier	1	Lough Boora Discovery Park
22-Feb-22	Northern Harrier	1	Lough Boora Discovery Park
21-Feb-22	Northern Harrier	1	Lough Boora Discovery Park
08-Feb-22	Northern Harrier	1	Lough Boora Discovery Park
06-Feb-22	Northern Harrier	1	Lough Boora Discovery Park
04-Feb-22	Northern Harrier	1	Lough Boora Discovery Park
01-Feb-22	Northern Harrier	1	Lough Boora Discovery Park
30-Jan-22	Northern Harrier	1	Lough Boora Discovery Park
29-Jan-22	Northern Harrier	1	Lough Boora Discovery Park
22-Jan-22	Northern Harrier	1	Lough Boora Discovery Park
21-Jan-22	Northern Harrier	1	Lough Boora Discovery Park
18-Jan-22	Northern Harrier	1	Lough Boora Discovery Park
08-Jan-22	Northern Harrier	1	Lough Boora Discovery Park
05-Jan-22	Northern Harrier	1	Lough Boora Discovery Park
03-Jan-22	Northern Harrier	1	Lough Boora Discovery Park
02-Jan-22	Northern Harrier	1	Lough Boora Discovery Park
01-Jan-22	Northern Harrier	1	Lough Boora Discovery Park
31-Dec-21	Northern Harrier	1	Lough Boora Discovery Park
30-Dec-21	Northern Harrier	1	Lough Boora Discovery Park
28-Dec-21	Northern Harrier	1	Lough Boora Discovery Park
26-Dec-21	Northern Harrier	1	Lough Boora Discovery Park
05-Dec-21	Northern Harrier	1	Lough Boora Discovery Park
21-Nov-21	Northern Harrier	1	Lough Boora Discovery Park
20-Nov-21	Northern Harrier	1	Lough Boora Discovery Park
19-Nov-21	Northern Harrier	1	Lough Boora Discovery Park
18-Nov-21	Northern Harrier	1	Lough Boora Discovery Park

15-Nov-21	Northern Harrier	1	Lough Boora Park
15-Nov-21	Northern Harrier	1	Lough Boora Discovery Park
14-Nov-21	Northern Harrier	1	Lough Boora Discovery Park
13-Nov-21	Northern Harrier	3	Lough Boora Discovery Park
12-Nov-21	Northern Harrier	1	Lough Boora Discovery Park
01-Jun-25	Northern Lapwing	100	Lough Boora Discovery Park
31-Jul-24	Northern Lapwing	50	Lough Boora Discovery Park
27-Oct-23	Northern Lapwing	100	Little Brosna Callows / Calaí na Brosnaí Bige
05-Mar-22	Northern Lapwing	12	Croghan
29-May-21	Northern Lapwing	10	Lough Boora Discovery Park
21-Apr-21	Northern Lapwing	6	Daingean
18-Mar-21	Northern Lapwing	5	Daingean
22-Oct-22	Osprey	1	Lough Boora Discovery Park
20-Oct-22	Osprey	1	Ballycon Bog
02-Oct-22	Osprey	1	Ballycon
20-Sept-22	Osprey	1	Lough Boora Discovery Park
10-Sept-22	Osprey	1	Lough Boora Discovery Park
18-May-21	Osprey	1	Ballycon Bog
31-Jul-20	Osprey	1	Shannon Bridge
08-Nov-22	Oystercatcher	1	Shannon Harbour
04-Sept-20	Oystercatcher	1	Drinagh
05-Jan-22	Peregrine	1	Lough Boora Discovery Park
28-Dec-21	Peregrine	1	Lough Boora Discovery Park
18-Mar-21	Peregrine	2	Daingean
22-Feb-23	Pink-footed Goose	6	Brosna Callows
10-Feb-23	Pink-footed Goose	6	Brosna Callows
08-Feb-23	Pink-footed Goose	6	Brosna Callows
09-Mar-23	Pintail	2	Raheen Lough
08-Oct-23	Raven	5	Lough Boora Discovery Park
02-May-23	Raven	1	Clonmacnois
22-Feb-23	Raven	1	Lough Boora Discovery Park
21-Oct-22	Raven	6	Clonmacnoise
25-Nov-21	Raven	3	Lough Boora Discovery Park
06-Sept-21	Raven	3	Lough Boora Discovery Park
29-May-21	Raven	1	Lough Boora Discovery Park
13-Sept-20	Raven	6	Lough Boora Discovery Park
06-Sept-20	Raven	6	Lough Boora Discovery Park
03-Aug-20	Raven	12	Lough Boora Discovery Park
16-Nov-19	Raven	1	Lough Boora Discovery Park
02-Jul-24	Red Grouse	1	Slieve Bloom Mountains
02-May-21	Red Grouse	3	Slieve Bloom Mountains
21-Jun-21	Red Kite	1	Tullamore
26-Sept-20	Red Kite	1	Lough Boora Discovery Park
03-Jul-21	Red-necked Phalarope	2	Undisclosed Location
29-Jun-21	Red-necked Phalarope	1	Undisclosed Location
02-Jul-22	Redshank	1	Ragheen Lake
12-Jun-22	Redshank	2	Undisclosed Location
10-May-25	Reed Warbler	1	Turraun Wetlands
09-Jun-24	Reed Warbler	1	Cloghan

10-Mar-22	Ringed Plover	5	Shannon Callows
18-May-21	Ringed Plover	1	Ballycon Bog
14-Oct-25	Ruff	2	Shannon Harbour
31-Aug-24	Ruff	1	Drinagh Wetlands
01-Sept-22	Ruff	2	Raheen Lough
07-Jan-26	Russian White-fronted Goose	2	Little Brosna Callows
20-Apr-25	Russian White-fronted Goose	1	Lough Boora Discovery Park
01-Jun-25	Sand Martin	100	Lough Boora Discovery Park
11-Mar-25	Sand Martin	6	Shannon Bridge
21-Mar-23	Sand Martin	6	Lough Boora Discovery Park
31-Mar-22	Sand Martin	11	Shannonbridge / Droichead na Sionainne
18-Aug-20	Sandwich Tern	1	Derryarkin
23-Nov-21	Short-eared Owl	1	Lough Boora Discovery Park
06-Nov-19	Short-eared Owl	1	Lough Boora Discovery Park
22-Oct-19	Short-eared Owl	1	Lough Boora Discovery Park
05-Nov-22	Skylark	20	Lough Boora Discovery Park
29-May-21	Skylark	3	Lough Boora Discovery Park
22-Feb-23	Snow Goose	1	Brosna Callows
10-Feb-23	Snow Goose	1	Brosna Callows
08-Feb-23	Snow Goose	1	Brosna Callows
21-Dec-22	Snow Goose	1	Brosna Callows
05-Feb-22	Sparrowhawk	1	Lough Boora Discovery Park
30-Jan-22	Sparrowhawk	1	Lough Boora Discovery Park
05-Jan-22	Sparrowhawk	1	Lough Boora Discovery Park
23-Nov-21	Sparrowhawk	1	Lough Boora Discovery Park
04-Jun-21	Sparrowhawk	1	Crinkill
13-Sept-20	Sparrowhawk	1	Lough Boora Discovery Park
06-Sept-20	Sparrowhawk	1	Lough Boora Discovery Park
30-Aug-20	Sparrowhawk	2	Lough Boora Discovery Park
06-Jun-20	Sparrowhawk	1	Birr
13-Jul-24	Spotted Flycatcher	1	Little Brosna Callows
18-Jun-24	Spotted Flycatcher	5	Lough Boora Discovery Park
18-Jul-22	Spotted Flycatcher	1	Lough Boora Discovery Park
08-Jul-20	Spotted Redshank	1	Banagher
22-Feb-23	Stock Dove	2	Lough Boora Discovery Park
23-Mar-22	Stock Dove	26	Lough Boora Discovery Park
17-Mar-22	Stock Dove	1	Lough Boora Discovery Park
04-Feb-22	Stock Dove	17	Lough Boora Discovery Park
30-Jan-22	Stock Dove	28	Lough Boora Discovery Park
13-Nov-21	Stock Dove	50	Lough Boora Discovery Park
12-Nov-21	Stock Dove	63	Lough Boora Discovery Park
04-Mar-20	Stock Dove	1	Lough Boora Discovery Park
22-Oct-21	Swallow	1	Birr
06-Apr-20	Swallow	1	Tullamore
01-Jun-25	Swift	50	Lough Boora Discovery Park
18-May-24	Swift	1	Lough Boora Discovery Park
25-May-23	Swift	4	Clara
24-May-25	Water Rail	1	Lough Boora Discovery Park
12-Jun-22	Water Rail	3	Cloghan

20-Mar-22	Water Rail	1	Lough Boora Discovery Park
07-Jun-21	Water Rail	1	Lough Boora Discovery Park
09-Sept-25	Wheatear	1	Shannon Harbour
08-Apr-25	Wheatear	1	Shannon Harbour
24-Sept-24	Wheatear	2	Clonmacnoise
29-Apr-23	Wheatear	3	Lough Boora Discovery Park
20-Apr-23	Wheatear	1	Lough Boora Discovery Park
18-Mar-22	Wheatear	1	Undisclosed Location
23-Sept-21	Wheatear	1	Shannon Harbour
01-May-21	Wheatear	4	Lough Boora Discovery Park
21-Apr-21	Wheatear	2	Daingean
21-Apr-21	Wheatear	2	Daingean
01-May-21	Whimbrel	4	Cloghan
07-Mar-21	Whimbrel	1	Tullamore
09-May-25	Whinchat	3	Shannon Callows
02-May-25	Whinchat	2	Shannon Callows
28-Apr-22	Whinchat	2	Clonmacnoise / Cluain Mhic Nóis)
27-Apr-25	White Stork	1	Tullamore
27-Aug-22	White Wagtail	2	Garryhinch
22-Feb-23	White-fronted Goose	80	Brosna Callows
31-Mar-20	White-fronted Goose	100	Tullamore
08-Mar-25	White-tailed Eagle	2	Shannon Callows
26-Dec-24	White-tailed Eagle	1	Lough Boora Discovery Park
07-May-24	White-tailed Eagle	2	Clonmacnoise
05-Feb-24	White-tailed Eagle	3	Little Brosna Callows
03-Feb-24	White-tailed Eagle	2	Little Brosna Callows
06-Jan-24	White-tailed Eagle	1	An Féar Bán
05-Mar-23	White-tailed Eagle	1	Banagher
22-Feb-23	White-tailed Eagle	1	Undisclosed Location
19-Feb-23	White-tailed Eagle	1	Brosna Callows
14-May-25	Whitethroat	1	Lough Boora Discovery Park
13-Jul-24	Whitethroat	1	Little Brosna Callows
09-Feb-25	Whooper Swan	49	Daingean
08-Feb-25	Whooper Swan	48	Croghan Hill
31-Oct-24	Whooper Swan	20	Tullamore
14-Feb-24	Whooper Swan	26	Lough Boora Discovery Park
27-Oct-23	Whooper Swan	30	Little Brosna Callows / Calaí na Brosnaí Bige
18-Feb-23	Whooper Swan	18	Lough Boora Discovery Park
06-Feb-23	Whooper Swan	84	Lough Boora Discovery Park
29-Apr-22	Whooper Swan	1	Daingean
16-Apr-22	Whooper Swan	1	Lough Boora Discovery Park
20-Mar-22	Whooper Swan	13	Lough Boora Discovery Park
17-Mar-22	Whooper Swan	42	Lough Boora Discovery Park
05-Mar-22	Whooper Swan	98	Croghan
21-Feb-22	Whooper Swan	51	Rathangan
08-Feb-22	Whooper Swan	23	Lough Boora Discovery Park
30-Jan-22	Whooper Swan	53	Lough Boora Discovery Park
29-Jan-22	Whooper Swan	34	Lough Boora Discovery Park
29-Dec-21	Whooper Swan	22	Ballycon Bog

28-Dec-21	Whooper Swan	79	Killure
17-Jun-20	Whooper Swan	2	Daingean
09-Dec-19	Whooper Swan	100	Ballycon Wetland
16-Nov-19	Whooper Swan	22	Lough Boora Discovery Park
26-Oct-19	Whooper Swan	7	Lough Boora Discovery Park
09-Apr-23	Willow Warbler	100	Lough Boora Discovery Park
12-Apr-20	Willow Warbler	1	Tullamore
27-Mar-20	Willow Warbler	1	Raheenmore Bog
29-Aug-22	Wood Sandpiper	1	Raheen Lough
07-Apr-23	Woodcock	2	Lough Boora Discovery Park
05-Mar-22	Woodcock	4	Croghan
21-Apr-21	Woodcock	1	Daingean
06-Nov-19	Woodcock	1	Lough Boora Discovery Park
04-Feb-22	Yellowhammer	4	Lough Boora Discovery Park

Table 2 - OFFALY BIRD SPECIES - Table 2 – by Location

Date	Common Name	Number	Location
06-Jan-24	White-tailed Eagle	1	An Fear Bán
03-Nov-20	Barn Owl	1	Ballinagar
25-Jan-24	Great Spotted Woodpecker	1	Ballincor
25-Jan-24	Hen Harrier	1	Ballincor
26-Jan-24	Jack Snipe	9	Ballincor
25-Jan-24	Merlin	2	Ballincor
06-Mar-25	Great Spotted Woodpecker	1	Ballybeg
27-Dec-25	Kingfisher	1	Ballycommon
08-Nov-25	Merlin	1	Ballycommon
02-Oct-22	Osprey	1	Ballycon
18-May-21	Cuckoo	1	Ballycon Bog
20-Oct-22	Osprey	1	Ballycon Bog
18-May-21	Osprey	1	Ballycon Bog
18-May-21	Ringed Plover	1	Ballycon Bog
29-Dec-21	Whooper Swan	22	Ballycon Bog
09-Dec-19	Whooper Swan	100	Ballycon Wetland
02-May-23	Cuckoo	1	Ballycumber
18-Dec-21	Brambling	1	Ballyduff
08-Jul-20	Spotted Redshank	1	Banagher
05-Mar-23	White-tailed Eagle	1	Banagher
12-May-22	Cuckoo	1	Banagher / Beannchar na Sionna
16-Dec-21	Buzzard	1	Birr
17-Jul-21	Buzzard	2	Birr
09-Jul-20	Buzzard	1	Birr
05-Jun-23	Cuckoo	1	Birr
06-Jun-20	Sparrowhawk	1	Birr
22-Oct-21	Swallow	1	Birr
27-Jan-22	Buzzard	1	Birr Castle Demesne
27-Jan-22	Kingfisher	1	Birr Castle Demesne
07-Apr-23	Barn Owl	1	Blueball

22-Feb-23	Pink-footed Goose	6	Brosna Callows
10-Feb-23	Pink-footed Goose	6	Brosna Callows
08-Feb-23	Pink-footed Goose	6	Brosna Callows
22-Feb-23	Snow Goose	1	Brosna Callows
10-Feb-23	Snow Goose	1	Brosna Callows
08-Feb-23	Snow Goose	1	Brosna Callows
21-Dec-22	Snow Goose	1	Brosna Callows
22-Feb-23	White-fronted Goose	80	Brosna Callows
19-Feb-23	White-tailed Eagle	1	Brosna Callows
30-May-21	Cuckoo	1	Cadamstown
15-Apr-20	Barn Owl	1	Cavemount Bog
13-Apr-20	Lesser Redpoll	1	Cavemount Bog
27-Jan-22	Buzzard	1	Charleville Castle
25-May-23	Swift	4	Clara
14-Apr-25	Cuckoo	1	Clara Bog
19-Apr-22	Cuckoo	1	Cloghan
09-Jun-24	Reed Warbler	1	Cloghan
12-Jun-22	Water Rail	3	Cloghan
01-May-21	Whimbrel	4	Cloghan
01-Jun-22	Long-eared Owl	1	Cloneyhurke
02-May-23	Raven	1	Clonmacnois
17-Apr-21	Cuckoo	1	Clonmacnoise
23-Jan-26	Glossy Ibis	1	Clonmacnoise
26-Apr-21	Great White Egret	1	Clonmacnoise
17-Apr-21	Jack Snipe	1	Clonmacnoise
21-Oct-22	Kingfisher	1	Clonmacnoise
21-Oct-22	Mistle Thrush	50	Clonmacnoise
21-Oct-22	Raven	6	Clonmacnoise
24-Sept-24	Wheatear	2	Clonmacnoise
07-May-24	White-tailed Eagle	2	Clonmacnoise
28-Apr-22	Whinchat	2	Clonmacnoise / Cluain Mhic Nóis)
21-Oct-24	Great White Egret	1	Clurraghbee
23-Aug-20	Long-eared Owl	3	Cor More
04-Jun-21	Sparrowhawk	1	Crinkill
05-Mar-22	Northern Lapwing	12	Croghan
05-Mar-22	Whooper Swan	98	Croghan
05-Mar-22	Woodcock	4	Croghan
08-Feb-25	Whooper Swan	48	Croghan Hill
12-Jun-22	Cuckoo	1	Cultree
25-Apr-21	Cuckoo	1	Daingean
03-Nov-20	Kingfisher	1	Daingean
21-Apr-21	Northern Lapwing	6	Daingean
18-Mar-21	Northern Lapwing	5	Daingean
18-Mar-21	Peregrine	2	Daingean
21-Apr-21	Wheatear	2	Daingean
21-Apr-21	Wheatear	2	Daingean
09-Feb-25	Whooper Swan	49	Daingean
29-Apr-22	Whooper Swan	1	Daingean
17-Jun-20	Whooper Swan	2	Daingean

21-Apr-21	Woodcock	1	Daingean
18-Aug-20	Sandwich Tern	1	Derryarkin
29-Apr-21	Cuckoo	1	Derryounce Bog
04-Sept-20	Oystercatcher	1	Drinagh
31-Aug-24	Black-tailed Godwit	5	Drinagh Wetlands
31-Aug-24	Ruff	1	Drinagh Wetlands
10-Aug-21	Buzzard	1	Dunkerrin
11-Dec-24	Great White Egret	2	Ferbane
28-Nov-21	Brambling	1	Garryhinch
05-Dec-21	Great Spotted Woodpecker	1	Garryhinch
27-Aug-22	White Wagtail	2	Garryhinch
22-Feb-21	Brambling	2	Geashill
01-Jul-20	Long-eared Owl	4	Geashill
12-Jan-22	Barn Owl	1	Kilcormac
20-May-25	Cuckoo	1	Killeigh
28-Dec-21	Whooper Swan	79	Killure
02-Apr-23	Great Spotted Woodpecker	1	Kinnity
27-May-20	Great Spotted Woodpecker	1	Knocknamase or Golden Grove Wood
04-May-20	Great Spotted Woodpecker	1	Knocknamase or Golden Grove Wood
02-May-20	Great Spotted Woodpecker	1	Knocknamase or Golden Grove Wood
29-Apr-20	Great Spotted Woodpecker	1	Knocknamase or Golden Grove Wood
14-May-24	Cuckoo	1	Lackagh More
13-Jul-24	Great Spotted Woodpecker	1	Little Brosna Callows
07-Jan-26	Russian White-fronted Goose	2	Little Brosna Callows
13-Jul-24	Spotted Flycatcher	1	Little Brosna Callows
05-Feb-24	White-tailed Eagle	3	Little Brosna Callows
03-Feb-24	White-tailed Eagle	2	Little Brosna Callows
13-Jul-24	Whitethroat	1	Little Brosna Callows
26-Aug-23	Crane	3	Little Brosna Callows / Calaí na Brosnaí Bige
27-Oct-23	Fieldfare	1	Little Brosna Callows / Calaí na Brosnaí Bige
27-Oct-23	Northern Lapwing	100	Little Brosna Callows / Calaí na Brosnaí Bige
27-Oct-23	Whooper Swan	30	Little Brosna Callows / Calaí na Brosnaí Bige
19-Jun-21	Barn Owl	2	Lough Boora Discovery Park
09-Jan-26	Brambling	2	Lough Boora Discovery Park
29-Dec-25	Brambling	1	Lough Boora Discovery Park
26-Dec-25	Brambling	2	Lough Boora Discovery Park
25-Dec-25	Brambling	2	Lough Boora Discovery Park
04-Feb-22	Brambling	1	Lough Boora Discovery Park
29-Sept-25	Buzzard	3	Lough Boora Discovery Park
01-Jun-25	Buzzard	3	Lough Boora Discovery Park
14-Oct-24	Buzzard	1	Lough Boora Discovery Park
06-Sept-24	Buzzard	1	Lough Boora Discovery Park
08-Oct-23	Buzzard	7	Lough Boora Discovery Park
13-Aug-23	Buzzard	4	Lough Boora Discovery Park
09-Apr-23	Buzzard	2	Lough Boora Discovery Park
22-Feb-23	Buzzard	2	Lough Boora Discovery Park
13-Nov-22	Buzzard	2	Lough Boora Discovery Park
05-Nov-22	Buzzard	1	Lough Boora Discovery Park
23-Mar-22	Buzzard	18	Lough Boora Discovery Park

23-Mar-22	Buzzard	15	Lough Boora Discovery Park
15-Mar-22	Buzzard	3	Lough Boora Discovery Park
06-Mar-22	Buzzard	4	Lough Boora Discovery Park
06-Feb-22	Buzzard	3	Lough Boora Discovery Park
05-Feb-22	Buzzard	2	Lough Boora Discovery Park
30-Jan-22	Buzzard	5	Lough Boora Discovery Park
29-Jan-22	Buzzard	2	Lough Boora Discovery Park
05-Jan-22	Buzzard	4	Lough Boora Discovery Park
25-Nov-21	Buzzard	3	Lough Boora Discovery Park
23-Nov-21	Buzzard	4	Lough Boora Discovery Park
23-Nov-21	Buzzard	4	Lough Boora Discovery Park
13-Nov-21	Buzzard	4	Lough Boora Discovery Park
12-Nov-21	Buzzard	4	Lough Boora Discovery Park
22-Sept-21	Buzzard	1	Lough Boora Discovery Park
06-Sept-21	Buzzard	6	Lough Boora Discovery Park
30-Jul-21	Buzzard	5	Lough Boora Discovery Park
29-May-21	Buzzard	5	Lough Boora Discovery Park
26-May-21	Buzzard	2	Lough Boora Discovery Park
12-May-21	Buzzard	1	Lough Boora Discovery Park
14-Sept-20	Buzzard	5	Lough Boora Discovery Park
13-Sept-20	Buzzard	4	Lough Boora Discovery Park
06-Sept-20	Buzzard	5	Lough Boora Discovery Park
30-Aug-20	Buzzard	5	Lough Boora Discovery Park
23-Jan-20	Buzzard	1	Lough Boora Discovery Park
16-Nov-19	Buzzard	1	Lough Boora Discovery Park
28-Oct-19	Buzzard	2	Lough Boora Discovery Park
20-Mar-22	Chiffchaff	4	Lough Boora Discovery Park
23-Nov-19	Chiffchaff	1	Lough Boora Discovery Park
14-Mar-22	Crane	2	Lough Boora Discovery Park
16-May-21	Crane	2	Lough Boora Discovery Park
03-Feb-24	Crossbill	2	Lough Boora Discovery Park
29-May-22	Crossbill	3	Lough Boora Discovery Park
01-May-25	Cuckoo	1	Lough Boora Discovery Park
29-May-22	Cuckoo	1	Lough Boora Discovery Park
07-Jun-21	Cuckoo	2	Lough Boora Discovery Park
29-May-21	Cuckoo	2	Lough Boora Discovery Park
12-May-21	Cuckoo	1	Lough Boora Discovery Park
08-Oct-23	Curlew	100	Lough Boora Discovery Park
10-Sept-23	Curlew	20	Lough Boora Discovery Park
13-Aug-23	Curlew	15	Lough Boora Discovery Park
19-Jun-22	Curlew	2	Lough Boora Discovery Park
25-Nov-21	Curlew	28	Lough Boora Discovery Park
16-Nov-19	Curlew	40	Lough Boora Discovery Park
13-Nov-21	Fieldfare	10	Lough Boora Discovery Park
03-Aug-20	Garden Warbler	1	Lough Boora Discovery Park
09-Sept-25	Glossy Ibis	1	Lough Boora Discovery Park
09-Apr-23	Golden Plover	100	Lough Boora Discovery Park
05-Nov-22	Golden Plover	100	Lough Boora Discovery Park
25-Nov-21	Golden Plover	100	Lough Boora Discovery Park

12-Nov-21	Golden Plover	100	Lough Boora Discovery Park
18-Jul-22	Grasshopper Warbler	1	Lough Boora Discovery Park
24-May-25	Great Spotted Woodpecker	1	Lough Boora Discovery Park
13-Feb-24	Great Spotted Woodpecker	1	Lough Boora Discovery Park
05-May-25	Great White Egret	1	Lough Boora Discovery Park
22-Oct-22	Great White Egret	1	Lough Boora Discovery Park
14-Aug-25	Green Sandpiper	1	Lough Boora Discovery Park
25-Apr-21	Green Sandpiper	1	Lough Boora Discovery Park
13-Apr-26	Grey Partridge	1	Lough Boora Discovery Park
19-Dec-25	Grey Partridge	4	Lough Boora Discovery Park
24-May-25	Grey Partridge	2	Lough Boora Discovery Park
14-May-25	Grey Partridge	1	Lough Boora Discovery Park
22-Apr-25	Grey Partridge	2	Lough Boora Discovery Park
02-Jun-24	Grey Partridge	3	Lough Boora Discovery Park
18-May-24	Grey Partridge	3	Lough Boora Discovery Park
01-May-23	Grey Partridge	2	Lough Boora Discovery Park
29-Apr-23	Grey Partridge	2	Lough Boora Discovery Park
09-Apr-23	Grey Partridge	2	Lough Boora Discovery Park
18-Jul-22	Grey Partridge	2	Lough Boora Discovery Park
01-Jun-22	Grey Partridge	18	Lough Boora Discovery Park
25-May-22	Grey Partridge	2	Lough Boora Discovery Park
16-Apr-22	Grey Partridge	4	Lough Boora Discovery Park
31-Mar-22	Grey Partridge	2	Lough Boora Discovery Park
29-Mar-22	Grey Partridge	2	Lough Boora Discovery Park
15-Mar-22	Grey Partridge	2	Lough Boora Discovery Park
12-Mar-22	Grey Partridge	2	Lough Boora Discovery Park
04-Mar-22	Grey Partridge	6	Lough Boora Discovery Park
29-Jan-22	Grey Partridge	2	Lough Boora Discovery Park
23-Nov-21	Grey Partridge	6	Lough Boora Discovery Park
13-Nov-21	Grey Partridge	1	Lough Boora Discovery Park
07-Jun-21	Grey Partridge	2	Lough Boora Discovery Park
30-Aug-20	Grey Partridge	20	Lough Boora Discovery Park
26-Aug-20	Grey Partridge	8	Lough Boora Discovery Park
03-Aug-20	Grey Partridge	14	Lough Boora Discovery Park
28-Oct-19	Grey Partridge	25	Lough Boora Discovery Park
17-Mar-22	Greylag Goose	23	Lough Boora Discovery Park
30-Jan-22	Greylag Goose	18	Lough Boora Discovery Park
23-Oct-25	Hen Harrier	2	Lough Boora Discovery Park
26-Dec-24	Hen Harrier	1	Lough Boora Discovery Park
14-Feb-24	Hen Harrier	1	Lough Boora Discovery Park
28-Dec-23	Hen Harrier	1	Lough Boora Discovery Park
22-Feb-23	Hen Harrier	2	Lough Boora Discovery Park
18-Feb-23	Hen Harrier	1	Lough Boora Discovery Park
06-Feb-23	Hen Harrier	1	Lough Boora Discovery Park
13-Nov-22	Hen Harrier	2	Lough Boora Discovery Park
03-Nov-22	Hen Harrier	1	Lough Boora Discovery Park
10-Sept-22	Hen Harrier	2	Lough Boora Discovery Park
23-Mar-22	Hen Harrier	1	Lough Boora Discovery Park
20-Mar-22	Hen Harrier	1	Lough Boora Discovery Park

17-Mar-22	Hen Harrier	1	Lough Boora Discovery Park
15-Mar-22	Hen Harrier	3	Lough Boora Discovery Park
14-Mar-22	Hen Harrier	2	Lough Boora Discovery Park
12-Mar-22	Hen Harrier	1	Lough Boora Discovery Park
04-Mar-22	Hen Harrier	1	Lough Boora Discovery Park
25-Feb-22	Hen Harrier	1	Lough Boora Discovery Park
06-Feb-22	Hen Harrier	1	Lough Boora Discovery Park
05-Feb-22	Hen Harrier	1	Lough Boora Discovery Park
04-Feb-22	Hen Harrier	2	Lough Boora Discovery Park
30-Jan-22	Hen Harrier	3	Lough Boora Discovery Park
29-Jan-22	Hen Harrier	2	Lough Boora Discovery Park
21-Jan-22	Hen Harrier	2	Lough Boora Discovery Park
05-Jan-22	Hen Harrier	3	Lough Boora Discovery Park
01-Jan-22	Hen Harrier	3	Lough Boora Discovery Park
30-Dec-21	Hen Harrier	2	Lough Boora Discovery Park
25-Nov-21	Hen Harrier	2	Lough Boora Discovery Park
23-Nov-21	Hen Harrier	2	Lough Boora Discovery Park
22-Sept-21	Hen Harrier	1	Lough Boora Discovery Park
06-Sept-21	Hen Harrier	1	Lough Boora Discovery Park
30-Jul-21	Hen Harrier	2	Lough Boora Discovery Park
26-May-21	Hen Harrier	1	Lough Boora Discovery Park
14-Sept-20	Hen Harrier	1	Lough Boora Discovery Park
13-Sept-20	Hen Harrier	2	Lough Boora Discovery Park
06-Sept-20	Hen Harrier	4	Lough Boora Discovery Park
26-Aug-20	Hen Harrier	1	Lough Boora Discovery Park
03-Aug-20	Hen Harrier	1	Lough Boora Discovery Park
04-Mar-20	Hen Harrier	2	Lough Boora Discovery Park
17-Nov-19	Hen Harrier	2	Lough Boora Discovery Park
16-Nov-19	Hen Harrier	1	Lough Boora Discovery Park
28-Oct-19	Hen Harrier	1	Lough Boora Discovery Park
26-Oct-19	Hen Harrier	1	Lough Boora Discovery Park
22-Oct-19	Hen Harrier	1	Lough Boora Discovery Park
09-Jan-26	Jack Snipe	1	Lough Boora Discovery Park
29-Sept-25	Kestrel	1	Lough Boora Discovery Park
13-Nov-22	Kestrel	1	Lough Boora Discovery Park
05-Nov-22	Kestrel	1	Lough Boora Discovery Park
06-Feb-22	Kestrel	1	Lough Boora Discovery Park
29-Jan-22	Kestrel	1	Lough Boora Discovery Park
05-Jan-22	Kestrel	1	Lough Boora Discovery Park
25-Nov-21	Kestrel	2	Lough Boora Discovery Park
23-Nov-21	Kestrel	1	Lough Boora Discovery Park
12-Nov-21	Kestrel	1	Lough Boora Discovery Park
06-Sept-21	Kestrel	1	Lough Boora Discovery Park
14-Sept-20	Kestrel	2	Lough Boora Discovery Park
13-Sept-20	Kestrel	2	Lough Boora Discovery Park
06-Sept-20	Kestrel	3	Lough Boora Discovery Park
30-Aug-20	Kestrel	3	Lough Boora Discovery Park
04-Mar-20	Kestrel	2	Lough Boora Discovery Park
10-Sept-23	Kingfisher	1	Lough Boora Discovery Park

18-Jul-21	Kingfisher	1	Lough Boora Discovery Park
29-Sept-25	Little Egret	1	Lough Boora Discovery Park
29-Dec-25	Marsh Harrier	1	Lough Boora Discovery Park
29-Sept-25	Marsh Harrier	1	Lough Boora Discovery Park
22-Sept-25	Marsh Harrier	1	Lough Boora Discovery Park
16-Mar-25	Marsh Harrier	1	Lough Boora Discovery Park
17-Oct-24	Marsh Harrier	1	Lough Boora Discovery Park
18-Feb-23	Marsh Harrier	1	Lough Boora Discovery Park
23-Mar-22	Marsh Harrier	1	Lough Boora Discovery Park
26-May-21	Marsh Harrier	1	Lough Boora Discovery Park
10-Sept-20	Marsh Harrier	1	Lough Boora Discovery Park
06-Sept-20	Marsh Harrier	1	Lough Boora Discovery Park
30-Aug-20	Marsh Harrier	1	Lough Boora Discovery Park
23-Nov-19	Marsh Harrier	1	Lough Boora Discovery Park
29-May-21	Meadow Pipit	4	Lough Boora Discovery Park
27-Dec-25	Merlin	1	Lough Boora Discovery Park
26-Dec-25	Merlin	1	Lough Boora Discovery Park
19-Dec-25	Merlin	1	Lough Boora Discovery Park
16-Mar-25	Merlin	1	Lough Boora Discovery Park
22-Feb-23	Merlin	1	Lough Boora Discovery Park
05-Nov-22	Merlin	1	Lough Boora Discovery Park
23-Mar-22	Merlin	1	Lough Boora Discovery Park
15-Mar-22	Merlin	1	Lough Boora Discovery Park
05-Feb-22	Merlin	1	Lough Boora Discovery Park
04-Feb-22	Merlin	1	Lough Boora Discovery Park
30-Jan-22	Merlin	1	Lough Boora Discovery Park
01-Jan-22	Merlin	2	Lough Boora Discovery Park
23-Nov-21	Merlin	2	Lough Boora Discovery Park
13-Nov-21	Merlin	2	Lough Boora Discovery Park
18-Oct-21	Merlin	1	Lough Boora Discovery Park
04-Mar-20	Merlin	1	Lough Boora Discovery Park
20-Feb-20	Merlin	1	Lough Boora Discovery Park
27-Oct-19	Merlin	1	Lough Boora Discovery Park
23-Mar-22	Northern Harrier	1	Lough Boora Discovery Park
17-Mar-22	Northern Harrier	1	Lough Boora Discovery Park
15-Mar-22	Northern Harrier	1	Lough Boora Discovery Park
14-Mar-22	Northern Harrier	1	Lough Boora Discovery Park
12-Mar-22	Northern Harrier	1	Lough Boora Discovery Park
06-Mar-22	Northern Harrier	1	Lough Boora Discovery Park
04-Mar-22	Northern Harrier	1	Lough Boora Discovery Park
02-Mar-22	Northern Harrier	1	Lough Boora Discovery Park
27-Feb-22	Northern Harrier	1	Lough Boora Discovery Park
26-Feb-22	Northern Harrier	1	Lough Boora Discovery Park
25-Feb-22	Northern Harrier	1	Lough Boora Discovery Park
22-Feb-22	Northern Harrier	1	Lough Boora Discovery Park
21-Feb-22	Northern Harrier	1	Lough Boora Discovery Park
08-Feb-22	Northern Harrier	1	Lough Boora Discovery Park
06-Feb-22	Northern Harrier	1	Lough Boora Discovery Park
04-Feb-22	Northern Harrier	1	Lough Boora Discovery Park

01-Feb-22	Northern Harrier	1	Lough Boora Discovery Park
30-Jan-22	Northern Harrier	1	Lough Boora Discovery Park
29-Jan-22	Northern Harrier	1	Lough Boora Discovery Park
22-Jan-22	Northern Harrier	1	Lough Boora Discovery Park
21-Jan-22	Northern Harrier	1	Lough Boora Discovery Park
18-Jan-22	Northern Harrier	1	Lough Boora Discovery Park
08-Jan-22	Northern Harrier	1	Lough Boora Discovery Park
05-Jan-22	Northern Harrier	1	Lough Boora Discovery Park
03-Jan-22	Northern Harrier	1	Lough Boora Discovery Park
02-Jan-22	Northern Harrier	1	Lough Boora Discovery Park
01-Jan-22	Northern Harrier	1	Lough Boora Discovery Park
31-Dec-21	Northern Harrier	1	Lough Boora Discovery Park
30-Dec-21	Northern Harrier	1	Lough Boora Discovery Park
28-Dec-21	Northern Harrier	1	Lough Boora Discovery Park
26-Dec-21	Northern Harrier	1	Lough Boora Discovery Park
05-Dec-21	Northern Harrier	1	Lough Boora Discovery Park
21-Nov-21	Northern Harrier	1	Lough Boora Discovery Park
20-Nov-21	Northern Harrier	1	Lough Boora Discovery Park
19-Nov-21	Northern Harrier	1	Lough Boora Discovery Park
18-Nov-21	Northern Harrier	1	Lough Boora Discovery Park
15-Nov-21	Northern Harrier	1	Lough Boora Discovery Park
14-Nov-21	Northern Harrier	1	Lough Boora Discovery Park
13-Nov-21	Northern Harrier	3	Lough Boora Discovery Park
12-Nov-21	Northern Harrier	1	Lough Boora Discovery Park
01-Jun-25	Northern Lapwing	100	Lough Boora Discovery Park
31-Jul-24	Northern Lapwing	50	Lough Boora Discovery Park
29-May-21	Northern Lapwing	10	Lough Boora Discovery Park
22-Oct-22	Osprey	1	Lough Boora Discovery Park
20-Sept-22	Osprey	1	Lough Boora Discovery Park
10-Sept-22	Osprey	1	Lough Boora Discovery Park
05-Jan-22	Peregrine	1	Lough Boora Discovery Park
28-Dec-21	Peregrine	1	Lough Boora Discovery Park
08-Oct-23	Raven	5	Lough Boora Discovery Park
22-Feb-23	Raven	1	Lough Boora Discovery Park
25-Nov-21	Raven	3	Lough Boora Discovery Park
06-Sept-21	Raven	3	Lough Boora Discovery Park
29-May-21	Raven	1	Lough Boora Discovery Park
13-Sept-20	Raven	6	Lough Boora Discovery Park
06-Sept-20	Raven	6	Lough Boora Discovery Park
03-Aug-20	Raven	12	Lough Boora Discovery Park
16-Nov-19	Raven	1	Lough Boora Discovery Park
26-Sept-20	Red Kite	1	Lough Boora Discovery Park
20-Apr-25	Russian White-fronted Goose	1	Lough Boora Discovery Park
01-Jun-25	Sand Martin	100	Lough Boora Discovery Park
21-Mar-23	Sand Martin	6	Lough Boora Discovery Park
23-Nov-21	Short-eared Owl	1	Lough Boora Discovery Park
06-Nov-19	Short-eared Owl	1	Lough Boora Discovery Park
22-Oct-19	Short-eared Owl	1	Lough Boora Discovery Park
05-Nov-22	Skylark	20	Lough Boora Discovery Park

29-May-21	Skylark	3	Lough Boora Discovery Park
05-Feb-22	Sparrowhawk	1	Lough Boora Discovery Park
30-Jan-22	Sparrowhawk	1	Lough Boora Discovery Park
05-Jan-22	Sparrowhawk	1	Lough Boora Discovery Park
23-Nov-21	Sparrowhawk	1	Lough Boora Discovery Park
13-Sept-20	Sparrowhawk	1	Lough Boora Discovery Park
06-Sept-20	Sparrowhawk	1	Lough Boora Discovery Park
30-Aug-20	Sparrowhawk	2	Lough Boora Discovery Park
18-Jun-24	Spotted Flycatcher	5	Lough Boora Discovery Park
18-Jul-22	Spotted Flycatcher	1	Lough Boora Discovery Park
22-Feb-23	Stock Dove	2	Lough Boora Discovery Park
23-Mar-22	Stock Dove	26	Lough Boora Discovery Park
17-Mar-22	Stock Dove	1	Lough Boora Discovery Park
04-Feb-22	Stock Dove	17	Lough Boora Discovery Park
30-Jan-22	Stock Dove	28	Lough Boora Discovery Park
13-Nov-21	Stock Dove	50	Lough Boora Discovery Park
12-Nov-21	Stock Dove	63	Lough Boora Discovery Park
04-Mar-20	Stock Dove	1	Lough Boora Discovery Park
01-Jun-25	Swift	50	Lough Boora Discovery Park
18-May-24	Swift	1	Lough Boora Discovery Park
24-May-25	Water Rail	1	Lough Boora Discovery Park
20-Mar-22	Water Rail	1	Lough Boora Discovery Park
07-Jun-21	Water Rail	1	Lough Boora Discovery Park
29-Apr-23	Wheatear	3	Lough Boora Discovery Park
20-Apr-23	Wheatear	1	Lough Boora Discovery Park
01-May-21	Wheatear	4	Lough Boora Discovery Park
26-Dec-24	White-tailed Eagle	1	Lough Boora Discovery Park
14-May-25	Whitethroat	1	Lough Boora Discovery Park
14-Feb-24	Whooper Swan	26	Lough Boora Discovery Park
18-Feb-23	Whooper Swan	18	Lough Boora Discovery Park
06-Feb-23	Whooper Swan	84	Lough Boora Discovery Park
16-Apr-22	Whooper Swan	1	Lough Boora Discovery Park
20-Mar-22	Whooper Swan	13	Lough Boora Discovery Park
17-Mar-22	Whooper Swan	42	Lough Boora Discovery Park
08-Feb-22	Whooper Swan	23	Lough Boora Discovery Park
30-Jan-22	Whooper Swan	53	Lough Boora Discovery Park
29-Jan-22	Whooper Swan	34	Lough Boora Discovery Park
16-Nov-19	Whooper Swan	22	Lough Boora Discovery Park
26-Oct-19	Whooper Swan	7	Lough Boora Discovery Park
09-Apr-23	Willow Warbler	100	Lough Boora Discovery Park
07-Apr-23	Woodcock	2	Lough Boora Discovery Park
06-Nov-19	Woodcock	1	Lough Boora Discovery Park
04-Feb-22	Yellowhammer	4	Lough Boora Discovery Park
15-Nov-21	Northern Harrier	1	Lough Boora Park
24-Jan-22	Barn Owl	1	M6
16-Apr-23	Buzzard	5	M7
16-Apr-23	Kestrel	2	M7
23-May-24	Buzzard	2	Moneygall
07-Aug-22	Buzzard	1	Moneygall

15-Aug-21	Buzzard	1	Moneygall
04-Jun-21	Buzzard	1	N52
09-Apr-23	Blackcap	4	Pollagh
02-Jul-22	Green Sandpiper	3	Ragheen Lake
02-Jul-22	Redshank	1	Ragheen Lake
22-Feb-22	Green Sandpiper	3	Ragheen Lough
16-Dec-24	Great White Egret	1	Raheen Lough
01-Nov-24	Great White Egret	1	Raheen Lough
22-Mar-23	Green Sandpiper	1	Raheen Lough
29-Aug-22	Green Sandpiper	5	Raheen Lough
29-Jul-22	Green Sandpiper	3	Raheen Lough
05-May-23	Greenshank	2	Raheen Lough
09-Mar-23	Pintail	2	Raheen Lough
01-Sept-22	Ruff	2	Raheen Lough
29-Aug-22	Wood Sandpiper	1	Raheen Lough
27-Mar-20	Chiffchaff	2	Raheenmore Bog
27-Mar-20	Willow Warbler	1	Raheenmore Bog
21-Feb-22	Whooper Swan	51	Rathangan
27-Dec-24	Great White Egret	1	Shannon Bridge
31-Jul-20	Osprey	1	Shannon Bridge
11-Mar-25	Sand Martin	6	Shannon Bridge
08-Mar-25	Merlin	1	Shannon Callows
10-Mar-22	Ringed Plover	5	Shannon Callows
09-May-25	Whinchat	3	Shannon Callows
02-May-25	Whinchat	2	Shannon Callows
08-Mar-25	White-tailed Eagle	2	Shannon Callows
19-Oct-25	American Golden Plover	1	Shannon Harbour
15-Oct-25	American Golden Plover	1	Shannon Harbour
14-Oct-25	American Golden Plover	1	Shannon Harbour
24-Sept-24	Great Spotted Woodpecker	1	Shannon Harbour
09-Sept-25	Green Sandpiper	1	Shannon Harbour
08-Nov-22	Oystercatcher	1	Shannon Harbour
14-Oct-25	Ruff	2	Shannon Harbour
09-Sept-25	Wheatear	1	Shannon Harbour
08-Apr-25	Wheatear	1	Shannon Harbour
23-Sept-21	Wheatear	1	Shannon Harbour
31-Mar-22	Sand Martin	11	Shannonbridge / Droichead na Sionainne
02-May-22	Cuckoo	1	Sharavogue
06-May-25	Cuckoo	1	Slieve Bloom Mountains
29-May-22	Cuckoo	4	Slieve Bloom Mountains
02-May-21	Cuckoo	1	Slieve Bloom Mountains
02-Jul-24	Red Grouse	1	Slieve Bloom Mountains
02-May-21	Red Grouse	3	Slieve Bloom Mountains
12-Nov-21	Green Sandpiper	2	Sullane Delta
28-May-23	Barn Owl	1	Tullamore
14-Dec-22	Barn Owl	1	Tullamore
21-Nov-21	Buzzard	1	Tullamore
18-Mar-22	Chiffchaff	1	Tullamore
21-Mar-21	Chiffchaff	1	Tullamore

12-May-20	Cuckoo	1	Tullamore
09-Jan-21	Curlew	2	Tullamore
31-Dec-20	Great Spotted Woodpecker	1	Tullamore
23-Oct-24	Great White Egret	1	Tullamore
21-Nov-21	Kestrel	1	Tullamore
21-Jun-21	Red Kite	1	Tullamore
06-Apr-20	Swallow	1	Tullamore
07-Mar-21	Whimbrel	1	Tullamore
27-Apr-25	White Stork	1	Tullamore
31-Mar-20	White-fronted Goose	100	Tullamore
31-Oct-24	Whooper Swan	20	Tullamore
12-Apr-20	Willow Warbler	1	Tullamore
02-Jun-24	Crane	2	Turan wetlands
02-Jun-24	Cuckoo	3	Turan wetlands
01-Jun-25	Grasshopper Warbler	1	Turraun
27-Nov-25	Great White Egret	1	Turraun Wetland
10-May-25	Reed Warbler	1	Turraun Wetlands
27-Dec-21	Brambling	1	Undisclosed Location
18-Mar-22	Chiffchaff	1	Undisclosed Location
22-May-22	Crane	1	Undisclosed Location
18-Mar-22	Crane	1	Undisclosed Location
12-May-22	Curlew	1	Undisclosed Location
15-Apr-20	Curlew	2	Undisclosed Location
03-Jul-21	Red-necked Phalarope	2	Undisclosed Location
29-Jun-21	Red-necked Phalarope	1	Undisclosed Location
12-Jun-22	Redshank	2	Undisclosed Location
18-Mar-22	Wheatear	1	Undisclosed Location
22-Feb-23	White-tailed Eagle	1	Undisclosed Location
21-Feb-21	Brambling	2	Walsh Island

Table 3 - TIPPERARY BIRD SPECIES – by species

Date	Common Name	Number	Location
16-Nov-24	American Wigeon	1	Ashton's Callow
29-Mar-26	Barn Owl	1	Lorrha
07-Mar-26	Barn Owl	1	Terryglass
27-Dec-24	Barn Owl	1	Horse and Jockey
26-Oct-24	Barn Owl	1	Lisballyard
28-Feb-23	Barn Owl	1	Lorrha
21-Jan-22	Barn Owl	1	Lorrha
08-Jan-21	Barn Owl	1	Lorrha
13-Nov-20	Barn Owl	1	M8
17-Nov-21	Barnacle Goose	4	Ashton's Callow
10-Apr-22	Blackcap	1	Thurles
21-Mar-22	Black-tailed Godwit	2	Thurles
10-Mar-22	Black-tailed Godwit	100	Little Brosna Callows
22-Jan-24	Brambling	1	Thurles
26-Feb-22	Brambling	2	Thurles
13-Feb-22	Brambling	1	Thurles
23-Jan-22	Brambling	2	Roscrea
04-Nov-21	Brambling	1	Clonmel
05-Sept-25	Buzzard	1	Birdhill
02-Aug-25	Buzzard	2	Galtee Mountains
02-Aug-25	Buzzard	3	Holycross
07-May-25	Buzzard	1	Galtee Mountains
16-Mar-25	Buzzard	4	Cashel
12-Jan-25	Buzzard	1	Ballymoreen
11-Jan-25	Buzzard	1	Loughnavatta
06-Oct-24	Buzzard	1	Holycross
13-Aug-24	Buzzard	1	Golden
06-Aug-24	Buzzard	4	Golden
19-Jul-24	Buzzard	1	Castlelough Forest
23-Jun-24	Buzzard	2	Templederry
24-Apr-24	Buzzard	1	Cashel
20-Apr-24	Buzzard	1	Cashel
03-Apr-24	Buzzard	2	Golden
08-Mar-24	Buzzard	1	Cashel
16-Jan-24	Buzzard	1	Cashel
29-Oct-23	Buzzard	2	Holycross
29-Jun-23	Buzzard	3	Cashel
23-May-23	Buzzard	1	Thurles
16-May-23	Buzzard	3	M8
05-May-23	Buzzard	2	Cashel
05-May-23	Buzzard	1	Cashel
10-Sept-22	Buzzard	3	Lorrha
23-Aug-22	Buzzard	1	Cahir
23-Aug-22	Buzzard	1	Golden
25-Jul-22	Buzzard	2	Thurles
13-Jul-22	Buzzard	2	Bansha
28-Jun-22	Buzzard	2	Golden

28-Jun-22	Buzzard	2	Cashel
22-Jun-22	Buzzard	1	Kilfeacle
11-Jun-22	Buzzard	1	Nenagh
13-Apr-22	Buzzard	1	Kilfeacle
04-Mar-22	Buzzard	1	Roscrea
04-Mar-22	Buzzard	2	Nenagh
18-Sept-21	Buzzard	5	Golden
09-Sept-21	Buzzard	1	Bansha
25-Jul-21	Buzzard	2	Thurles
07-Jul-21	Buzzard	1	Roscrea
08-Jun-21	Buzzard	2	Cappawhite
05-Jun-21	Buzzard	2	Roscrea
05-Jun-21	Buzzard	2	Moneygall
05-Jun-21	Buzzard	2	Nenagh
26-May-21	Buzzard	1	Roscrea
02-Apr-21	Buzzard	1	Cashel
19-Mar-21	Buzzard	9	Thurles
28-Feb-21	Buzzard	1	Thurles
15-Feb-21	Buzzard	1	Cashel
13-Feb-21	Buzzard	1	Dundrum
01-Feb-22	Cattle Egret	1	N62
18-Mar-22	Chiffchaff	1	Thurles
17-Mar-22	Chiffchaff	1	Thurles
25-Jul-21	Common Sandpiper	1	Nenagh
15-Apr-26	Cormorant	7	Cashel
29-Nov-25	Cormorant	7	Thurles
04-Apr-25	Cormorant	8	Cashel
20-Mar-26	Crane	1	Undisclosed Location
10-Jul-24	Crane	1	Undisclosed Location
10-May-24	Crane	3	Ashton Callows
22-Apr-24	Crane	1	Ashton Callows
07-May-25	Cuckoo	3	Galtee Mountains
01-May-25	Cuckoo	1	Birr
28-Apr-25	Cuckoo	1	Lorrha
27-Apr-25	Cuckoo	2	Galtee Mountains
25-Apr-25	Cuckoo	1	Kilcommon
04-Apr-25	Cuckoo	1	Rearcross
25-Apr-24	Cuckoo	1	Galtee Mountains
20-Apr-24	Cuckoo	1	Lisheen
31-May-23	Cuckoo	1	Lorrha
30-Apr-23	Cuckoo	2	Galtee Mountains
13-May-22	Cuckoo	1	Littleton
28-Apr-22	Cuckoo	1	Littleton
17-Apr-22	Cuckoo	1	Hollyford Hills
08-Jun-21	Cuckoo	3	Cappawhite
18-Apr-21	Cuckoo	1	Annaholty
18-Dec-23	Dunlin	20	Thurles
24-Jan-21	Dunlin	1	Ballymacegan
10-Apr-22	Gadwall	2	Thurles

15-Feb-21	Gadwall	7	Thurles
27-Feb-24	Garganey	2	Thurles
04-Jan-24	Garganey	1	Nenagh
21-Mar-22	Garganey	1	Thurles
20-Mar-22	Garganey	1	Thurles
15-Feb-21	Garganey	1	Thurles
06-Feb-21	Garganey	1	Thurles
31-Dec-24	Glossy Ibis	1	Ashton Callows
06-May-23	Glossy Ibis	1	Shannon Callows
19-May-25	Golden Oriole	1	Cloughtaney
05-Oct-25	Golden Plover	70	Galtee Mountains
23-Apr-23	Grasshopper Warbler	1	Shannon Callows
26-Mar-26	Great Black-backed Gull	2	Roscrea
05-Dec-23	Great Crested Grebe	1	Golden
21-Dec-20	Great Northern Diver	1	Drommeer
10-Dec-20	Great Northern Diver	1	Drumineer
17-Jan-26	Great Spotted Woodpecker	1	Holycross
02-Jul-25	Great Spotted Woodpecker	2	Cahir
10-Jun-25	Great Spotted Woodpecker	2	Cahir
27-May-25	Great Spotted Woodpecker	1	Cahir
12-May-25	Great Spotted Woodpecker	1	Knockmealdown Mountains
12-Apr-25	Great Spotted Woodpecker	1	Commonaline
16-Jan-25	Great Spotted Woodpecker	1	Carrick-on-Suir
04-Oct-24	Great Spotted Woodpecker	1	Ballymacegan
18-May-24	Great Spotted Woodpecker	2	Dundrum
15-May-24	Great Spotted Woodpecker	1	Cloughjordan / Cloghjordan
29-Feb-24	Great Spotted Woodpecker	1	Thurles
05-Dec-23	Great Spotted Woodpecker	1	Cahir
05-Sept-23	Great Spotted Woodpecker	1	Cahir
02-Jul-23	Great Spotted Woodpecker	2	Roscrea
06-Jun-23	Great Spotted Woodpecker	1	Littleton / An Baile Dháith
30-Jan-22	Great Spotted Woodpecker	1	Aherlow
28-Jul-21	Great Spotted Woodpecker	1	Birdhill
30-Apr-21	Great Spotted Woodpecker	2	Slieveardagh Hills
26-Apr-21	Great Spotted Woodpecker	1	Slieveardagh Hills
31-Dec-20	Great Spotted Woodpecker	1	Ballyhourigan Wood
09-Oct-25	Great White Egret	1	Templetouhy
28-Sept-25	Great White Egret	1	Ashton's Callow
26-Nov-24	Great White Egret	1	Templetouhy
09-Nov-23	Great White Egret	1	Templetuohy Bog
10-Jul-25	Green Sandpiper	1	Borrisokane
05-Dec-23	Green Sandpiper	1	Golden
02-Jan-23	Green Sandpiper	1	Graigue
18-Dec-22	Green Sandpiper	1	Graigue
09-Sept-22	Green Sandpiper	1	Thurles
02-Sept-22	Green Sandpiper	4	Holycross
19-Feb-22	Green Sandpiper	1	Longfordpass
31-Jan-22	Green Sandpiper	1	Thurles
03-Aug-21	Green Sandpiper	1	Nenagh

21-Jan-21	Green Sandpiper	1	Graigue
18-Jan-21	Green Sandpiper	1	Tipperary
11-Jan-21	Green Sandpiper	1	Urlingford
11-Dec-24	Greenshank	1	Thurles
01-Sept-24	Greenshank	2	Longfordpass
04-Jan-22	Greenshank	1	Ashton's Callow
07-Jan-21	Greenshank	1	Thurles
22-Feb-23	Green-winged Teal	1	Inishlounaght
08-Mar-21	Green-winged Teal	1	Thurles
28-Feb-21	Green-winged Teal	1	Thurles
21-Feb-21	Green-winged Teal	1	Thurles
19-Jan-21	Green-winged Teal	1	Thurles
16-Jan-24	Hen Harrier	1	Shannon Callows
29-Jun-21	Hen Harrier	1	Galtee Mountains
26-Mar-21	Hen Harrier	1	Thurles
17-Nov-20	Hen Harrier	1	Ballymacegan
13-Nov-20	Hen Harrier	1	Ballymacegan
11-Apr-25	Hoopoe	1	Garrykennedy
18-Apr-24	House Martin	2	Thurles
23-May-23	House Martin	30	Thurles
13-Apr-22	House Martin	4	Golden
02-May-21	House Martin	2	Cashel
20-Oct-23	Jack Snipe	1	Shannon Callows
09-Dec-22	Jack Snipe	1	Ballymacegan
14-Feb-22	Jack Snipe	1	Knockmealdown Mountains
27-Nov-24	Jay	2	Cashel
19-Oct-24	Jay	2	Cashel
16-May-22	Jay	1	Carrick-on-Suir
18-Sept-25	Kestrel	1	Cashel
02-Aug-25	Kestrel	1	Galtee Mountains
31-Jul-25	Kestrel	1	Golden
19-May-25	Kestrel	1	Cashel
07-May-25	Kestrel	1	Galtee Mountains
06-Oct-24	Kestrel	1	Holycross
10-Sept-24	Kestrel	1	Knockmealdown Mountains
13-Aug-24	Kestrel	1	Golden
06-Aug-24	Kestrel	1	Golden
23-Jun-24	Kestrel	1	Templederry
20-Apr-24	Kestrel	1	Cashel
09-Apr-24	Kestrel	1	Cashel
08-Apr-24	Kestrel	1	Cashel
07-Apr-24	Kestrel	1	Cashel
15-Oct-23	Kestrel	1	Galtee Mountains
06-Oct-23	Kestrel	1	Cashel
12-Sept-23	Kestrel	2	Golden
30-Apr-23	Kestrel	1	Galtee Mountains
23-Aug-22	Kestrel	1	Cahir
23-Aug-22	Kestrel	1	Golden
23-Aug-22	Kestrel	1	Littleton

07-Aug-22	Kestrel	1	Birdhill
25-Jul-22	Kestrel	1	Thurles
28-Jun-22	Kestrel	1	Golden
11-Jun-22	Kestrel	1	Nenagh
07-Jun-22	Kestrel	1	Nenagh
28-Apr-22	Kestrel	1	Littleton
04-Apr-22	Kestrel	1	Cashel
15-Aug-21	Kestrel	1	Nenagh
10-Aug-21	Kestrel	1	Carrigatogher
10-Aug-21	Kestrel	1	Roscrea
22-Jul-21	Kestrel	1	Thurles
22-Jul-21	Kestrel	1	Horse and Jockey
07-Jul-21	Kestrel	1	Nenagh
05-Jun-21	Kestrel	1	Nenagh
02-Jun-21	Kestrel	1	Bansha
15-Apr-21	Kestrel	1	Cashel
05-Sept-25	Kingfisher	1	Birdhill
21-Nov-24	Kingfisher	1	Cashel
23-Oct-24	Kingfisher	1	Cahir
15-Oct-24	Kingfisher	1	Cahir
18-Sept-24	Kingfisher	1	Thurles
13-Aug-24	Kingfisher	1	Cahir
15-Aug-23	Kingfisher	1	Cahir
27-Jun-23	Kingfisher	1	Cahir
16-May-23	Kingfisher	1	Cahir
04-Oct-22	Kingfisher	2	Cahir
21-Mar-22	Knot	1	Thurles
26-Mar-26	Lesser Black-backed Gull	100	Roscrea
13-Feb-26	Little Egret	8	Cashel
23-Feb-24	Little Egret	6	Cashel
11-Feb-24	Little Egret	17	Thurles
15-Dec-23	Little Egret	10	Cashel
20-Oct-23	Little Egret	1	Portumna Forest Park
29-Dec-20	Little Egret	7	Cashel
09-Jul-24	Little Ringed Plover	6	Undisclosed Location
16-Apr-21	Little Ringed Plover	2	Borrisokane
08-Jul-22	Long-eared Owl	4	Ballymacegan
29-Apr-22	Long-eared Owl	1	Lorrha
17-Mar-24	Marsh Harrier	1	Pat Reddan's Lake
07-Dec-22	Marsh Harrier	1	Thurles
09-Sept-22	Marsh Harrier	1	Thurles
08-Sept-22	Marsh Harrier	1	Thurles
23-Feb-24	Merlin	1	Thurles
20-Nov-20	Merlin	1	Undisclosed Location
11-Jan-26	Northern Lapwing	100	Nenagh
23-May-23	Northern Lapwing	5	Thurles
01-Sept-25	Osprey	2	Newcastle
13-Jul-24	Osprey	1	Cahir
14-Mar-26	Peregrine	1	Cashel

01-Mar-26	Peregrine	1	Cashel
17-Feb-26	Peregrine	1	Cashel
25-May-25	Peregrine	1	Cashel
04-Apr-25	Peregrine	1	Cashel
06-Aug-24	Peregrine	1	Golden
11-May-24	Peregrine	1	Cashel
07-May-24	Peregrine	1	Golden
29-Apr-24	Peregrine	1	Cashel
24-Apr-24	Peregrine	1	Cashel
08-Apr-24	Peregrine	1	Undisclosed Location
07-Apr-24	Peregrine	1	Undisclosed Location
08-Mar-24	Peregrine	1	Undisclosed Location
23-Feb-24	Peregrine	1	Cashel
15-Oct-23	Peregrine	1	Galtee Mountains
12-Jul-23	Peregrine	1	Nenagh
11-Jul-23	Peregrine	1	Cahir
21-May-23	Peregrine	1	Toomevara / Tuaim Ui Mheara
30-Apr-23	Peregrine	2	Galtee Mountains
01-Jul-22	Peregrine	1	Undisclosed Location
17-Nov-20	Peregrine	1	Ballymacegan
29-Oct-21	Pink-footed Goose	3	Parteen Weir
22-Oct-21	Pink-footed Goose	3	Ashton's Callow
10-May-24	Pintail	1	Ashton Callows
11-Jan-26	Raven	2	Nenagh
06-Oct-24	Raven	1	Holycross
18-Jul-24	Raven	2	Rathanny
07-May-24	Raven	2	Golden
03-Apr-24	Raven	2	Golden
24-Dec-23	Raven	2	Holycross
05-May-23	Raven	2	Cashel
11-Aug-22	Raven	1	Oola
28-Jun-22	Raven	6	Cahir
28-Jun-22	Raven	1	Golden
13-Apr-22	Raven	1	Kilfeacle
13-Apr-22	Raven	2	Cashel
04-Apr-22	Raven	2	Cashel
21-Oct-21	Raven	30	Cashel
22-Aug-21	Raven	1	Slievenamon / Sliabh na mBan
29-Jan-21	Raven	2	Cashel
19-Dec-20	Raven	3	Cashel
17-Sept-25	Red Kite	1	Cashel
17-May-25	Red Kite	1	M8
10-Sept-24	Red-breasted Goose	1	Undisclosed Location
01-Apr-26	Red-necked Grebe	1	Nenagh
15-Oct-23	Redstart	1	Galtee Mountains
18-Jun-24	Reed Warbler	1	Templetuohy
23-Oct-22	Ring Ouzel	2	Undisclosed Location
04-Apr-24	Ring-necked Duck	4	Ashton Callows
27-Feb-24	Ring-necked Duck	3	Ashton Callows

11-Apr-23	Ruddy Shelduck	1	Ashton Callows
18-Jan-26	Ruff	1	Thurles
11-Dec-24	Ruff	1	Thurles
18-Dec-23	Ruff	1	Thurles
11-Apr-23	Ruff	4	Ashton Callows
25-Oct-21	Ruff	2	Clonmacnoise
25-Oct-21	Ruff	3	Ashton's Callow
13-Aug-21	Ruff	1	Nenagh
16-Apr-21	Ruff	1	Borrisokane
02-Aug-25	Sand Martin	22	Galtee Mountains
27-Apr-25	Sand Martin	15	Galtee Mountains
02-Apr-23	Sand Martin	7	Holycross
11-Apr-22	Sand Martin	30	Cashel
02-May-21	Sand Martin	20	Holycross
02-Apr-21	Sand Martin	20	Thurles
11-May-24	Sedge Warbler	1	Cashel
07-May-24	Sedge Warbler	1	Golden
07-May-24	Sedge Warbler	1	Cahir
20-Apr-24	Sedge Warbler	1	Lisheen
16-May-23	Sedge Warbler	3	Cashel
10-Apr-22	Sedge Warbler	1	Thurles
05-Dec-23	Shelduck	1	Golden
05-Dec-23	Short-eared Owl	1	Littleton Bog
26-Jan-25	Siberian Chiffchaff	1	Ashton Callows
27-Jan-22	Snow Bunting	1	Keeper Hill
15-Apr-26	Sparrowhawk	1	Cashel
28-Mar-26	Sparrowhawk	1	Cashel
05-Feb-26	Sparrowhawk	1	Cashel
06-Dec-25	Sparrowhawk	1	Cashel
30-Nov-25	Sparrowhawk	1	Cashel
05-Sept-25	Sparrowhawk	1	Birdhill
10-Jun-25	Sparrowhawk	1	Cahir
12-Jan-25	Sparrowhawk	1	Fennor
13-Aug-24	Sparrowhawk	1	Golden
13-Mar-24	Sparrowhawk	1	Cashel
23-Feb-24	Sparrowhawk	1	Cashel
23-Oct-23	Sparrowhawk	1	Cashel
12-Sept-23	Sparrowhawk	1	Golden
16-May-23	Sparrowhawk	1	Cahir
23-Aug-22	Sparrowhawk	1	Golden
12-Jul-22	Sparrowhawk	1	Cahir
28-Jun-22	Sparrowhawk	1	Cashel
30-Mar-21	Sparrowhawk	1	Mooncoin
30-Aug-24	Spotted Flycatcher	3	Cashel
29-Sept-25	Stone-curlew	1	Slievenamon / Slievenaman
04-Apr-25	Swallow	2	Cashel
09-Apr-24	Swallow	5	Cashel
13-Apr-23	Swallow	5	Ardmayle
12-Apr-23	Swallow	1	Golden

09-Apr-23	Swallow	3	Cashel
02-Apr-23	Swallow	4	Cashel
17-Mar-23	Swallow	6	Thurles
14-Apr-22	Swallow	2	Cashel
13-Apr-22	Swallow	2	Killenaule
15-Apr-21	Swallow	6	Cashel
23-Jun-25	Swift	6	Cashel
13-May-25	Swift	8	Golden
07-May-25	Swift	6	Cahir
20-May-24	Swift	6	Cashel
11-May-24	Swift	4	Cashel
07-May-24	Swift	8	Cahir
25-Jul-23	Swift	20	Cahir
11-Jul-23	Swift	12	Cashel
11-Jul-23	Swift	15	Cashel
27-Jun-23	Swift	1	Cahir
27-Jun-23	Swift	8	Golden
26-May-23	Swift	2	Thurles
17-May-23	Swift	2	Cashel
05-May-23	Swift	5	Cashel
13-Jul-22	Swift	7	Tipperary Town
23-Jun-22	Swift	10	Cashel
15-May-22	Swift	16	Cashel
14-May-22	Swift	10	Tipperary Town
11-May-22	Swift	3	Cashel
11-May-22	Swift	6	Cahir
25-Jul-21	Swift	22	Ballingarry
01-Jul-21	Swift	11	Cashel
02-Jun-21	Swift	2	Tipperary Town
16-May-21	Swift	3	Cashel
08-May-21	Swift	4	Cashel
02-May-21	Swift	2	Holycross
05-Sept-21	Teal	3	Thurles
11-Apr-21	Tree Sparrow	3	Ballymacegan
03-Feb-22	Tundra Bean Goose	1	Tibberaghny
08-Oct-25	Turtle Dove	1	Nenagh
23-May-23	Water Rail	2	Thurles
05-Sept-21	Water Rail	1	Thurles
25-Jul-21	Water Rail	6	Thurles
24-Oct-23	Waxwing	10	Birdhill
09-Oct-25	Wheatear	1	Templetouhy
07-May-25	Wheatear	2	Galtee Mountains
27-Apr-25	Wheatear	1	Galtee Mountains
27-Sept-24	Wheatear	1	Kylenamuck, Riverstown
19-Sept-24	Wheatear	1	Golden
15-Oct-23	Wheatear	5	Galtee Mountains
30-Apr-23	Wheatear	1	Galtee Mountains
18-Sept-22	Wheatear	1	Galtee Mountains
14-May-22	Whinchat	1	Ashton's Callow

27-May-21	Whinchat	2	Ballymacegan Island
26-Apr-21	Whinchat	2	Ashton's Callow
12-Jun-25	White Stork	1	Cahir
30-May-25	White Stork	1	Templemore
29-May-25	White Stork	1	Thurles
03-Apr-26	White-tailed Eagle	1	Cashel
14-Feb-26	White-tailed Eagle	1	Ballymacegan
09-Feb-25	White-tailed Eagle	2	Ashton Callows
18-Aug-24	White-tailed Eagle	1	Newport
16-Jan-24	White-tailed Eagle	1	Shannon Callows
14-Nov-23	White-tailed Eagle	1	Shannon Callows
05-Jun-23	White-tailed Eagle	1	Terryglass / Tir Dhá Ghlas
08-May-23	White-tailed Eagle	1	Nenagh
11-Jun-21	White-tailed Eagle	1	Lough Derg
14-Mar-26	Whooper Swan	30	Clonoulty
25-Feb-26	Whooper Swan	20	Clonoulty
17-Feb-26	Whooper Swan	7	Clonoulty
13-Feb-26	Whooper Swan	8	Cashel
30-Jan-26	Whooper Swan	15	Clonoulty
13-Nov-25	Whooper Swan	20	Clonoulty
30-Oct-25	Whooper Swan	20	Clonoulty
24-Nov-24	Whooper Swan	20	Cashel
26-Oct-24	Whooper Swan	3	Cashel
12-Oct-24	Whooper Swan	42	Ballymacegan
13-Mar-24	Whooper Swan	51	Clogher
08-Mar-24	Whooper Swan	42	Cashel
29-Feb-24	Whooper Swan	56	Clonoulty
14-Feb-24	Whooper Swan	50	Cashel
12-Jan-24	Whooper Swan	45	Clonoulty
11-Jan-24	Whooper Swan	60	Clonoulty
08-Jan-24	Whooper Swan	63	Cashel
06-Jan-24	Whooper Swan	40	Cashel
01-Jan-24	Whooper Swan	14	Cashel
30-Nov-23	Whooper Swan	30	Clogher
11-Nov-23	Whooper Swan	40	Golden
20-Oct-23	Whooper Swan	20	Shannon Callows
18-Jan-23	Whooper Swan	65	Cashel
31-Mar-22	Whooper Swan	4	Cashel
18-Jan-22	Whooper Swan	80	Cashel
07-Jan-22	Whooper Swan	50	Cashel
04-Jan-22	Whooper Swan	55	Cashel
26-Mar-21	Whooper Swan	1	Thurles
07-Mar-21	Whooper Swan	75	Cashel
04-Mar-21	Whooper Swan	48	Cashel
28-Feb-21	Whooper Swan	26	Thurles
21-Feb-21	Whooper Swan	65	Cashel
15-Feb-21	Whooper Swan	100	Cashel
12-Feb-21	Whooper Swan	100	Clonoulty
08-Feb-21	Whooper Swan	100	Clonoulty

05-Feb-21	Whooper Swan	17	Clonoulty
29-Jan-21	Whooper Swan	7	Cashel
15-Apr-22	Willow Warbler	1	Cashel
10-Apr-22	Willow Warbler	2	Thurles
15-Apr-21	Willow Warbler	2	Cashel
18-Jul-24	Yellowhammer	2	Lorrha
16-Jul-24	Yellowhammer	1	Lorrha
23-Jun-24	Yellowhammer	2	Terryglass
14-Jun-24	Yellowhammer	2	Terryglass
16-Mar-26	Yellow-legged Gull	1	Roscrea
12-Mar-26	Yellow-legged Gull	1	Roscrea

Table 4 – Tipperary species - by Location

Date	Common Name	Number	Location
30-Jan-22	Great Spotted Woodpecker	1	Aherlow
18-Apr-21	Cuckoo	1	Annaholty
13-Apr-23	Swallow	5	Ardmayle
10-May-24	Crane	3	Ashton Callows
22-Apr-24	Crane	1	Ashton Callows
31-Dec-24	Glossy Ibis	1	Ashton Callows
10-May-24	Pintail	1	Ashton Callows
04-Apr-24	Ring-necked Duck	4	Ashton Callows
27-Feb-24	Ring-necked Duck	3	Ashton Callows
11-Apr-23	Ruddy Shelduck	1	Ashton Callows
11-Apr-23	Ruff	4	Ashton Callows
26-Jan-25	Siberian Chiffchaff	1	Ashton Callows
09-Feb-25	White-tailed Eagle	2	Ashton Callows
16-Nov-24	American Wigeon	1	Ashton's Callow
17-Nov-21	Barnacle Goose	4	Ashton's Callow
28-Sept-25	Great White Egret	1	Ashton's Callow
04-Jan-22	Greenshank	1	Ashton's Callow
22-Oct-21	Pink-footed Goose	3	Ashton's Callow
25-Oct-21	Ruff	3	Ashton's Callow
14-May-22	Whinchat	1	Ashton's Callow
26-Apr-21	Whinchat	2	Ashton's Callow
25-Jul-21	Swift	22	Ballingarry
31-Dec-20	Great Spotted Woodpecker	1	Ballyhourigan Wood
24-Jan-21	Dunlin	1	Ballymacegan
04-Oct-24	Great Spotted Woodpecker	1	Ballymacegan
17-Nov-20	Hen Harrier	1	Ballymacegan
13-Nov-20	Hen Harrier	1	Ballymacegan
09-Dec-22	Jack Snipe	1	Ballymacegan
08-Jul-22	Long-eared Owl	4	Ballymacegan
17-Nov-20	Peregrine	1	Ballymacegan
11-Apr-21	Tree Sparrow	3	Ballymacegan
14-Feb-26	White-tailed Eagle	1	Ballymacegan
12-Oct-24	Whooper Swan	42	Ballymacegan
27-May-21	Whinchat	2	Ballymacegan Island
12-Jan-25	Buzzard	1	Ballymoreen
13-Jul-22	Buzzard	2	Bansha
09-Sept-21	Buzzard	1	Bansha
02-Jun-21	Kestrel	1	Bansha
05-Sept-25	Buzzard	1	Birdhill
28-Jul-21	Great Spotted Woodpecker	1	Birdhill
07-Aug-22	Kestrel	1	Birdhill
05-Sept-25	Kingfisher	1	Birdhill
05-Sept-25	Sparrowhawk	1	Birdhill
24-Oct-23	Waxwing	10	Birdhill
01-May-25	Cuckoo	1	Birr
10-Jul-25	Green Sandpiper	1	Borrisokane
16-Apr-21	Little Ringed Plover	2	Borrisokane

16-Apr-21	Ruff	1	Borrisokane
23-Aug-22	Buzzard	1	Cahir
02-Jul-25	Great Spotted Woodpecker	2	Cahir
10-Jun-25	Great Spotted Woodpecker	2	Cahir
27-May-25	Great Spotted Woodpecker	1	Cahir
05-Dec-23	Great Spotted Woodpecker	1	Cahir
05-Sept-23	Great Spotted Woodpecker	1	Cahir
23-Aug-22	Kestrel	1	Cahir
23-Oct-24	Kingfisher	1	Cahir
15-Oct-24	Kingfisher	1	Cahir
13-Aug-24	Kingfisher	1	Cahir
15-Aug-23	Kingfisher	1	Cahir
27-Jun-23	Kingfisher	1	Cahir
16-May-23	Kingfisher	1	Cahir
04-Oct-22	Kingfisher	2	Cahir
13-Jul-24	Osprey	1	Cahir
11-Jul-23	Peregrine	1	Cahir
28-Jun-22	Raven	6	Cahir
07-May-24	Sedge Warbler	1	Cahir
10-Jun-25	Sparrowhawk	1	Cahir
16-May-23	Sparrowhawk	1	Cahir
12-Jul-22	Sparrowhawk	1	Cahir
07-May-25	Swift	6	Cahir
07-May-24	Swift	8	Cahir
25-Jul-23	Swift	20	Cahir
27-Jun-23	Swift	1	Cahir
11-May-22	Swift	6	Cahir
12-Jun-25	White Stork	1	Cahir
08-Jun-21	Buzzard	2	Cappawhite
08-Jun-21	Cuckoo	3	Cappawhite
16-Jan-25	Great Spotted Woodpecker	1	Carrick-on-Suir
16-May-22	Jay	1	Carrick-on-Suir
10-Aug-21	Kestrel	1	Carrigatogher
16-Mar-25	Buzzard	4	Cashel
24-Apr-24	Buzzard	1	Cashel
20-Apr-24	Buzzard	1	Cashel
08-Mar-24	Buzzard	1	Cashel
16-Jan-24	Buzzard	1	Cashel
29-Jun-23	Buzzard	3	Cashel
05-May-23	Buzzard	2	Cashel
05-May-23	Buzzard	1	Cashel
28-Jun-22	Buzzard	2	Cashel
02-Apr-21	Buzzard	1	Cashel
15-Feb-21	Buzzard	1	Cashel
15-Apr-26	Cormorant	7	Cashel
04-Apr-25	Cormorant	8	Cashel
02-May-21	House Martin	2	Cashel
27-Nov-24	Jay	2	Cashel
19-Oct-24	Jay	2	Cashel

18-Sept-25	Kestrel	1	Cashel
19-May-25	Kestrel	1	Cashel
20-Apr-24	Kestrel	1	Cashel
09-Apr-24	Kestrel	1	Cashel
08-Apr-24	Kestrel	1	Cashel
07-Apr-24	Kestrel	1	Cashel
06-Oct-23	Kestrel	1	Cashel
04-Apr-22	Kestrel	1	Cashel
15-Apr-21	Kestrel	1	Cashel
21-Nov-24	Kingfisher	1	Cashel
13-Feb-26	Little Egret	8	Cashel
23-Feb-24	Little Egret	6	Cashel
15-Dec-23	Little Egret	10	Cashel
29-Dec-20	Little Egret	7	Cashel
14-Mar-26	Peregrine	1	Cashel
01-Mar-26	Peregrine	1	Cashel
17-Feb-26	Peregrine	1	Cashel
25-May-25	Peregrine	1	Cashel
04-Apr-25	Peregrine	1	Cashel
11-May-24	Peregrine	1	Cashel
29-Apr-24	Peregrine	1	Cashel
24-Apr-24	Peregrine	1	Cashel
23-Feb-24	Peregrine	1	Cashel
05-May-23	Raven	2	Cashel
13-Apr-22	Raven	2	Cashel
04-Apr-22	Raven	2	Cashel
21-Oct-21	Raven	30	Cashel
29-Jan-21	Raven	2	Cashel
19-Dec-20	Raven	3	Cashel
17-Sept-25	Red Kite	1	Cashel
11-Apr-22	Sand Martin	30	Cashel
11-May-24	Sedge Warbler	1	Cashel
16-May-23	Sedge Warbler	3	Cashel
15-Apr-26	Sparrowhawk	1	Cashel
28-Mar-26	Sparrowhawk	1	Cashel
05-Feb-26	Sparrowhawk	1	Cashel
06-Dec-25	Sparrowhawk	1	Cashel
30-Nov-25	Sparrowhawk	1	Cashel
13-Mar-24	Sparrowhawk	1	Cashel
23-Feb-24	Sparrowhawk	1	Cashel
23-Oct-23	Sparrowhawk	1	Cashel
28-Jun-22	Sparrowhawk	1	Cashel
30-Aug-24	Spotted Flycatcher	3	Cashel
04-Apr-25	Swallow	2	Cashel
09-Apr-24	Swallow	5	Cashel
09-Apr-23	Swallow	3	Cashel
02-Apr-23	Swallow	4	Cashel
14-Apr-22	Swallow	2	Cashel
15-Apr-21	Swallow	6	Cashel

23-Jun-25	Swift	6	Cashel
20-May-24	Swift	6	Cashel
11-May-24	Swift	4	Cashel
11-Jul-23	Swift	12	Cashel
11-Jul-23	Swift	15	Cashel
17-May-23	Swift	2	Cashel
05-May-23	Swift	5	Cashel
23-Jun-22	Swift	10	Cashel
15-May-22	Swift	16	Cashel
11-May-22	Swift	3	Cashel
01-Jul-21	Swift	11	Cashel
16-May-21	Swift	3	Cashel
08-May-21	Swift	4	Cashel
03-Apr-26	White-tailed Eagle	1	Cashel
13-Feb-26	Whooper Swan	8	Cashel
24-Nov-24	Whooper Swan	20	Cashel
26-Oct-24	Whooper Swan	3	Cashel
08-Mar-24	Whooper Swan	42	Cashel
14-Feb-24	Whooper Swan	50	Cashel
08-Jan-24	Whooper Swan	63	Cashel
06-Jan-24	Whooper Swan	40	Cashel
01-Jan-24	Whooper Swan	14	Cashel
18-Jan-23	Whooper Swan	65	Cashel
31-Mar-22	Whooper Swan	4	Cashel
18-Jan-22	Whooper Swan	80	Cashel
07-Jan-22	Whooper Swan	50	Cashel
04-Jan-22	Whooper Swan	55	Cashel
07-Mar-21	Whooper Swan	75	Cashel
04-Mar-21	Whooper Swan	48	Cashel
21-Feb-21	Whooper Swan	65	Cashel
15-Feb-21	Whooper Swan	100	Cashel
29-Jan-21	Whooper Swan	7	Cashel
15-Apr-22	Willow Warbler	1	Cashel
15-Apr-21	Willow Warbler	2	Cashel
19-Jul-24	Buzzard	1	Castlelough Forest
13-Mar-24	Whooper Swan	51	Clogher
30-Nov-23	Whooper Swan	30	Clogher
25-Oct-21	Ruff	2	Clonmacnoise
04-Nov-21	Brambling	1	Clonmel
14-Mar-26	Whooper Swan	30	Clonoulty
25-Feb-26	Whooper Swan	20	Clonoulty
17-Feb-26	Whooper Swan	7	Clonoulty
30-Jan-26	Whooper Swan	15	Clonoulty
13-Nov-25	Whooper Swan	20	Clonoulty
30-Oct-25	Whooper Swan	20	Clonoulty
29-Feb-24	Whooper Swan	56	Clonoulty
12-Jan-24	Whooper Swan	45	Clonoulty
11-Jan-24	Whooper Swan	60	Clonoulty
12-Feb-21	Whooper Swan	100	Clonoulty

08-Feb-21	Whooper Swan	100	Clonoulty
05-Feb-21	Whooper Swan	17	Clonoulty
15-May-24	Great Spotted Woodpecker	1	Cloughjordan / Cloghjordan
19-May-25	Golden Oriole	1	Cloughtaney
12-Apr-25	Great Spotted Woodpecker	1	Commonafine
21-Dec-20	Great Northern Diver	1	Dromineer
10-Dec-20	Great Northern Diver	1	Drumineer
13-Feb-21	Buzzard	1	Dundrum
18-May-24	Great Spotted Woodpecker	2	Dundrum
12-Jan-25	Sparrowhawk	1	Fennor
02-Aug-25	Buzzard	2	Galtee Mountains
07-May-25	Buzzard	1	Galtee Mountains
07-May-25	Cuckoo	3	Galtee Mountains
27-Apr-25	Cuckoo	2	Galtee Mountains
25-Apr-24	Cuckoo	1	Galtee Mountains
30-Apr-23	Cuckoo	2	Galtee Mountains
05-Oct-25	Golden Plover	70	Galtee Mountains
29-Jun-21	Hen Harrier	1	Galtee Mountains
02-Aug-25	Kestrel	1	Galtee Mountains
07-May-25	Kestrel	1	Galtee Mountains
15-Oct-23	Kestrel	1	Galtee Mountains
30-Apr-23	Kestrel	1	Galtee Mountains
15-Oct-23	Peregrine	1	Galtee Mountains
30-Apr-23	Peregrine	2	Galtee Mountains
15-Oct-23	Redstart	1	Galtee Mountains
02-Aug-25	Sand Martin	22	Galtee Mountains
27-Apr-25	Sand Martin	15	Galtee Mountains
07-May-25	Wheatear	2	Galtee Mountains
27-Apr-25	Wheatear	1	Galtee Mountains
15-Oct-23	Wheatear	5	Galtee Mountains
30-Apr-23	Wheatear	1	Galtee Mountains
18-Sept-22	Wheatear	1	Galtee Mountains
11-Apr-25	Hoopoe	1	Garrykennedy
13-Aug-24	Buzzard	1	Golden
06-Aug-24	Buzzard	4	Golden
03-Apr-24	Buzzard	2	Golden
23-Aug-22	Buzzard	1	Golden
28-Jun-22	Buzzard	2	Golden
18-Sept-21	Buzzard	5	Golden
05-Dec-23	Great Crested Grebe	1	Golden
05-Dec-23	Green Sandpiper	1	Golden
13-Apr-22	House Martin	4	Golden
31-Jul-25	Kestrel	1	Golden
13-Aug-24	Kestrel	1	Golden
06-Aug-24	Kestrel	1	Golden
12-Sept-23	Kestrel	2	Golden
23-Aug-22	Kestrel	1	Golden
28-Jun-22	Kestrel	1	Golden
06-Aug-24	Peregrine	1	Golden

07-May-24	Peregrine	1	Golden
07-May-24	Raven	2	Golden
03-Apr-24	Raven	2	Golden
28-Jun-22	Raven	1	Golden
07-May-24	Sedge Warbler	1	Golden
05-Dec-23	Shelduck	1	Golden
13-Aug-24	Sparrowhawk	1	Golden
12-Sept-23	Sparrowhawk	1	Golden
23-Aug-22	Sparrowhawk	1	Golden
12-Apr-23	Swallow	1	Golden
13-May-25	Swift	8	Golden
27-Jun-23	Swift	8	Golden
19-Sept-24	Wheatear	1	Golden
11-Nov-23	Whooper Swan	40	Golden
02-Jan-23	Green Sandpiper	1	Graigue
18-Dec-22	Green Sandpiper	1	Graigue
21-Jan-21	Green Sandpiper	1	Graigue
17-Apr-22	Cuckoo	1	Hollyford Hills
02-Aug-25	Buzzard	3	Holycross
06-Oct-24	Buzzard	1	Holycross
29-Oct-23	Buzzard	2	Holycross
17-Jan-26	Great Spotted Woodpecker	1	Holycross
02-Sept-22	Green Sandpiper	4	Holycross
06-Oct-24	Kestrel	1	Holycross
06-Oct-24	Raven	1	Holycross
24-Dec-23	Raven	2	Holycross
02-Apr-23	Sand Martin	7	Holycross
02-May-21	Sand Martin	20	Holycross
02-May-21	Swift	2	Holycross
27-Dec-24	Barn Owl	1	Horse and Jockey
22-Jul-21	Kestrel	1	Horse and Jockey
22-Feb-23	Green-winged Teal	1	Inishlounaght
27-Jan-22	Snow Bunting	1	Keeper Hill
25-Apr-25	Cuckoo	1	Kilcommon
22-Jun-22	Buzzard	1	Kilfeacle
13-Apr-22	Buzzard	1	Kilfeacle
13-Apr-22	Raven	1	Kilfeacle
13-Apr-22	Swallow	2	Killenaule
12-May-25	Great Spotted Woodpecker	1	Knockmealdown Mountains
14-Feb-22	Jack Snipe	1	Knockmealdown Mountains
10-Sept-24	Kestrel	1	Knockmealdown Mountains
27-Sept-24	Wheatear	1	Kylenamuck, Riverstown
26-Oct-24	Barn Owl	1	Lisballyard
20-Apr-24	Cuckoo	1	Lisheen
20-Apr-24	Sedge Warbler	1	Lisheen
10-Mar-22	Black-tailed Godwit	100	Little Brosna Callows
13-May-22	Cuckoo	1	Littleton
28-Apr-22	Cuckoo	1	Littleton
23-Aug-22	Kestrel	1	Littleton

28-Apr-22	Kestrel	1	Littleton
06-Jun-23	Great Spotted Woodpecker	1	Littleton / An Baile Dháith
05-Dec-23	Short-eared Owl	1	Littleton Bog
19-Feb-22	Green Sandpiper	1	Longfordpass
01-Sept-24	Greenshank	2	Longfordpass
29-Mar-26	Barn Owl	1	Lorrha
28-Feb-23	Barn Owl	1	Lorrha
21-Jan-22	Barn Owl	1	Lorrha
08-Jan-21	Barn Owl	1	Lorrha
10-Sept-22	Buzzard	3	Lorrha
28-Apr-25	Cuckoo	1	Lorrha
31-May-23	Cuckoo	1	Lorrha
29-Apr-22	Long-eared Owl	1	Lorrha
18-Jul-24	Yellowhammer	2	Lorrha
16-Jul-24	Yellowhammer	1	Lorrha
11-Jun-21	White-tailed Eagle	1	Lough Derg
11-Jan-25	Buzzard	1	Loughnavatta
13-Nov-20	Barn Owl	1	M8
16-May-23	Buzzard	3	M8
17-May-25	Red Kite	1	M8
05-Jun-21	Buzzard	2	Moneygall
30-Mar-21	Sparrowhawk	1	Mooncoin.
01-Feb-22	Cattle Egret	1	N62
11-Jun-22	Buzzard	1	Nenagh
04-Mar-22	Buzzard	2	Nenagh
05-Jun-21	Buzzard	2	Nenagh
25-Jul-21	Common Sandpiper	1	Nenagh
04-Jan-24	Garganey	1	Nenagh
03-Aug-21	Green Sandpiper	1	Nenagh
11-Jun-22	Kestrel	1	Nenagh
07-Jun-22	Kestrel	1	Nenagh
15-Aug-21	Kestrel	1	Nenagh
07-Jul-21	Kestrel	1	Nenagh
05-Jun-21	Kestrel	1	Nenagh
11-Jan-26	Northern Lapwing	100	Nenagh
12-Jul-23	Peregrine	1	Nenagh
11-Jan-26	Raven	2	Nenagh
01-Apr-26	Red-necked Grebe	1	Nenagh
13-Aug-21	Ruff	1	Nenagh
08-Oct-25	Turtle Dove	1	Nenagh
08-May-23	White-tailed Eagle	1	Nenagh
01-Sept-25	Osprey	2	Newcastle
18-Aug-24	White-tailed Eagle	1	Newport
11-Aug-22	Raven	1	Oola
29-Oct-21	Pink-footed Goose	3	Parteen Weir
17-Mar-24	Marsh Harrier	1	Pat Reddan's Lake
20-Oct-23	Little Egret	1	Portumna Forest Park
18-Jul-24	Raven	2	Rathanny
04-Apr-25	Cuckoo	1	Rearcross

23-Jan-22	Brambling	2	Roscrea
04-Mar-22	Buzzard	1	Roscrea
07-Jul-21	Buzzard	1	Roscrea
05-Jun-21	Buzzard	2	Roscrea
26-May-21	Buzzard	1	Roscrea
26-Mar-26	Great Black-backed Gull	2	Roscrea
02-Jul-23	Great Spotted Woodpecker	2	Roscrea
10-Aug-21	Kestrel	1	Roscrea
26-Mar-26	Lesser Black-backed Gull	100	Roscrea
16-Mar-26	Yellow-legged Gull	1	Roscrea
12-Mar-26	Yellow-legged Gull	1	Roscrea
06-May-23	Glossy Ibis	1	Shannon Callows
23-Apr-23	Grasshopper Warbler	1	Shannon Callows
16-Jan-24	Hen Harrier	1	Shannon Callows
20-Oct-23	Jack Snipe	1	Shannon Callows
16-Jan-24	White-tailed Eagle	1	Shannon Callows
14-Nov-23	White-tailed Eagle	1	Shannon Callows
20-Oct-23	Whooper Swan	20	Shannon Callows
30-Apr-21	Great Spotted Woodpecker	2	Slieveardagh Hills
26-Apr-21	Great Spotted Woodpecker	1	Slieveardagh Hills
22-Aug-21	Raven	1	Slievenamon / Sliabh na mBan
29-Sept-25	Stone-curlew	1	Slievenamon / Slievenaman
23-Jun-24	Buzzard	2	Templederry
23-Jun-24	Kestrel	1	Templederry
30-May-25	White Stork	1	Templemore
09-Oct-25	Great White Egret	1	Templetouhy
26-Nov-24	Great White Egret	1	Templetouhy
09-Oct-25	Wheatear	1	Templetouhy
18-Jun-24	Reed Warbler	1	Templetuohy
09-Nov-23	Great White Egret	1	Templetuohy Bog
07-Mar-26	Barn Owl	1	Terryglass
23-Jun-24	Yellowhammer	2	Terryglass
14-Jun-24	Yellowhammer	2	Terryglass
05-Jun-23	White-tailed Eagle	1	Terryglass / Tir Dhá Ghlas
10-Apr-22	Blackcap	1	Thurles
21-Mar-22	Black-tailed Godwit	2	Thurles
22-Jan-24	Brambling	1	Thurles
26-Feb-22	Brambling	2	Thurles
13-Feb-22	Brambling	1	Thurles
23-May-23	Buzzard	1	Thurles
25-Jul-22	Buzzard	2	Thurles
25-Jul-21	Buzzard	2	Thurles
19-Mar-21	Buzzard	9	Thurles
28-Feb-21	Buzzard	1	Thurles
18-Mar-22	Chiffchaff	1	Thurles
17-Mar-22	Chiffchaff	1	Thurles
29-Nov-25	Cormorant	7	Thurles
18-Dec-23	Dunlin	20	Thurles
10-Apr-22	Gadwall	2	Thurles

15-Feb-21	Gadwall	7	Thurles
27-Feb-24	Garganey	2	Thurles
21-Mar-22	Garganey	1	Thurles
20-Mar-22	Garganey	1	Thurles
15-Feb-21	Garganey	1	Thurles
06-Feb-21	Garganey	1	Thurles
29-Feb-24	Great Spotted Woodpecker	1	Thurles
09-Sept-22	Green Sandpiper	1	Thurles
31-Jan-22	Green Sandpiper	1	Thurles
11-Dec-24	Greenshank	1	Thurles
07-Jan-21	Greenshank	1	Thurles
08-Mar-21	Green-winged Teal	1	Thurles
28-Feb-21	Green-winged Teal	1	Thurles
21-Feb-21	Green-winged Teal	1	Thurles
19-Jan-21	Green-winged Teal	1	Thurles
26-Mar-21	Hen Harrier	1	Thurles
18-Apr-24	House Martin	2	Thurles
23-May-23	House Martin	30	Thurles
25-Jul-22	Kestrel	1	Thurles
22-Jul-21	Kestrel	1	Thurles
18-Sept-24	Kingfisher	1	Thurles
21-Mar-22	Knot	1	Thurles
11-Feb-24	Little Egret	17	Thurles
07-Dec-22	Marsh Harrier	1	Thurles
09-Sept-22	Marsh Harrier	1	Thurles
08-Sept-22	Marsh Harrier	1	Thurles
23-Feb-24	Merlin	1	Thurles
23-May-23	Northern Lapwing	5	Thurles
18-Jan-26	Ruff	1	Thurles
11-Dec-24	Ruff	1	Thurles
18-Dec-23	Ruff	1	Thurles
02-Apr-21	Sand Martin	20	Thurles
10-Apr-22	Sedge Warbler	1	Thurles
17-Mar-23	Swallow	6	Thurles
26-May-23	Swift	2	Thurles
05-Sept-21	Teal	3	Thurles
23-May-23	Water Rail	2	Thurles
05-Sept-21	Water Rail	1	Thurles
25-Jul-21	Water Rail	6	Thurles
29-May-25	White Stork	1	Thurles
26-Mar-21	Whooper Swan	1	Thurles
28-Feb-21	Whooper Swan	26	Thurles
10-Apr-22	Willow Warbler	2	Thurles
03-Feb-22	Tundra Bean Goose	1	Tibberaghny
18-Jan-21	Green Sandpiper	1	Tipperary
13-Jul-22	Swift	7	Tipperary Town
14-May-22	Swift	10	Tipperary Town
02-Jun-21	Swift	2	Tipperary Town
21-May-23	Peregrine	1	Toomevara / Tuaim Ui Mheára

20-Mar-26	Crane	1	Undisclosed Location
10-Jul-24	Crane	1	Undisclosed Location
09-Jul-24	Little Ringed Plover	6	Undisclosed Location
20-Nov-20	Merlin	1	Undisclosed Location
08-Apr-24	Peregrine	1	Undisclosed Location
07-Apr-24	Peregrine	1	Undisclosed Location
08-Mar-24	Peregrine	1	Undisclosed Location
01-Jul-22	Peregrine	1	Undisclosed Location
10-Sept-24	Red-breasted Goose	1	Undisclosed Location
23-Oct-22	Ring Ouzel	2	Undisclosed Location
11-Jan-21	Green Sandpiper	1	Urlingford

Appendix 7.3							
Table 7.3.2 Summary of Winter Walkover - number of individuals							
	2020	**2021**	**2022**	**2023**	**2024**	**2025**	**6 year Total**
Buzzard		5	11	15	9	11	**51**
Golden Plover		2	12	26	6	2	**48**
Hen Harrier				3	1		**4**
Kestrel		6	10	8	1		**25**
Kingfisher			2		1		**3**
Lapwing	1			2	3	4	**10**
Little Egret			1		1		**2**
Meadow Pippet		89	150	69	63	13	**384**
Merlin			1	2			**3**
Peregrine Falcon			2	2			**4**
Redwing		25	50	21	104	5	**205**
Snipe	6	8	40	45	24	5	**128**
Sparrow Hawk			2	5	3	3	**13**
Whooper Swan		68	38	191	8	10	**315**
Annual Total	**7**	**203**	**319**	**389**	**224**	**53**	**1195**
Table 7.3.3 Summary of Summer Breeding Walkover							
	2020	**2021**	**2022**	**2023**	**2024**	**2025**	**4 year Total**
Black Headed Gull		5	4	1	37		**47**
Buzzard		54	27	57	22		**160**
Crane					4		**4**
Curlew				5			**5**
Golden Plover			16	13O			**16**
Kestrel		34	15	33	13		**95**
Kingfisher			7	7	6		**20**
Lapwing		2		37	28		**67**
Little Egret				1			**1**
Meadow Pippet		100	198	183	103		**584**

Peregrine Falcon			3	1	3		**7**
Snipe		2	2	9	30		**43**
Sparrow Hawk		4	2	3	2		**11**
Swift		2	3		15		**20**
Woodcock			5				**5**
Annual Total		**203**	**282**	**337**	**263**		**1085**

Table 7.3.4 Summary of Waterbird distribution

	2020	**2021**	**2022**	**2023**	**2024**	**2025**	**6 Year Total**
Black Headed Gull		301	636	294	134	377	**1742**
Curlew	307	486	422	449	496	586	**2746**
Golden Plover	11170	4793	6357	4589	6927	3309	**37145**
Grey Wagtail					7	2	
Kingfisher	1	5			5		**11**
Lapwing	3037	1702	3541	2425	3868	2086	**16659**
Little Egret	8	24	26	27	14	9	**108**
Snipe		17			3	10	
Whooper Swan	400	222	242	416	362	318	**1960**
Hen Harrier	13	4		10	7		**34**
Annual Total	**14936**	**7554**	**11224**	**8210**	**11823**	**6697**	**60444**

Appendix 3: Cutaway Bog Decommissioning And Rehabilitation Plan (Lemanaghan, Curraghalassa, Derrynagun*)*
Bord na Móna: Lemanaghan (Windfarm) Draft Decommissioning and Rehabilitation Plan 2024

Several bird species were noted on the site during the survey.

- Lapwing (4) on Derrynagun Bog.
- Kestrel
- Bullfinch (3)
- Woodcock (1)
- Jay (2)
- Snipe (1)
- Long-tailed Tit (using conifers adjacent to bog and road in SW area)
- Other more common species included Meadow Pipit, Wood Pigeon, Pheasant, Blue Tit (4), Grey Crow Wren, Rook and Blackbird.

Note: These are not referenced in the Bird list above

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6.1.1.1 Golden Plover

The species was recorded flying within PCH during vantage point surveys. A "Random" collision risk analysis has been undertaken (full details in Appendix 9). The model used for the analysis assumes that waterbird species are active for 25% of dark hours, in addition to daylight hours.

A key factor in calculating the predicted rate of collisions for a given species is the application of an avoidance rate. The avoidance rate accounts for the ability of a bird to take evasive action to avoid a collision with a turbine. Where species-specific avoidance rates are available these rates are usually very high, e.g. all swan species have been shown to avoid colliding with operating turbines 99.8% of the time. Until recently a species-specific avoidance rate has not been available for golden plover. A review of golden plover collision avoidance from four UK wind farms has been undertaken and is outlined in Appendix 9. The output of this new research was a golden plover avoidance rate of 99.6 to 99.8%. Following a precautionary approach, the lower of these avoidance rates (i.e. 99.6%) was used in the collision risk analysis.

The collision risk has been calculated at a rate of 10.665 collisions per year. Annual mortality of adult golden plover has been calculated at 27% per annum (Sandercock, 2003). If 10.665 collisions were to occur per year, it would mean that the losses at the Proposed Project site would increase the annual mortality of the county population by 0.80%. The predicted collision risk is therefore of negligible magnitude as per Percival (2003) criteria. Therefore, no adverse effects are predicted and no mitigation is required.

Displacement & Barrier Effect: 6.1.2.1 Golden Plover

Hötker et al. (2006) state that golden plover will approach wind turbines to an average distance of 175m in non-breeding season. Of the 161 no. observations of golden plover throughout the survey period, 24 no. observations were within 175m of the proposed turbine layout. The majority of these related to birds in flight, and with two observations relating to birds utilising habitats. Of the total 7 no. observations of golden plover utilising habitats across the Proposed Project site, usage was not recorded on more than one occasion in any area. Golden plover are therefore not reliant on any specific area of the Proposed Project site and utilise habitats on an opportunistic basis. As such, in the event of displacement, there are extensive areas of similar habitat in the wider area. Similar quality habitat is widely available, with good quality habitat abundantly present in the River Shannon catchment. Additionally, the rehabilitation schemes within some of these peatland habitats (on deep peat) are likely to increase the quality of these habitats in the wider surroundings for the species and, relatedly, their potential carrying capacity. The low rate of occurrence limits the potential for disturbance displacement associated with the turbines and/or foot traffic on the amenity tracks. These factors likely render displacement effects inconsequential.

Over the lifetime of the Proposed Wind Farm, with the succession to scrub mosaic on shallower peat, the site will likely become increasingly less suitable for open habitat species like golden plover.

Survey results indicate that the Proposed Project site does not lie on a migratory/regular commuting route for this species, therefore barrier effect is not anticipated. Adverse effect due to displacement and barrier effects are not anticipated and no mitigation is required.

6.2.2 **Ex Situ Habitat Loss: 6.2.2.1 Golden Plover**

Golden plover were observed within, or partially within, the Proposed Project site on 62 occasions over the five wintering seasons. The majority of these observations related to birds in flight over the Proposed Project site. Birds were observed landing and/or roosting within the Proposed Project site on a total of seven occasions over four and a half years of surveying, with flocks recorded ranging from 2 to 80 birds. The Proposed Project site is not considered an important foraging or roosting habitat for golden plover and the potential for construction works to result in ecologically significant habitat loss for golden plover is limited. Furthermore, the results of waterbird distribution and abundance surveys in the wider area demonstrate that the Proposed Project site is not a preferred habitat for golden plover, with activity concentrated on peatlands over 5km south of the Proposed Project site including Boora Bog environs and Tumduff Wetlands (see Appendix 7).

The land lost to the permanent infrastructure footprint of the Proposed Project is small relative to the total area within the Proposed Project site (i.e., approx. 3%). Given the abundance of similar suitable habitats (peatlands and improved agricultural grasslands) in the wider area as those found within the Proposed Project site, and that extensive areas of suitable foraging and roosting habitat will remain post construction, no adverse impacts are predicted and no mitigation is required.

6.2.3 **Disturbance: 6.2.3.2 Golden Plover**

There were 7 records of golden plover utilising habitats within the Proposed Project site over the four and a half years of surveying. All these records related to different areas of the Proposed Project site, with no repeat usage of any area recorded. The Proposed Project site is therefore not an important foraging or roosting habitat for golden plover and the potential for construction works to result in ecologically significant disturbance effects on golden plover is limited.

Significant areas of suitable roosting and foraging habitat for the species occur in the wider landscape and will be retained. In the event of disturbance, there are extensive areas of similar habitats in the wider area. Similar quality habitat is widely available, with good quality habitat abundantly present in the River Shannon catchment. Additionally, the rehabilitation schemes within some of these peatland habitats (on deep peat) are likely to increase the quality of these habitats in the wider surroundings for the species and, relatedly, their potential carrying capacity.

These factors likely render such an effect inconsequential. Adverse effects are therefore not predicted and no mitigation is required.

8.2.1.1.8 ***Cumulative Assessment of SCI Bird Species*** : Golden Plover

Golden plover were observed within, or partially within, the Proposed Project site on 62 occasions during the survey period. The majority of these observations related to birds in flight over the site. Birds were recorded landing and/or roosting within the Proposed Project site on 7 occasions over the 4.5 years of survey effort, with flock sizes ranging from two to 80 birds.

The potential for cumulative displacement and barrier effects was considered in combination with other existing, permitted or proposed wind farm developments within 25km of the Proposed Project. No adverse effects due to displacement or barrier effects for golden plover were identified in the available reports for these developments. Golden plover recorded within the Proposed Project site occurred at relatively low frequency and suitable foraging and roosting habitat remains widely available across the surrounding landscape. On this basis, the Proposed Project, when considered in combination with other existing, permitted or proposed wind farm developments in the wider area, is not predicted to result in cumulative displacement or barrier effects that would undermine the conservation objectives for wintering golden plover of Middle Shannon Callows SPA.

The habitats within the Proposed Project site principally comprise regenerating formerly cutover peatland and agricultural grassland. These habitat types are characteristic of the wider landscape and other existing, permitted or proposed wind farm sites within 25km. The existing Leabeg and Cloghan Wind Farms are located within agricultural grassland, the existing Derrinlough Wind Farm and the proposed Bellair Wind Farm are situated within regenerating cutover peatland, the existing Cush Wind Farm comprises commercial forestry with some peatland and grassland, and the proposed Umma More Wind Farm is located predominantly within agricultural grassland. While these habitats may provide foraging opportunities for golden plover, they are not of particularly high quality and are widely available across the county, with abundant good quality habitat present within the River Shannon catchment. Therefore, adverse cumulative effects as a result of ex situ habitat loss that would undermine the conservation objectives for wintering golden plover of Middle Shannon Callows SPA are not anticipated.

The cumulative predicted collision mortality from existing, permitted or proposed wind farms within 25km of the Proposed Project is 26.274 birds per annum, of which approximately 10 birds are associated with the proposed Umma More Wind Farm (Table 8-3 above). As set out in Section 6, birds recorded within the Proposed Project site are considered to form part of the wider county wintering population, which includes the SPA population, rather than representing a discrete SPA population. Only a proportion of the cumulative predicted mortality would therefore be attributable to birds associated with Middle Shannon Callows SPA.

When considered cumulatively, and taking into account that only a proportion of predicted mortality would be associated with the SPA population, the cumulative collision risk is not of a scale that would undermine the conservation objectives for wintering golden plover of Middle Shannon Callows SPA.

Having regard to the predicted displacement effects, the availability of suitable habitat within the wider landscape, and the cumulative predicted collision mortality, it is concluded that the Proposed Project, in combination with other plans and projects, will not adversely affect the integrity of Middle Shannon Callows SPA in respect of its conservation objectives for wintering golden plover.

6.1.1.2 **Lapwing**

The species was recorded flying within PCH during vantage point surveys. A "Random" collision risk analysis has been undertaken (full details in Appendix 9). The model used for the analysis assumes that waterbird species are active for 25% of dark hours, in addition to daylight hours.

The collision risk has been calculated at a rate of 2.007 collisions per year. Annual mortality of adult lapwing has been calculated at 29.5% per annum (Peach et al. 1994). If 2.007 collisions were to occur per year, it would mean that the losses at the Proposed Project site would increase the annual mortality of the county population by 0.26% (full details in Appendix 9). The predicted collision risk is therefore of negligible magnitude as per Percival (2003) criteria. No adverse effects are predicted and no mitigation is required.

Displacement & Barrier Effect: 6.1.2.2 Lapwing

There were three records of lapwing utilising habitats within the Proposed Project site over the five winter seasons surveyed. This species was not observed to regularly utilise any areas of the Proposed Project site during winter months but was primarily recorded travelling over the Proposed Project site. There are extensive areas of suitable habitat in the wider area, as identified during the Waterbird Distribution and Abundance Surveys (Appendix 7), including Lough Boora Parklands and Tumduff, outside any potential displacement buffer. Similar quality habitat is widely available, with good quality habitat abundantly present in the River Shannon catchment.

Over the lifetime of the Proposed Wind Farm, with the succession to scrub mosaic on shallower peat, the site will likely become increasingly less suitable for open habitat species like lapwing.

Survey results indicate that the Proposed Project site does not lie on a migratory corridor for lapwing, and no regular or patterned flight was identified over the site. Adverse effects to displacement and barrier effects are not predicted and no mitigation is required.

6.2.2 **Ex Situ Habitat Loss: 6.2.2.2 Lapwing**

Lapwing were observed within, or partially within, the Proposed Project site on 19 occasions across the five winter seasons surveyed. The majority of these observations related to birds in flight over the Proposed Project site. Birds were observed landing or on the ground within the Proposed Project site on a total of three occasions over the five winter seasons surveyed, with flocks recorded ranging from one to four birds. The Proposed Project site is therefore not an important foraging or roosting habitat for wintering lapwing and the potential for construction works to result in ecologically significant habitat loss for wintering lapwing is limited. Furthermore, the results of waterbird distribution and abundance surveys in the wider area demonstrate that the Proposed Project site is not a preferred habitat for lapwing, with activity concentrated on peatlands over 5km south of the Proposed Project site (i.e. Boora Bogs, Tumduff Wetlands and Turraun Wetlands).

The land lost to the permanent infrastructure footprint of the Proposed Project is small relative to the total area within the Proposed Project site (i.e., approx. 3%). Given the abundance of similar suitable habitats (peatlands and improved agricultural grasslands) in the wider area as those found within the Proposed Project site, and that extensive areas of suitable foraging and roosting habitat will remain post construction, no adverse impacts are predicted and no mitigation is required.

6.2.3 **Disturbance: 6.2.3.3 Lapwing**

There were only 3 records of lapwing utilising habitats within the Proposed Project site over the five winter seasons surveyed. This is a very low rate of occurrence. The Proposed Project site is therefore not an important foraging or roosting habitat for wintering lapwing and the potential for construction works to result in ecologically significant disturbance impacts on wintering populations of lapwing is limited.

Significant areas of suitable roosting and foraging habitat for the species occur in the wider landscape and will be retained. In the event of disturbance, there are extensive areas of similar or alternative habitat in the wider area. Similar quality habitat is widely available, with good quality habitat abundantly present in the River Shannon catchment. These factors likely render such an effect inconsequential. Adverse effects are not predicted and no mitigation measures are required.

8.2.1.1.8 ***Cumulative Assessment of SCI Bird Species: Lapwing***

Lapwing were observed within the Proposed Project site on 19 occasions across the five winter seasons surveyed. The majority of these observations related to birds in flight over the site.

The potential for cumulative displacement and barrier effects was considered in combination with other existing, permitted or proposed wind farm developments within 25km of the Proposed Project. No adverse effects due to displacement or barrier effects for wintering lapwing were identified in the available reports for these other existing, permitted or proposed wind farms. Lapwing recorded within the Proposed Project site occurred at low frequency and suitable foraging and roosting habitat remains widely available across the surrounding landscape. In addition, over the operational lifetime of the Proposed Project, natural succession to scrub mosaic on shallower peat is likely to reduce the suitability of the site for open habitat species such as lapwing. On this basis, the Proposed Project, when considered in combination with other existing, permitted or proposed wind farm developments in the wider area, is not

predicted to result in cumulative displacement or barrier effects that would undermine the conservation objectives for wintering lapwing of Middle Shannon Callows SPA.

The habitats within the Proposed Project site broadly comprise regenerating formerly cutover peatland and agricultural grassland. These habitat types are characteristic of the wider landscape and other wind farm sites within 25km. The existing Leabeg and Cloghan Wind Farms are located within agricultural grassland, the existing Derrinlough Wind Farm and the proposed Bellair Wind Farm are situated within regenerating cutover peatland, the existing Cush Wind Farm comprises commercial forestry with some peatland and grassland, and the proposed Umma More Wind Farm is located predominantly within agricultural grassland. While these habitats may provide foraging and roosting opportunities for lapwing, they are not of particularly high quality and are widely available across the county, with abundant good quality habitat present within the River Shannon catchment. In addition, peatland rehabilitation schemes within parts of the wider landscape are likely to enhance habitat quality locally. Therefore, adverse cumulative effects as a result of ex situ habitat loss that would undermine the conservation objectives for wintering lapwing of Middle Shannon Callows SPA are not anticipated.

The cumulative predicted collision mortality from other existing, permitted or proposed wind farms within 25km of the Proposed Project is 37.65 birds per annum, 19 of which are associated with the proposed Umma More Wind Farm. As set out in Section 6, birds recorded within the Proposed Project site are considered to form part of the wider county wintering population, which includes the SPA population, rather than representing a discrete SPA population. Only a proportion of the cumulative predicted mortality would therefore be attributable to birds associated with Middle Shannon Callows SPA.

When considered cumulatively, and taking into account that only a proportion of predicted mortality would be associated with the SPA population, the cumulative collision risk is not of a scale that would undermine the conservation objectives for wintering lapwing of Middle Shannon Callows SPA.

Having regard to the predicted displacement effects, the availability of suitable habitat within the wider landscape, and the cumulative predicted collision mortality, it is concluded that the Proposed Project, in combination with other plans and projects, will not adversely affect the integrity of Middle Shannon Callows SPA in respect of its conservation objectives for wintering lapwing.

6.2 **Potential for Indirect Effects on the European Sites**

Potential indirect effects on Middle Shannon Callows SPA arising from deterioration of water quality are limited to SCI species and supporting wetland habitat occurring downstream of the Proposed Project site, where hydrological connectivity is present. These are

- [A038] Whooper Swan (Cygnus cygnus)
- [A050] Wigeon (Anas Penelope)
- [A140] Golden Plover (Pluvialis apricaria)
- [A142] Lapwing (Vanellus vanellus)
- [A156] Black-tailed Godwit (Limosa limosa)
- [A179] Black-headed Gull (Chroicocephalus ridibundus)
- [A999] Wetlands

Appendix 9 Collision Risk Modelling NIS Appendices – F – 2026.03.19 – 200804

Table 7 - 6 - 1 Turbine specifications Component	**Scenario Modelled**
Latitude (°N)	**53.3**
Turbine model	**Vestas 150**
Number of turbines	**15**
Hub height (m)	**145**
Rotor diameter (m)	**150**
Blade pitch (°)	**6**
Maximum blade width (m)	**4.2**
Rotational speed (rpm)	**8.45**

Number of blades	3

Response from MLavelle: The Rotor diameter is given as 150m. The circumference is thus $2\pi r = 2x3.14159x75 =$ 471.28m. This converts using revolutions/minute [471.28x8.45] into 3,981.96m/minute (66.366m/s) and 238.9km/hr. And one of the 3 blades passes every 2.3668 seconds [60/8.45/3]. Note Table 7-6 below for flight speed of different species. A bird flying at 8-17.3m/s cannot dodge a 4.2m blade travelling at 66.366m/s every 2.3668 seconds.

The V150 Brochure speed is given as 82m/s and this is higher than MLavelle calculation of 66.366m/s

Reference No 36 : Wind Turbine - Vestas V150-4.5

Datasheet
Power
Rated power: 4,500.0 kW
Flexible power ratings: - Cut-in wind speed: 3.0 m/s
Rated wind speed: - Cut-out wind speed: 24.5 m/s
Survival wind speed: -
Wind zone (DIBt): -
Wind class (IEC): S

Rotor Diameter: 150.0 m
Swept area: 17,671.0 m²
Number of blades: 3
Rotor speed, max: 10.4 U/min
Tipspeed: 82 m/s
Type: 73.65m
Material: Carbon fibre reinforced epoxy and glass fibre reinforced epoxy
Manufacturer: Vestas Wind Systems A/S
Power density 1: 254.7 W/m²
Power density 2: 3.9 m²/kW

Reference No 37 : Wind Turbine - Vestas V150-6.0 MW™

Power regulation operational data
Pitch regulated with variable speed
Rated power 6,000kW
Cut-out wind speed 3m/s
Cut-out wind speed 25m/s
Wind class IEC S
Standard operating temperature range from -20°C* to +45°C

SOUND POWER
Maximum 104.9dB(A)**

ROTOR
Rotor diameter 150m
Swept area 17,672m2
Aerodynamic brake
full blade feathering with 3 pitch cylinders
ELECTRICAL
Frequency
50/60 Hz
Converter
full scale

GEARBOX
Type - two planetary stages

TOWER
Hub heights
105 m (IEC S), 125 m (IEC S/DIBt S), 148 m (DIBt S), 155 m (IEC S) and 166 m (DIBt S)

SUSTAINABILITY METRICS
Carbon Footprint 5.6g CO2e/kWh
Return on energy break-even 5.9 months
Lifetime return on energy 41 times
Recyclability rate 85%
Configuration: 155m hub height, Vavg=8.0m/s, k=2.48. Depending on site-specific conditions. Metrics are based on an externally reviewed Life Cycle Assessment available on vestas.com

This speed is the speed of a F1 Grand Prix motor car. No bird, bat or any living creature could escape alive from such a speed scenario. References to small wind turbines collision reductions from Table 7-6-11 & Percival 2003 is just nonsense.

Table 7 - 6 - 6 Species biometrics, flight type and nocturnal activity factor Species	Length (cm)	Width (cm)	Flight Speed (m/s)	Flight Type	Nocturnal Activity Factor
Black-headed Gull	35.5	105.0	11.9	flapping	25
Buzzard	54.0	120.5	11.6	gliding	0
Golden Plover	27.5	71.5	17.9	flapping	25
Hen Harrier	48.0	110.0	8.0	flapping	0
Kestrel	33.5	75.5	10.1	flapping	0
Lapwing	29.5	84.5	12.8	flapping	50
Merlin	27.5	56.0	10.9	flapping	0
Peregrine Falcon	44.5	105.0	12.1	flapping	0
Snipe	25.5	42.0	17.1	flapping	100
Sparrowhawk	33.0	62.5	10.0	flapping	0
Woodcock	34.0	60.0	17.1	flapping	100
Whooper Swan	150.0	220.0	17.3	flapping	25

Stage C Probability of Collision

Stage C of the modelling process calculates the probability of collision during a single bird rotor transit. The likelihood of a bird colliding with a turbine blade during a single pass through the rotor was calculated using the turbine specifications, species biometrics and flight characteristics outlined in the previous sections.

Collision risk was assessed across different parts of the rotor, as blade speed and width varies from the hub to the tip. Because of the geometry of the blades in relation to the flight direction, the collision risk for upwind flight is higher than for downwind (even if the bird's flight speed relative to the ground is taken to be the same), therefore collision risk probabilities were calculated separately for birds flying upwind and downwind. These were then averaged assuming a 50:50 weighting because both upwind and downwind flights are equally likely (further information in Section 4 'Worked Example'). This produced **a probability of collision for a bird during a single transit of the rotor**, which is presented for each species in Table 7 - 6 - 11. Note we have a single transit of the rotor every 2.3668 seconds.

Table 7 - 6 - 11 Probability of collision Species	Upwind	Downwind	Average
Black-headed Gull	0.058	0.042	0.05
Buzzard	0.064	0.047	0.055
Golden Plover	0.049	0.038	0.044
Hen Harrier	0.074	0.049	0.061
Kestrel	0.06	0.04	0.05
Lapwing	0.055	0.039	0.047
Merlin	0.055	0.037	0.046
Peregrine Falcon	0.061	0.044	0.052

Snipe	0.047	0.036	0.042
Sparrowhawk	0.059	0.039	0.049
Woodcock	0.05	0.038	0.044
Whooper Swan	0.081	0.07	0.076

Reference No 28 : Oriel Windfarm ACP Response - Ornithology [Repeat from above]

From the information presented, the Board note concerns that there is an over- reliance on baseline surveys to include, and exclude, important ecological features potentially affected by the project. It is noted that species "recorded in very small numbers or very infrequently during the baseline surveys are excluded because the risk of impact to their populations is considered negligible." The Board requires that a clear, evidence-based justification for the inclusion and/or exclusion of species is submitted, particularly given the risk of excluding species that are less readily sampled by the particular survey methodologies applied and given the location of the site partially within the North-west Irish Sea cSPA, and location relative to bird colonies at Rockabill SPA, Lambay Island SPA & Irelands Eye SPA.

It is noted that the surveys were undertaken prior to the 2022 Highly Pathogenic Avian Influenza (HPAI) season, which is known to have had significant negative impacts on range of seabird species. The applicant is requested to provide justification that the original digital area surveys and boat-based data remain relevant and appropriate at the point of submitting additional information to support the proposed development.

Reference Population

The robustness of population calculations used within Chapter 11: Offshore Ornithology, and associated appendices, is important in assessing the potential effects of the proposed development. While the Board notes the approach of estimating reference populations employed in the EIAR, the applicant is requested to provide further detail on the breeding season populations used - including both breeding adults and juveniles / immature birds - and how the

treated in the population estimates. The applicant should provide evidence-based justification for the method applied, which should comprise the most appropriate and precautionary method for estimating the breeding season populations to inform assessment conclusions.

The applicant is requested to clearly present the values and equations used to derive the population estimates, including their sources (e.g. a list of colonies or sites included within the reference populations), to allow validation of the methodology. The applicant should also address this issue in the Cumulative Impact Assessment.

Disturbance & Displacement

The rationale for decisions to screen out bird species for assessment of disturbance and displacement if determined to have a low sensitivity to disturbance and displacement or which were recorded in low numbers is not clear, giving rise to concerns regarding the robustness of the conclusions in the EIAR and NIS. The applicant is requested to provide justification for the approaches taken for screening out in such instances.

The Board notes the submission of Appendix 11- 07: Offshore Ornithology Apportioning Impacts to Individual Colonies of the EIAR which seeks to apportion predicted mortalities from displacement and collisions of the project to seabird colonies. In terms of disturbance and displacement, fours species have been identified as potentially at risk:
Common Guillemot (*Uria aalge*);

Razorbill (*Alca torda*);

Great northern Diver (*Gavia immer*); and

Northern Gannet (*Morus bassanus);*

The Board notes that the applicant has assessed predicted annual mortalities for a number of species based on a single mortality rate, rather than the industry recommended range of mortality rates. Chapter 11 of the EIAR bases conclusions on a rate of 50% displacement and 1% mortality rate for auks1

) The SNCB (2022) recommend a displacement rate of between 30% and 70% and a mortality rate of 1% and Nature Scot 60% and 1% respectively, 100% displacement and 0.5% mortality for GND and 60% to 80% displacement and 1% mortality rate for gannet during the operational phase of the project. Given the location of the site partially within the North-west Irish Sea SPA (and proximity to colonies at Rockabill SPA, Lambay Island SPA & Irelands Eye SPA) the applicant is requested to update the EIAR to adopt a range of relevant mortality rates in the estimates of predicted mortalities for relevant species, and that these be clearly presented in the EIAR.

Dundalk Bay is noted to be a very important foraging area for birds, likely linked to the prey resources known to exist there, including spawning habitat of the Atlantic Herring *Clupea harengus*. The rate of displacement does not appear to have been fully considered in the context of potential indirect and cumulative effects of the project on birds, such as Manx Shearwater, who forage in Dundalk Bay in large numbers, where a low rate of displacement may induce a population-scale impact. The applicant is requested to address potential changes in the distribution and abundance of important prey populations on birds.

Collision Risk

The Board notes the submission of Appendix 11-4 – Offshore Ornithology Collision Risk Modelling (CRM) which identifies five seabird species as potentially at risk due to their recorded abundance in the offshore wind farm area and their likelihood of flying at potential collision height (PCH) between the lowest and highest sweep of the WTG rotor blades above sea level: Northern Gannet (*Morus bassanus*);

Kittiwake (*Rissa tridactyla*);

Common gull (*Larus canus*);

Herring gull *(Larus argentatus*); and

Great black-backed gull (*Larus marinus*).

It is noted that the findings of the CRM rely on limited empirical data and avoidance rates for waterbirds which are not up to date. The level of confidence with regard to avoidance rates for a significant proportion of waterbirds is very low and this should be given due consideration when drawing conclusions on impacts. The use of the original Band (2012) model in its various forms may not be justified, and the Board is concerned that the conclusion of the applicants' assessment is not supported given the limitations identified. It is recommended that more appropriate methodologies are developed and implemented to gather relevant empirical data to support the assessment of effects, including updating all parameters using the most up to date empirical data, or if not appropriate, provide comprehensive justification for the methodology employed.

In terms of the estimated collisions for the above bird species, the Board notes that Natural England have accepted a 70% reduction in Northern Gannet collision mortality estimates to account for macro-avoidance at previous developments, such as Hornsea 4. However, this is applied where developments are much further from the coast and from Northern Gannet colonies. Given the proximity of the project to the coast and to the gannet colony at Ireland's Eye SPA and Lambay SPA, approximately 52km to the south of the project site and within the foraging range of this species, a more precautionary approach is recommended. The applicant is requested to consider the approach taken in relation to Northern Gannet collision estimates, so they are not reduced by 70% to account for macro-avoidance.

The Board notes that a number of species have been screened out as being vulnerable to collision risk, where abundances are noted to be high or very high due to their flight behaviours and responses, particularly, tending to fly below the sweep of the turbine blades. It is noted that those include species associated with nearby SPAs. The applicant is requested to provide further information on the rationale to exclude certain species in terms of the abundances identified and where, in certain conditions, they may fly higher than expected. Where a species is numerous, modelling of collision risk may produce fatality estimates that are concerning for particular populations, the Manx Shearwater *(Puffinus puffinus)* for example (a Qualifying Interest (QI) of the North-west Irish Sea SPA and the second most frequently recorded species within the Offshore Ornithological Study. Accordingly, Any potential specific mitigation measures to minimise the effects of the project on birds, such as painting of turbine blades, the use of curtailment systems in particular conditions or at particular times etc, if considered appropriate, should also be included and addressed in the application documentation.

Combined Disturbance and Displacement and Collision Risk:

Northern Gannet (*Morus bassanus*) - The Board notes that the overall impacts to species in terms of the predicted mortalities arising from displacement and/or collision events, are contextualised using the BDMPS as set out in Furness (2015). This area is significantly larger than the western Irish Sea and it is requested that the EIAR is revised to ensure that the assessment of predicted annual mortalities uses the western Irish Sea for context.

Red-throated diver (*Gavia stellata*) - Red-throated diver is identified as a QI for the Northwest Irish Sea SPA and a species known to be highly sensitive to offshore wind farm developments due to displacement effects. Recent empirical evidence indicates that the species avoids a larger area than the 4km buffer afforded in the EIAR and NIS, with a 10 km buffer being recommended as per UK Joint SNCB Interim Displacement Advice Note (2022). The EIAR indicates that the species was identified in low abundance (106 birds) in the north and west of the study area during the surveys. While noting the high sensitivity of the species to disturbance and displacement however, the low abundance recorded during site-specific surveys resulted in the species being screened out for EIA purposes. However, the 'Digital video aerial survey of birds in intertidal habitats of Gormanstown December 2018 to March 2019' (HiDef, 2019), commissioned by the Marine Institute, indicates the known extent of Red-throated Diver and their densities and shows the species concentrating in the shallow Dundalk Bay waters and in and around the proposed Oriel Project area. This survey data (HiDef, 2019) suggest that notable densities of the species may be present within

km of the array area. In this regard, the Board is concerned that the EIAR does not set out the recorded density values for this species and scopes out red-throated diver for further consideration in terms of disturbance, displacement and mortality. The applicant is requested to include the HiDef surveys in the assessment of potential impacts on red-throated diver and other North-west Irish Sea SPA QI species sensitive to displacement during both construction and operational phases of the project (e.g. Great Northern Diver *Gavia immer*, Common Scoter *Melanitta nigra*), in terms of predicted mortalities based on a displacement buffer of 10km with regard to the North-west Irish Sea SPA and consider the significance of the effects on this species for all seasons, individually and combined.

Black-legged Kittiwake (*Rissa tridactyla*) - The Board note that Black-legged kittiwake, a species identified as being in decline, is a QI for North-west Irish Sea cSPA, as well as Lambay Island SPA and Ireland's Eye SPA, and that Black-legged Kittiwake has variable responses to offshore wind farms (OWFs). There is a colony in Northern Ireland which may also forage in this area. In this regard, the Board requests that the applicant include this species as a receptor of disturbance and displacement impacts during operation and maintenance. The scoping out of the species is considered to run contrary to the advice of NatureScot (2023) for species where both collision risk and displacement are considered. The applicant is requested to submit further information to identify and evaluate the impact of displacement of Black-legged Kittiwake in conjunction with collision risk. The application documentation should be revised to fully address the potential for significant impacts on this species.

Great Northern Diver (*Gavia immer*) – The Board note that the application area is important for wintering Great Northern Divers, a species known to be vulnerable to disturbance, including from construction activities and associated vessel movements as well as during the operational phase of the project. Bird Watch Ireland raise concerns about this Annex I species who consider that the

international importance. A 'no mitigation' approach as proposed, particularly during the construction and operational phases is not considered appropriate. The applicant is requested to address these concerns, particularly in terms of the cumulative unknowns identified in the EIAR.

Colonies at Rockabill – the applicant is requested to provide additional information on the movement of auks (Guillemots *(Uria aalge)* and Razorbills (*Alca torda*)) from Lambay to show that there is no significant impact on the Rockabill, Lambay and Irelands Eye populations, given their range of foraging grounds, including the area of the project.

Other - The waters in and adjacent to the proposed Oriel Wind Farm are an important resource for the western Irish Seas marine bird populations. The passage of marine birds through the development area does not appear to have been fully characterised because of the data regime adopted. It is requested that the EIAR adopt a range of relevant mortality rates in the estimates of predicted mortalities for relevant species and that the EIAR is revised to ensure that the assessment of predicted annual mortalities uses the western Irish Sea for context. It is recommended that the

developer cross reference to NPWS Article 12 reports which provide information on the current status, pressures and future prospects for sea birds.

The applicant is requested to provide further analysis of the potential effects of the proposed development in relation to predicted mortalities from both collision and displacement impacts for relevant species. This should, at a minimum, incorporate the relevant available data including for example, HiDef (2019) and ObSERVE Phase II data where appropriate. Graphical representation Population Variability Analysis (PVA) results are considered to be of assistance to interpret model outputs where appropriate.

Light-bellied Brent Goose (*Branta bernicla hrota*) - The Board notes the results of the vantage point surveys undertaken to establish the migratory movements of Light-Bellied Brent Geese across Dundalk Bay during the spring

-3: Migratory Geese Survey Report). The observed movements of birds, low and close to the shoreline, likely reflect commuting movements of flocks aligned to tidal cycles and movement between established foraging areas in Dundalk Bay and Carlingford Lough, while the significant migratory move of the 14/15th April would coincide with the northern migration of light-bellied brent geese. Autumn movements are noted to be different to the spring movements, particularly in terms of the volume of birds and sites being used from Strangford Lough and south towards Dublin and Wexford. The Board note the primary survey method of coastal vantage point surveys by human observers, at a distance of between 6-12km from the project site, and which the DAU have considered to be insufficient, with concerns that this methodology could discount the potential for the geese, and other species, to fly through the proposed array area. Reliance on published literature does not provide detailed or precise data movements, and as many of these movements occur overnight, the routes taken are not known. Therefore, and based on known flight heights and potential flightlines between the major concentrations in Strangford Lough and sites along the East Coast of Ireland, there is potential for there to be a significant potential for large numbers of Brent geese flying through the proposed array area during both day and night, over very short timescales, and particularly in autumn. The potential impact of siting wind turbines on a migratory route for this species without appropriate mitigation during such short-term events could be potentially catastrophic for Light-Bellied Brent Geese populations, the vast majority of which winter in Ireland. The applicant is requested to address these concerns in relation potential effects of the project on migrating geese. Any potential specific adaptive mitigation measures to minimise the effects of the project, particularly during the Spring and Autumn migrations and which identify the timings of the migrations, depletion of food supply etc, should also be included and addressed in the EIAR.

Migratory Species – Non seabirds

The Board notes the international importance of Ireland, including Dundalk Bay SPA, for a range of waterbird species. The AA screening report does not detail the potential impacts upon and interactions of the proposed project with migratory waterbirds, with a focus on foraging and breeding birds only. It is noted that all migrating birds have been scoped in for further assessment, which is welcome, but the applicant is requested to update the AA to include a reference to potential impacts and interactions with regard to migratory waterbirds which are SCIs of SPAs. A review of the screened-out Natura 2000 sites and water bodies is required to be undertaken to ensure that the NIS has considered all relevant pathways appropriately, as well as migratory or normal flight paths of avian species.

The applicant is further requested to clearly address the potential for ex situ impacts upon species listed for Dundalk Bay SPA that occur outside the red-line boundary.

The Board has concerns regarding the methodologies employed with regard to the survey and monitoring of the movement of migratory waterbirds at key migration times. The primary survey method of coastal vantage point surveys by human observers, at a distance of between 6-12km from the project site, and which appear to primarily focus on geese, is considered to be insufficient and inappropriate to assess the migratory movements of birds through the array area, and the potential impacts on these species. In addition, the reliance on literature to fill knowledge gaps, while useful, does not provide adequate data to ensure a comprehensive assessment of potential effects on birds. The applicant is requested, having regard to the comments above, to address the purported existing data gap to enable the assessment of potential impacts of the proposed development on migratory birds. Radar (horizontal and vertical surveys) or similar at the Array Area during peak migration periods might be utilised to provide site-specific data, which could be used to support the applicant's current assessment and provide quantitative information on passage of birds to feed into collision modelling. Should radar not be conducted and an alternative survey methodology utilised, comprehensive justification for the

alternative should be provided. Peak migration periods during which data are to be collected can be further informed through review of existing data and
makes reference to the key migration times being spring and autumn, the Board considers that migration information during the winter months would also be of assistance to the assessment (e.g. irruptive cold weather movements from the continent and UK). The applicant is invited consider this aspect for inclusion also.
In terms of the findings of the Migratory Non-Seabirds Collision Risk Modelling (Appendix 11-06 of the EIAR), and noting the comments in the DAU submission, the conclusions arrived at in this regard, may rely on limited empirical data and the avoidance rates applied in the model for waterbirds are not up to date. The level of confidence with regard to avoidance rates for a significant proportion of waterbirds is very low and as such, the validity of the conclusions arrived at are potentially understated. It appears therefore, that the conclusion of the NIS may not be fully supported given the limitations identified. The applicant is requested to address these concerns, having regard to the DAU submission.
The applicant is requested to justify the screening out for further assessment of all passerines (Table 11-15 of the EIAR), which considers the risks to migrating passerines as negligible 'due to the relative size of the project and the behaviour of the birds (e.g. passage movements restricted to twice annual events, large population sizes and flight heights typically above risk height)'. It is noted that many hundreds of thousands of migrants come to Ireland for the winter, moving west as autumn progresses and returning north and east as spring advances. The applicant is requested to provide more information and assessment with regard to these species and to consider the potential effects of the development at the project level as well as cumulatively.

Terrestrial Bird Species:

Chapter 19 of the EIAR considers the potential effects of the project on onshore birds and intertidal birds and includes Appendix 19-02: Intertidal Bird Survey and Onshore Bird Survey Reports. The DAU note that the focus of data collection to support the application has been on marine-dwelling avifauna as opposed to land-based avifauna, with knowledge gaps with respect to transboundary and migratory movements of land-based avifauna in Irish waters and beyond. As such, it is noted that no new empirical data have been collected for land-based migratory birds as part of the monitoring programme, to detect and assess the
This would provide a better understanding of the potential impact and cumulative impacts of the project, and other ORE developments in terms of the Irish Sea. The applicant is requested to address these concerns, including those raised in the DAU submission on the project.
The CRM identifies 3 terrestrial bird species as being vulnerable to wind turbines, including Corncrake (*Crex crex)*, Merlin (*Falco columbarius)* and Hen Harrier (*Circus cyaneus)*. However, the predictive power of the model employed is low, particularly for species that are not foraging in the offshore area. As such, the use of SOSS2
2 Strategic Ornithological Support Services
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.

SHOVELER

Irish Name:	Spadalach
Scientific name:	*Anas clypeata*
Bird Family:	Ducks

Status
Resident & winter migrant. Most occur between October and March. Wintering birds originate from breeding populations which range across France, northern Europe, the Baltic and western Russia. Ireland and northern Britain also support the small Icelandic breeding population during the winter.

Identification
Medium to large sized with a long and broad bill. Males with green head, white breast, chestnut belly and flanks, blue upper forewing. Females similar to Mallard but distinguished by the bill and darker brown belly.

Voice
Disyllabic nasal knocking call of male when flushed. Female similar though more wheezy 'kerr-ash'.

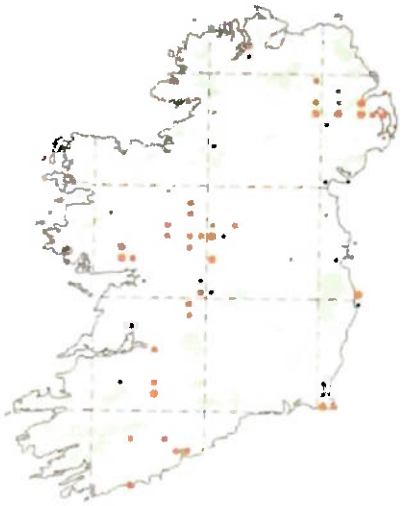
Diet
Feed predominantly on zooplankton which are found mostly on ephemeral wetlands, particularly turloughs and callows. They also feed on small molluscs, insects and larvae, seeds and plant material and are frequently seen dabbling around the edges of waterpools.

Breeding
Nests on the ground among waterside vegetation, often many nests in close proximity. Breeding in Ireland is centred around Lough Neagh and the mid- Shannon basin.

Wintering
Shoveler prefer shallow eutrophic waters rich in plankton, and occur on a variety of habitats while wintering in Ireland, including coastal estuaries, lagoons and inland lakes and callows.

Monitored by
Irish Wetland Bird Survey.

Resident population breeding mainly at inland lakes and waterways,
few at coastal estuaries.



Breeding Distribution

- Non-breeding
- Possible
- Probable
- Confirmed

Conservation Objectives for : Lough Corrib SPA [004042]

A056 **Shoveler *Anas clypeata***

To restore the favourable conservation condition of shoveler in Lough Corrib SPA, which is defined by the following list of attributes and targets:

Attribute	Measure	Target	Notes
Winter population trend	Percentage change in number of individuals	Long term winter population trend is stable or increasing	The national population of over-wintering shoveler in Ireland has declined by 11% from 1994/95 to 2019/20, as monitored via the Irish Wetland Bird Survey (I-WeBS; Kennedy et al., 2022). During the baseline assessments to inform SPA designation, 90 shoveler were estimated to be using this SPA (5 year mean of peak counts for baseline period 1995/96 to 1999/2000; see NPWS, 2013). More recent data showed a population of 15 shoveler were estimated to be using the SPA from 2012/13 to 2016/17 (3 year mean of peak counts from I-WeBS monitoring in 2012/13, 2013/14 and 2016/17). This represents a long term population decrease of 84% since the baseline period. This decline is significantly greater than the national trend. Note: the baseline and recent population estimates rely on survey data from the lower (southern) area of the lake
Winter spatial distribution	Hectares, time and intensity of use	Sufficient number of locations, area, and availability (in terms of timing and intensity of use) of suitable habitat to support the population target	Distribution encapsulates the number of locations and area of potentially suitable habitat for the wintering population and its availability for use. The suitability and availability of habitat areas are likely to vary throughout the season, for example, due to variation in land management practices or the abundance of resources available (due to natural variation and other factors). This will affect the spatio-temporal patterns of use of the habitats by the wintering population
Disturbance at wintering site	Intensity, frequency, timing and duration	Disturbance occurs at levels that do not significantly impact the achievement of targets for population trend and spatial distribution	The impact of any significant disturbance (direct or indirect) to the over-wintering population will ultimately affect the achievement of targets for population trend and/or spatial distribution. Disturbance contributes to increased energetic expenditure which can result in increased likelihood of over-winter mortality or reduced fitness (if energy expenditure is greater than energy gain) and, in turn, negatively impact population trends (see, for example, Madsen and Fox, 1995). Factors such as intensity, frequency, timing and duration of a (direct or indirect) disturbance source must be taken into account to determine the potential impact upon the targets for population trend and spatial distribution
Barriers to connectivity and site use	Number, location, shape and hectares	Barriers do not significantly impact the wintering population's access to the SPA or other ecologically important sites outside the SPA	Barriers limiting the population's access to this SPA or ecologically important sites outside the SPA will ultimately affect the achievement of targets for population trend and/or spatial distribution. Factors such as the number, location, shape and area of potential barriers must be taken into account to determine their potential impact
Forage spatial distribution, extent and abundance	Location, hectares, and forage biomass	Sufficient number of locations, area of suitable habitat and available forage biomass to support the population target	Foraging habitats include a range of wetlands, such as marshes, rivers, flood-waters, lakes, reservoirs, lagoons and estuaries, as well as grasslands. Shoveler are omnivorous and primarily forage at the surface (dabbling or up-ending) but also dive. The species demonstrates a highly specialised filter-feeding behaviour which allows it to consume a wide variety of planktonic prey items, including crustaceans, molluscs, insects, larvae and various plant materials. It can also dabble for these prey items

Roost spatial distribution and extent	Location and hectares of roosting habitat	Sufficient number of locations, area and availability of suitable roosting habitat to support the population target	Roosting is a critical ecological requirement for the over-wintering population. When roosting overnight, shoveler primarily utilise wetlands (see foraging habitats). Daytime roosting is also a common behaviour, where birds minimise activity levels to conserve energy, while benefitting from the vigilance of other flock members. A lack of sufficient and suitable roosting habitats can result in increased mortality risk, whether indirectly (e.g. via increased energy expenditure travelling to/from roost sites) or directly (e.g. via increased predation risk), or reduction in site use; this would ultimately affect the achievement of targets for population trend and/or spatial distribution

TUFTED DUCK

Irish Name:	Lacha bhadánach
Scientific name:	*Aythya fuligula*
Bird Family:	Ducks

Status
Resident & winter visitor. Birds breeding in southeast England have been seen to move to Ireland, possibly influenced by cold weather.

Identification
Small and short-bodied, with large head and crest which is longer in breeding males than other plumages or females. Males with black plumage, white flanks, yellow eye and blue-grey bill. Females largely brown with paler flanks, resembles Scaup, especially with some showing extensive white band around the base of the bill.

Voice
Display call described as nervous, quick, bubbly series of accelerating notes.

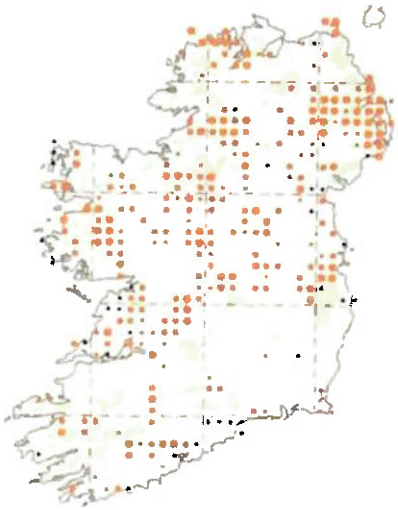
Diet
Feed predominantly on mussels, and to a lesser extent on crustaceans, insect larvae (particularly caddis-fly) and bryozoans.

Breeding
Show a preference for large open lakes in lowland areas, where nests are built in waterside vegetation. Many nests in close proximity to each other.

Wintering
Lowland freshwater lakes. Often seen on town lakes, canals and slow-moving rivers.

Monitored by
Irish Wetland Bird Survey.

Widespread resident with numbers increasing in Autumn and Winter from an influx of birds from Scandinavia. Loughs Neagh & Beg in County Antrim the most important site, supporting >20,000 birds. Lough Corrib in County Galway, Lough Ree in County Longford, Lough Ennell in County Westmeath and Lough Derg (Shannon) in County Tipperary are other important wintering sites (1,000-6,000 birds).



Breeding Distribution

- Non-breeding
- Possible
- Probable
- Confirmed

Conservation Objectives for : Lough Corrib SPA [004042]

A061 Tufted Duck *Aythya fuligula*

To restore the favourable conservation condition of tufted duck in Lough Corrib SPA, which is defined by the following list of attributes and targets:

Attribute	Measure	Target	Notes
Winter population trend	Percentage change in number of individuals	Long term winter population trend is stable or increasing	The Irish national population of over-wintering tufted duck has declined by 18% from 1994/95 to 2019/20, as monitored via the Irish Wetland Bird Survey (I-WeBS; Kennedy et al., 2022). During baseline assessments to inform SPA designation, 5,486 tufted duck were estimated to be using this SPA (5 year mean of peak counts for baseline period 1995/96 to 1999/2000; see NPWS, 2013). Latest available data showed a population of 2,399 tufted duck were estimated to be using the SPA during the period 2012/13 to 2016/17 (4 year mean of peak counts from I-WeBS monitoring, excluding winter 2015/16). This represents a population decrease of 56% since the baseline period. This trend is significantly greater than the noted national population decline. Population declines are likely linked, at least in part, to distribution shifts driven by climate change (see Pavón-Jordan et al., 2018). Note: the baseline and recent population estimates rely on survey data from the lower (southern) area of the lake
Winter spatial distribution	Hectares, time and intensity of use	Sufficient number of locations, area, and availability (in terms of timing and intensity of use) of suitable habitat to support the population target	Distribution encapsulates the number of locations and area of potentially suitable habitat for the wintering population and its availability for use. The suitability and availability of habitat areas is likely to vary throughout the season, for example, due to variation in land management practices or the abundance of resources available (due to natural variation and other factors). This will affect the spatio-temporal patterns of use of the habitats by the wintering population
Disturbance at wintering site	Intensity, frequency, timing and duration	Disturbance occurs at levels that do not significantly impact the achievement of targets for population trend and spatial distribution	The impact of any significant disturbance (direct or indirect) to the over-wintering population will ultimately affect the achievement of targets for population trend and/or spatial distribution. Disturbance contributes to increased energetic expenditure which can result in increased likelihood of over-winter mortality or reduced fitness (if energy expenditure is greater than energy gain) and, in turn, negatively impact population trends (see, for example, Madsen and Fox, 1995). Factors such as intensity, frequency, timing and duration of a (direct or indirect) disturbance source must be taken into account to determine the potential impact upon the targets for population trend and spatial distribution
Barriers to connectivity and site use	Number, location, shape and hectares	Barriers do not significantly impact the wintering population's access to the SPA or other ecologically important sites outside the SPA	Barriers limiting the population's access to this SPA or ecologically important sites outside the SPA will ultimately affect the achievement of targets for population trend and/or spatial distribution. Factors such as the number, location, shape and area of potential barriers must be taken into account to determine their potential impact

Forage spatial distribution, extent and abundance	Location, hectares, and forage biomass	Sufficient number of locations, area of suitable habitat and available forage biomass to support the population target	This species is omnivorous and forages primarily in open freshwater or brackish waterbodies. Molluscs are the main food source, and hence the species prefers shallow areas (to c. 15m depth), but will also consumes fish, insects, amphibians and various plant materials (leaves, shoots, tubers, seeds). Tufted duck feed primarily by diving, but to a lesser extent will also feed at the surface of waterbodies, wade in shallows, and forage onshore (e.g. for cereal grain). Utilised habitats include lakes, rivers, ponds, reservoirs, marshes, estuaries, lagoons, and (less so) coastal areas. In winter, individual tufted duck can forage alone or or as part of large aggregations
Roost spatial distribution and extent	Location and hectares of roosting habitat	Sufficient number of locations, area and availability of suitable roosting habitat to support the population target	When roosting overnight, the species uses a range of waterbodies, as noted for foraging habitat. Roosting is a critical ecological recuirement for the over-wintering population. Daytime roosting is also a common behaviour, where birds minimise activity levels to conserve energy, while benefitting from the vigilance of other flock members. A lack of sufficient and suitable roosting habitats can result in increased mortality risk, whether indirectly (e.g. via increased energy expenditure travelling to/from roost sites) or directly (e.g. via increased predation risk), or reduction in site use; this would ultimately affect the achievement of targets for population trend and/or spatial distribution

HEN HARRIER

Irish Name:	Cromán na gCearc
Scientific name:	*Circus cyaneus*
Bird Family:	Raptors

Status

Breeds in the uplands and bogs of Ireland.

Identification

Size between Montagu's Harrier and the larger Marsh Harrier. Females and juveniles similar - brown with white rump and dark rings on the tail, hence often referred to collectively as 'ringtails'. Females are bigger than males. Males very distinctive, appearing strikingly pale below, with blue grey upper parts and jet black wing-tips. Hen Harriers have somewhat of an owl-like face, particularly accentuated in female birds.

Voice

Usually only heard in the breeding season near the nest site. Quick, chattering calls in alarm and display and whistling calls from female to male, when receiving food.

Diet

Small birds and mammals, which are caught by surprise. Will sometimes use cover, such as woodland edges and bushes, to surprise prey.

Breeding

Breeding birds are confined largely to heather moorland and young forestry plantations, where they nest on the ground. Hen Harriers are found mainly in Counties Laois, Tipperary, Cork, Clare, Limerick, Galway, Monaghan, Cavan, Leitrim, Donegal and Kerry. The species has declined, probably due to the loss of quality moorland habitat due to agricultural changes, and maturing forest plantations. Hen Harriers mainly hunt over moorland whilst breeding where they take small ground nesting birds and mammals.

Wintering

Spends winter in more coastal and lowland areas throughout Ireland hence most easily seen on the coast in the winter months. Good sites include the North Slob Nature Reserve and Tacumshin Lake in County Wexford, as well as the East Coast Nature Reserve in Co. Wicklow.

Monitored by

BirdTrack and the Hen Harrier Roost Survey.

Breeding birds are confined largely to heather moorland.

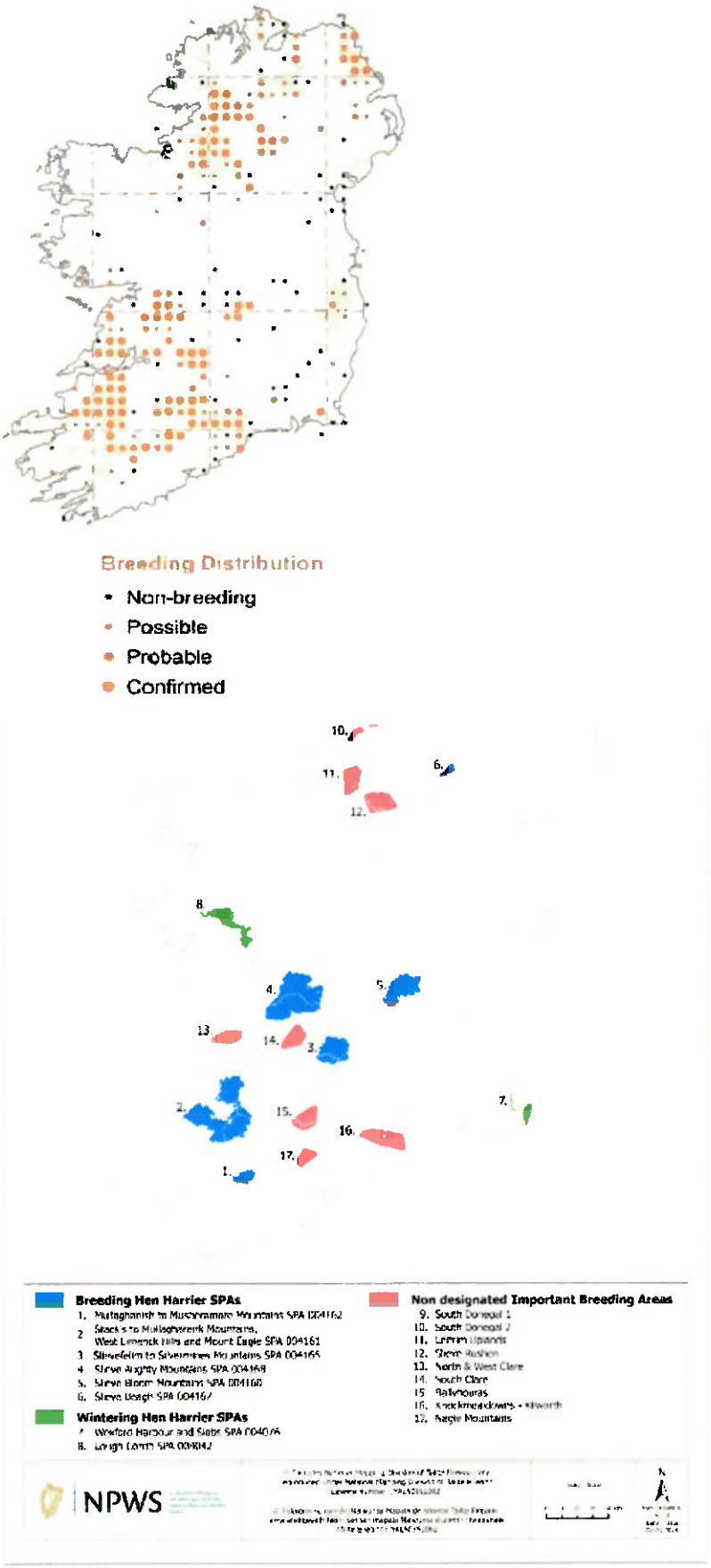


Figure 1. Map of Hen Harrier breeding and wintering SPAs, and non-designated regionally important areas.

6.1 Characteristics

The Hen Harrier is a medium sized raptor with long wings and tail. It possesses a hooked bill suitable for eating meat, like all raptors, and usually flies close to the ground with its wings held in a shallow 'V' above its back. Males are generally smaller than females while male and female adult plumage varies considerably. Adult males are blue-grey above and on the head and breast and white below. Additionally, males have broad black wing tips to both upper and lower wings and show white upper-wing coverts like female birds. Female birds are largely brown with fine markings and have white upper-wing coverts. The female tail is barred with dark bands and the body is streaked brown on a whitish background, especially on the breast. Juvenile birds resemble females but have darker secondary flight feathers, a rusty colour to the breast and less barring. This species is most similar to the Marsh Harrier (Circus aeruginosus).

6.2 Range in Ireland

The Hen Harrier has an extremely large range globally, stretching across the majority of the Palearctic from eastern Siberia to Ireland and south as far as North Africa and South East Asia (BirdLife International 2014). In Ireland, however, this species is a scarce summer visitor to uplands and bogs in western Ireland, as well as a scarce winter visitor to lowlands throughout Ireland. The predominance of this species distribution is found in Munster (notably the counties of Cork, Limerick and Kerry), southwest Leinster and the border counties, while more scarce winter roosts are mainly located in coastal regions of the south and east (Irwin et al. 2011).

6.3 Conservation status

The Hen Harrier is currently Amber-listed in Ireland due to a decline in the breeding population and continued persecution (Colhoun & Cummins 2013). Similarly, the UK population has been Red-listed (Hayhow et al. 2014). The European population of this species has been evaluated as Depleted due to a large historical decline and relatively low current population (less than 59,000 pairs). Though this decline has slowed in recent years, its population remains significantly lower than pre-decline assessments (BirdLife International 2004). This species is also listed under Annex I of the EC Council Directive on the Conservation of Wild Birds (2009/147/EC), with several Special Protection Areas (SPAs) designated for directed Hen Harrier protection. Internationally, the Hen Harrier is considered to be of Least Concern, owing to its extremely wide distribution despite recent taxonomic splits (BirdLife International 2014).

6.4 Population trend

Though the population of this species has stabilised in most of its European distribution since 2000 (BirdLife International 2004), it was once almost extinct in the wild in Britain and Ireland as a result of persecution (Watson 1977). This was followed by a large decline across it European distribution between 1970 and 1990 (BirdLife International 2004). There are currently an estimated 128 – 172 pairs in the Republic of Ireland (Ruddock et al. 2011) with a further 59 in Northern Ireland (Hayhow et al. 2013). Although, this figure represents an increase from a maximum of 129 pairs in 1998-2000 (Norris et al. 2002), substantial differences in surveying effort are thought to confound these estimates as more recent subsampling across surveys has revealed declines in some regions, particularly within several SPAs (J. Lusby pers. comm., 17th Apr. 2015). The UK and Isle of Man population of this species is estimated to have experienced an 18% decrease since 2004, with notable decreases in Scotland and the Isle of Man, likely as a result of habitat change and persecution (Hayhow et al. 2013). Changes to preferred uplands through afforestation and agricultural intensification (and particularly the availability of habitat and food) likely continue to threaten populations of this species (Irwin et al. 2011). It is thought that the carrying capacity of this species' breeding range is the most prominent limitation to current population levels (Norris et al. 2002).

6.5 Breeding ecology

Breeding Hen Harriers are confined to moorland and young forestry plantations, where they nest on the ground. In the spring, Hen Harrier pairs lay 1 - 6 eggs (Irwin et al. 2011). These are incubated for 34 days and fledge after an additional 37-42 days post-hatching, most of which has occurred by August (Irwin et al. 2011). Following this, individuals predominantly disperse to milder lowland and coastal areas for the winter, although some remain in upland breeding areas (Irwin et al. 2011). Pairs remain monogamous for the duration of breeding, apart from rare recordings of polygynous pairs (Scott 2010; Picozzi 1984). Adult survival is high in this species, at 0.81 annually. However, a longitudinal breeding biology report revealed that fledging success of Irish Hen Harriers, at 2.4 chicks per successful

breeding attempt, was lower than that of UK populations (Irwin et al. 2011). Though low, this is still regarded as being higher than the minimum effective replacement rate for this species.

6.6 Habitat requirements

Hen Harriers mainly hunt over moorland during the breeding season where they take ground nesting birds and mammals, which are caught by surprise using cover such as woodland edges and bushes. In particular, unmanaged grassland has been identified as important habitat for Hen Harrier feeding (Amar & Redpath 2005; Wilson et al. 2009). In general, Irish observations suggest that areas containing higher proportions of improved grassland are avoided (Wilson et al. 2009). Despite this and the assumed preference for open or younger-growth forestry, more recent assessments suggests that Hen Harrier feeding and breeding has been adapted to utilise older-growth forestry where necessary (Wilson et al. 2009). Time spent feeding differed between male and female birds and was significantly determined by vegetation height and proportion of managed grassland within a territory (Amar & Redpath 2005). It was thought that intensive sheep grazing, associated losses of heather (Calluna vulgaris) with increases in improved pasture and reductions on sward height have resulted in a contraction in suitable Hen Harrier feeding habitat.

6.7 Site fidelity

Though Hen Harriers may exhibit strong site fidelity, it is thought that persecution and continually changing forestry patterns may be reducing habitat predictability across breeding seasons and forcing more dispersed annual breeding. Whitfield and Fielding (2009) – in a study of Welsh Hen Harrier dispersal – found natal philopatry (the tendency to breed in a bird's place of birth) to be low, with average natal dispersal of 18.4 km for females and 12.1 km for males. The direction of this dispersal seemed universally towards areas of more suitable habitat. However, dispersal between breeding seasons exhibited much lower distances, with females dispersing significantly less than males and often breeding at the same site in consecutive years (Whitfield & Fielding 2009). Other observations have found that failed breeding attempts drive more distant breeding dispersal in subsequent years (Picozzi 1984).

6.8 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.

6.10 Data sources

Data for this assessment has been obtained from the results of extensive national Hen Harrier surveys conducted every 4-5 years in conjunction with the National Parks and Wildlife Service, the most recent of which was conducted in 2010 (Ruddock et al. 2011).

Conservation Objectives for : Lough Corrib SPA [004042]

A082 **Hen Harrier *Circus cyaneus***

To restore the favourable conservation condition of hen harrier in Lough Corrib SPA, which is defined by the following list of attributes and targets:

Attribute	Measure	Target	Notes
Roost attendance: individual hen harriers	Number	Long term winter population trend within the SPA is stable or increasing	Lough Corrib SPA holds Ireland's largest freshwater lake, along with numerous islands. Its lake fringe (e.g. reedbeds, calcareous fens) and terrestrial habitats (e.g. raised bog, scrub, wet grassland, deciduous birch woodland) provide roosting and foraging options for hen harriers and other raptors during the non-breeding season. However, the extent of suitable roost habitats, and limited visibility for observers in parts of the SPA, makes for challenging roost surveys. Further, more than one roost location can be occupied on any night. The four year mean peak recorded at this SPA (based on the period 2006/07 - 2009/10) was eight hen harriers, determined using standard survey methods (see O'Donoghue, 2011; 2019). Counts (NPWS unpublished data) indicate numbers regularly attending this communal roost site in the SPA have fallen over the past decade or so, likely linked to declines in the Slieve Aughty Mountains SPA breeding population ca. 30km away and nationally (NPWS, 2022)
Forage area spatial distribution, extent and abundance	Location and hectares; prey biomass	Sufficient extent of suitable habitats and biomass of available prey items across the site to help support the population	Key prey items: broad diet encompassing birds and mammals. The total extent of available foraging habitats are not defined here, but include the following key habitats: wetlands (including active and cutaway raised bog), scrub, grasslands and hedgerows. Adjacent areas outside the SPA are also likely used by hen harrier during the non-breeding season albeit to an unknown extent. As mentioned above, recent trends in numbers of harriers using this SPA during the non-breeding season are likely linked to declines in breeding populations elsewhere, as it is considered there has been little change in availability and condition of supporting habitats (and by association, prey biomass) for wintering harriers within the site over the past decade. However, maintaining sufficient availability of suitable foraging habitats across the site to help support the population is key
Roost spatial distribution and extent	Location and hectares of roosting habitat	Sufficient number of locations, area of suitable roosting habitat to support the population	This SPA holds a large communal nocturnal roost 'complex', with a number of locations used by hen harrier (and other raptor species) depending on factors such as water levels in the lake itself. Thus attendance at these locations, which can be kilometres apart, is variable on any given night. Confirmation of roost activity at some locations is more difficult due to due to the distances involved and lack of good vantage points, and so numbers observed on any survey may not accurately reflect roosting activity in the area. Thus, estimating a definitive size or extent for this roost complex is not possible, but ensuring sufficiency of suitable roosting options adjacent to the lake and on higher ground is necessary to provide adequate roost options and choice to help support the population for this SPA
Disturbance at the roost site	Level of impact	Human activities occur at levels that do not significantly impact upon wintering hen harrier	Hen harriers are sensitive to disturbance at roost sites during the non-breeding season. Factors such as location (e.g. proximity to roost site), intensity, frequency, timing and duration of a potentially disturbing activity (direct or indirect) need to be taken into account to determine its significance on the targets for the population, including roost attendance. Known pressures recorded locally at this SPA in the past and present day include wildfowling, burning, turf cutting; known pressures near/adjacent to the SPA have included clay pigeon shooting

COOT

Irish Name:	Cearc cheannann
Scientific name:	*Fulica atra*
Bird Family:	Crakes & Rails

Status

Resident at ponds and lakes throughout Ireland, augmented by winter visitors from the Continent and Britain - September to April.

Identification

A dark plump bird, similar to Moorhen in size and shape; has a short tail and small head. Useful to remember the old saying - 'as bald as a Coot' to remember the adult birds white forehead and bill, which contrast with its grey body and black head. Has sturdy legs with long lobbed toes, the lobes are used for swimming and are similar to the lobes on grebe toes. Dives from the surface with a small leap. The juvenile is brownish grey and can be told apart from juvenile moorhens by the extensive white on the neck and breast and the absence of any white on the under tail.

Voice

Various calls. Some loud, monosyllabic and often repeated. A frequent call sounds like a stone being struck with a metal bar, explosive and sharp.

Diet

Omnivorous. Feed on both plants and animals, but mainly on plants. Food taken from the water surface, including emergent plants and whilst diving. Food includes plant shoots, seeds, insects, algae and fish. Will sometimes steal food from other birds, off it own species or from other species, such as ducks.

Breeding

This species is not as widespread as the Moorhen as it requires larger bodies of water on which to nest. They nest in large shallow water bodies that are rich in nutrients and have abundant bottom vegetation for food and some emergent vegetation for nest anchorage. Widespread but absent from parts of Kerry, Cork, south-west Clare, west Galway, Mayo, Sligo and Donegal.

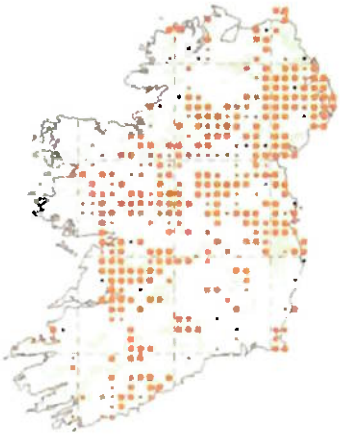
Wintering

Winter distribution is more widespread than breeding distribution, birds are found on lakes, coastal estuaries and river systems, but show a clear preference for large inland lakes.

Monitored by

Irish Wetland Bird Survey.

Common and widespread resident. Sedentary. Nesting on slow flowing watercourses and still water with reed fringes.



Breeding Distribution

- Non-breeding
- Possible
- Probable
- Confirmed

Conservation Objectives for : Lough Corrib SPA [004042]

A125 **Coot *Fulica atra***

To restore the favourable conservation condition of coot in Lough Corrib SPA, which is defined by the following list of attributes and targets:

Attribute	Measure	Target	Notes
Winter population trend	Percentage change in number of individuals	Long term population trend stable or increasing	The national population of over-wintering coot in Ireland has declined by 23% from 1994/95 to 2019/20, as monitored via the Irish Wetland Bird Survey (I-WeBS; Kennedy et al., 2022). During the baseline assessments to inform SPA designation, 14,426 coot were estimated to be using this SPA (5 year mean of peak counts for baseline period 1995/96 to 1999/2000; see NPWS, 2013). The latest available data shows a population of 1,912 coot were estimated to be using the SPA during the period 2012/13 to 2016/17 (4 year mean of peak counts from I-WeBS monitoring, excluding winter 2015/16). This represents a population decrease of 87% since the baseline period. This trend is significantly greater than the noted national population decline. Population declines are likely linked, at least in part, to distribution shifts driven by climate change (see Pavón-Jordan et al., 2018). Note: the baseline and recent population estimates rely on survey data from the lower (southern) area of the lake
Winter spatial distribution	Hectares, time and intensity of use	Sufficient number of locations, area, and availability (in terms of timing and intensity of use) of suitable habitat to support the population target	Distribution encapsulates the number of locations and area of potentially suitable habitat for the wintering population and its availability for use. The suitability and availability of habitat areas is likely to vary throughout the season, for example, due to variation in land management practices or the abundance of resources available (due to natural variation and other factors). This will affect the spatio-temporal patterns of use of the habitats by the wintering population
Disturbance at wintering site	Intensity, frequency, timing and duration	Disturbance occurs at levels that do not significantly impact the achievement of targets for population trend and spatial distribution	The impact of any significant disturbance (direct or indirect) to the over-wintering population will ultimately affect the achievement of targets for population trend and/or spatial distribution. Disturbance contributes to increased energetic expenditure which can result in increased likelihood of over-winter mortality or reduced fitness (if energy expenditure is greater than energy gain) and, in turn, negatively impact population trends (see, for example, Madsen and Fox, 1995). Factors such as intensity, frequency, timing and duration of a (direct or indirect) disturbance source must be taken into account to determine the potential impact upon the targets for population trend and spatial distribution
Barriers to connectivity and site use	Number, location, shape and hectares	Barriers do not significantly impact the wintering population's access to the SPA or other ecologically important sites outside the SPA	Barriers limiting the population's access to this SPA or ecologically important sites outside the SPA will ultimately affect the achievement of targets for population trend and/or spatial distribution. Factors such as the number, location, shape and area of potential barriers must be taken into account to determine their potential impact
Forage spatial distribution, extent and abundance	Location, hectares, and forage biomass	Sufficient number of locations, area of suitable habitat and available forage biomass to support the population target	This species is omnivorous; plants dominant the diet but it will also take invertebrate and vertebrate prey. It forages primarily in waterbodies, rarely foraging far from them. The species feeds at the surface and sub-surface of waterbodies by up-ending and diving. It prefers shallow, open, slow moving waterbodies with marginal, floating, emergent or bottom vegetation. Foraging habitats utilised by the coot include rivers, canals, lakes, reservoirs, ponds, lagoons, estuaries, drainage channels and flooded lands. In winter, individual coot can forage alone or or as part of large aggregations

Roost spatial distribution and extent	Location and hectares of roosting habitat	Sufficient number of locations, area and availability of suitable roosting habitat to support the population target	When roosting overnight, coot use a range of waterbodies, as noted for foraging habitat. Roosting is a critical ecological requirement for the over-wintering population. Daytime roosting is also a common behaviour, where birds minimise activity levels to conserve energy, while benefitting from the vigilance of other flock members. A lack of sufficient and suitable roosting habitats can result in increased mortality risk, whether indirectly (e.g. via increased energy expenditure travelling to/from roost sites) or directly (e.g. via increased predation risk), or reduction in site use; this would ultimately affect the achievement of targets for population trend and/or spatial distribution

GOLDEN PLOVER

Irish Name:	Feadóg bhuí
Scientific name:	*Pluvialis apricaria*
Bird Family:	Plovers

Status
Summer visitor from France & Iberia (though possibly some remain year-round in Ireland) & winter visitor from Iceland. Most in Ireland between October & February

Identification
Smaller than Grey Plover, with narrower, more pointed wings. Golden brown upperparts, which look grey at close range. Males in summer have more black below than females - extends from throat, towards each eye, and ventrally under neck, chest and belly. In winter, males and females similar in appearence, with no black underparts.

Voice
Flat whistle 'puu' in flight or when alarmed. Rythmic song 'pu-pee-oo' repeated in display flight, often followed by a repeated 'perpurrlya' when alighting, or when on the ground.

Diet
Feed on a variety of soil and surface-living invertebrates, principally beetles and earthworms, but also on plant material such as berries, seeds and grasses. They regularly feed in association with Lapwing & Black-headed Gulls.

Breeding
Breed in heather moors, blanket bogs & acidic grasslands. Distribution limited to the uplands of northwest counties in Ireland.

Wintering
Throughout the winter, Golden Plovers are regularly found in large, densely-packed flocks, and in a variety of habitats, both coastal and inland. Their distribution is widespread in Ireland.

Monitored by
Irish Wetland Bird Survey.

Breeding 4.1 Characteristics

The Golden Plover is a medium-sized stout breeding wader, with narrow, pointed wings and mottled golden brown upperparts which, in winter, look grey at close range. Males in summer have more black below than females, which extends from the throat towards each eye and ventrally under the neck, chest and belly. In winter, males and females are similar in appearance, with no black underparts.

4.2 Range in Ireland

This species is a partially migratory summer visitor from France and Iberia, though some occasionally remain year-round in Ireland, moving to the coast or suitable inland areas in winter. At this time, between October & February, the Irish population is significantly inflated by the arrival of migrants from Iceland. The breeding (summer) distribution in Ireland is limited to the uplands of western and north-western counties in Ireland (Cummins et al. 2003; Cummins et al. 2004). Though this breeding distribution is sparse, notable localities include the isolated uplands of Donegal,

western Mayo and south-western Galway. More recent resurveying of formerly occupied coastal machair sites of Sligo have resulted in these being lost from this species' breeding distribution since surveys of 1996 (Suddaby et al. 2010; Madden et al. 1998). At several of these sites, no evidence of breeding success was observed. More recent surveys of the Connemara Bog Complex SPA are currently underway, as part of National Parks and Wildlife Service monitoring efforts.

4.3 Conservation status

The Golden Plover is Red-listed in Ireland, as it has been for some time (Lynas et al. 2007; Colhoun & Cummins 2013), due to large declines in its breeding population and breeding range and more recent declines in wintering populations. The European population is considered Secure. Though declines were recorded in several populations in Western Europe, this was compensated for by increases in its Finnish population and stability elsewhere (BirdLife International 2004). This is further regarded as being of Least Concern internationally by the IUCN (BirdLife International 2012). Given its significant regional declines, this species is also listed under Annex I of the EC Council Directive on the Conservation of Wild Birds (2009/147/EC). It is thought that the southern extremities of its European breeding range (including populations in Ireland and the UK) have been in decline since the 19th Century (Tucker & Heath 1994).

4.4 Population trend

Currently, estimates of the Irish population of Golden Plover stand at circa. 120 pairs (Colhoun and Cummins 2013). In Ireland, this species has experienced a 40% population reduction in the last 20 years, while declines of up to 73% have been recorded in the breeding population between 1988/91 and 2008 (Lauder & Donaghy 2008). Similar declines in Britain have been attributed to afforestation and agricultural intensification (Boobyer 1992) which is likely a common driver of loss in Ireland also. A recent resurvey of 32 suitable machair sites within the Golden Plover's known range revealed a complete absence of breeding pairs, including a disappearance from formerly occupied Sligo machair (Suddaby et al. 2010), although Machair is not this species primary breeding habitat. This report warns that this current downward trend risks local extinction of this species as a breeding population. This same report did, however, find Golden Plover to be the most numerous species at other sites, though these large aggregations were thought to be passage migrants. Adult survival is low in comparison to other species at 0.73 (Sandercock 2003), meaning that any recovery of this species with improved habitat protection or restoration will be slow.

4.5 Breeding ecology

Golden Plovers nests consist of a shallow scrape on bare ground, usually in areas of low vegetation. This species is not a colonial nester though pairs may nest within 100m of each other. Nesting densities are conventionally much lower than this, however. A single clutch of 3-4 eggs is usually laid from April – May and is incubated for 28 – 31 days (Snow & Perrins 1998). Hatching success of these eggs was in other studies affected by predation by Carrion Crows (Corvus corone), Common Gull (Larus canus), American Mink (Mustela vison) and Foxes (Vulpes vulpes) (Parr 1993), while the breeding of Irish waders in general are thought be impacted by similar predation effects (Suddaby et al. 2010) . Adult foraging while nesting is widely dispersed, between 6 - 8 km during daylight and 2 - 3 km nocturnally (Pearce-Higgins & Yalden 2003).

4.6 Habitat requirements

During the breeding season, this species requires areas of heather (Calluna vulgaris) moors, blanket bogs & acidic grasslands for nesting, favouring those areas with shorter vegetation (Snow & Perrins 1998). Their selection and use of habitat seems strongly correlated with prey abundance and availability, and not necessarily with lower levels of disturbance experienced at these sites (PearceHiggins & Yalden 2003). Arable fields were predominantly used as feeding ground during breeding, with a strong preference shown for shorter grassland areas of this range. Nesting birds will forage several kilometres around these sites on a variety of invertebrates, principally beetles & earthworms, but also on plant material such as berries, seeds & grasses (Pearce-Higgins & Yalden 2003). A study on Golden Plover chick habitat selection found that they neither select for exclusively heather- or grass-dominated habitats, but favour areas of mixed cover consisting of heather and grass or mire dominated by bog-cotton (Eriophorum vaginatum) (Whittingham et al. 2001). Again, availability of suitable prey was found to be the main determinant. Additionally it was concluded that vegetation structure, including concealment from predators, may influence habitat use. Though

areas of calcareous grassland contained higher densities of suitable invertebrates, their exposed nature reduced this habitats utilization (Whittingham et al. 2001).

4.7 Site fidelity Given the Golden Plover's already limited distribution, remaining suitable habitat within its current range is of high priority. Though little research has been done on this aspect of the Golden Plover's ecology, limitations associated with habitat availability likely result in high site fidelity. The high specificity of breeding and feeding site selection of both adults and young (Snow & Perrins 1998; Whittingham et al. 2001) suggests that restriction to within these areas will remain so in the future. Though site selection of this species is narrow, disturbance within these sites as a result of wind energy developments was found to be very low in a recent assessment (Douglas et al. 2011), in contrast to the behavioural disturbance caused by walking tourists observed across a longitudinal study of a British Golden Plover population (Finney et al. 2005).

4.8 Sensitivity to development of wind energy

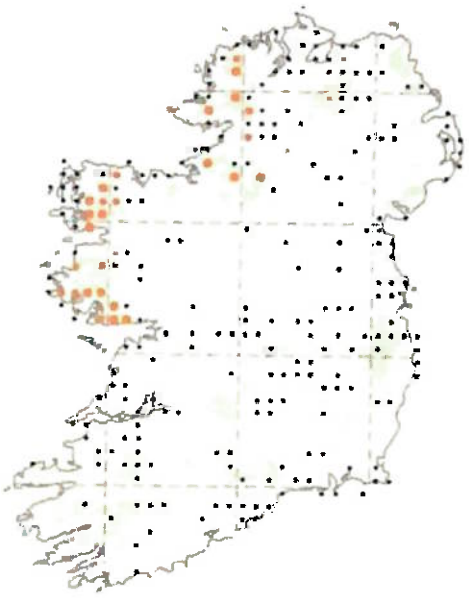
In general, breeding waders were identified by an EU assessment of wind energy impacts as being particularly susceptible to disturbance displacement and barriers to movement (Commission 2011). Collision risk for waders is generally deemed to be low, due to a relatively low cursory flight path, coupled with high flight manoeuvrability. A review of pan-European collision assessments revealed much lower Golden Plover collision records than other species, though this was not controlled for survey effort or corpse recovery rates (Hötker et al. 2006). An assessment of disturbance to Golden Plover nesting sites by walking tourists revealed substantially reduced habitat use with 200 m of unimproved paths and to within 50 m of improved paths which contained tourists more effectively. Generally, reduced use of suitable habitat surrounding operating turbines, to within 200 m of the turbine base, has been recorded (Pearce-Higgins et al. 2009). Additionally, a review of 29 other studies suggests Golden Plover will approach wind turbines to an average distance of 175 m in non-breeding season (Hötker et al. 2006), with turbine height positively correlated with displacement distance. Further, modelling of wind energy developments and potential Golden Plover habitat found a negative relationship between wind farms and predicted populations of this species (Pearce-Higgins et al. 2008). However, a recent paper by Douglas et al. (2011) revealed that the installation of wind farms had no observable effect on populations or distributions of breeding Golden Plover up to three years after the completion and operation of turbines. Conversely, disturbance effects observed by Hötker et al. (Hötker et al. 2006) were found in 72% of Golden Plover sites, though these data pertained to non-breeding birds only. This is supported by a longitudinal study of British Golden Plover in the Pennines which revealed that, though birds were disturbed often, reproductive performance did not fall (Finney et al. 2005). Furthermore, post-construction monitoring at 15 upland wind farms showed no significant decline in populations (Pearce-Higgins et al. 2012). Most disturbance effects were measured during the construction phase of these projects. Thus, current research indicates that care be taken in the planning of turbine height and with due diligence during construction of wind farms, especially when positioned on habitat known to support breeding Golden Plovers.

4.9 Zone of Sensitivity

Avoidance of wind turbines and associated infrastructure by breeding Golden Plovers has been observed at distances of at least 200 m (Pearce-Higgins et al. 2008; Finney et al. 2005), with strong correlation between turbine height and disturbance displacement (Hötker et al. 2006). Previous sensitivity mapping assessments have used no zone of sensitivity around Golden Plover habitat, instead demarcating Special Protected Areas (SPAs), within which this species occurs, as an indication of potential distribution. Additional to displacement, collision and barriers effects while migrating for forage up to 10km from nesting sites (Pearce-Higgins & Yalden 2003), as well as consideration of expert opinion, have resulted in the zone of sensitivity for this species being assigned a radius of 800 m around known breeding sites. Though this exceeds smaller recommended distances, the assigned radius allows for ranging around point locations and accounts for increased disturbance. In addition, Irish breeding populations of waders are at greater threat generally through habitat loss and disturbance.

4.10 Data sources

Data for this assessment was obtained from the Upland Bird Survey (Cummins et al. 2004; Cummins et al. 2003), the Resurvey of breeding wader populations of machair and associated wet grasslands in north-west Ireland, as commissioned by the National Parks and Wildlife Service (Suddaby et al. 2010)and the Irish Wetland Bird Survey (Boland & Crowe 2012).



Breeding Distribution

- Non-breeding
- Possible
- Probable
- Confirmed

Conservation Objectives for : Lough Corrib SPA [004042]

A140 Golden Plover *Pluvialis apricaria*

To maintain the favourable conservation condition of golden plover in Lough Corrib SPA, which is defined by the following list of attributes and targets:

Attribute	Measure	Target	Notes
Winter population trend	Percentage change in number of individuals	Long term winter population trend is stable or increasing	The national population of over-wintering golden plover in Ireland has declined by 54% from 1994/95 to 2019/20, as monitored via the Irish Wetland Bird Survey (I-WeBS; Kennedy et al., 2022). During the baseline assessments to inform SPA designation, 1,727 golden plover were estimated to be using this SPA (5 year mean of peak counts for baseline period 1995/96 to 1999/2000; see NPWS, 2013). A population of 2,088 golden plover was estimated to be using the SPA recently (4 year mean of peak counts from I-WeBS monitoring 2012/13 to 2016/17, excluding winter 2015/16; I-WeBS, 2022). This represents a population increase of 21% since the baseline period. Note: the baseline and recent population estimates rely on survey data from the lower (southern) area of the lake
Winter spatial distribution	Hectares, time and intensity of use	Sufficient number of locations, area, and availability (in terms of timing and intensity of use) of suitable habitat to support the population target	Distribution encapsulates the number of locations and area of potentially suitable habitat for the wintering population and its availability for use. The suitability and availability of habitat areas are likely to vary throughout the season, for example, due to variation in land management practices or the abundance of resources available (due to natural variation and other factors). This will affect the spatio-temporal patterns of use of the habitats by the wintering population

Disturbance at wintering site	Intensity, frequency, timing and duration	Disturbance occurs at levels that do not significantly impact the achievement of targets for population trend and spatial distribution	The impact of any significant disturbance (direct or indirect) to the over-wintering population will ultimately affect the achievement of targets for population trend and/or spatial distribution. Disturbance contributes to increased energetic expenditure which can result in increased likelihood of over-winter mortality or reduced fitness (if energy expenditure is greater than energy gain) and, in turn, negatively impact population trends (see, for example, Madsen and Fox, 1995). Factors such as intensity, frequency, timing and duration of a (direct or indirect) disturbance source must be taken into account to determine the potential impact upon the targets for population trend and spatial distribution
Barriers to connectivity and site use	Number, location, shape and hectares	Barriers do not significantly impact the wintering population's access to the SPA or other ecologically important sites outside the SPA	Barriers limiting the population's access to this SPA or ecologically important sites outside the SPA will ultimately affect the achievement of targets for population trend and/or spatial distribution. Factors such as the number, location, shape and area of potential barriers must be taken into account to determine their potential impact. Access to ecologically important sites outside the SPA must also be considered as a single SPA may not satisfy all the ecological requirements of the wintering population, and it may require access to other SPAs or sites for certain activities, such as foraging when preferred foraging areas are unavailable due to disturbance, extensive flooding, or other factors
Forage spatial distribution, extent and abundance	Location, hectares, and forage biomass	Sufficient number of locations, area of suitable habitat and available forage biomass to support the population target	This species forages exclusively at ground level and relies primarily on surface and sub-surface dwelling invertebrate prey, consuming a wide variety of prey items. The species is reliant on open habitats, including a wide range of wetland habitats such as the edges of lakes, turloughs, river floodplains, lagoons, estuaries, intertidal flats and other wetlands, as well as grasslands (wet grassland, semi-improved and improved grasslands), stubble fields and ploughed farmlands. While golden plover primarily forage diurnally, the species is also known to feed nocturnally on clear and moonlit nights
Roost spatial distribution and extent	Location and hectares of roosting habitat	Sufficient number of locations, area and availability of suitable roosting habitat to support the population target	Golden plover roost exclusively at ground level. Roosting is a critical ecological requirement for the over-wintering population. When roosting over-night, this species typically utilises a similar range of habitats as noted for foraging. Day-time roosting is also a common behaviour, where birds minimise activity levels to conserve energy, while benefitting from the vigilance of other flock members. A lack of sufficient and suitable roosting habitats can result in increased mortality risk, whether indirectly (e.g. via increased energy expenditure travelling to/from roost sites) or directly (e.g. via increased predation risk), or reduction in site use; this would ultimately affect the achievement of targets for population trend and/or spatial distribution
Supporting habitat: area and quality	Hectares and quality	Sufficient area of utilisable habitat available in ecologically important sites outside the SPA	The wintering population can make extensive use of suitable habitats in important areas outside the SPA, for foraging and roosting. The extent, availability and quality of these supporting habitats may be of importance for the resilience of the SPA population. Suitable supporting habitats include those highlighted in the attributes for foraging and roosting habitat

BLACK HEADED GULL

Irish Name:	Sléibhín
Scientific name:	*Larus ridibundus*
Bird Family:	Gulls

Status

Resident along all Irish coasts, with significant numbers arriving from the Continent in winter. Breeds in small numbers on islands in larger lakes in western Ireland.

Identification

A small gull, slightly smaller than Common Gull. Adults are pale grey above and white below. Adults are easily told apart from other Common Gull species by the thick white leading edge to outer wing, which can be seen at some distance. A blackish area bordering the white leading edge of the underwing is also evident. Pointed wings, and a small tail and head in proportion to the body, along with a long neck give a distinctive profile compared to other gulls. Adults have red legs, and in summer plumage, a dark brown hood on the head; in the winter, the hood in absent and is replaced by a dark spot behind the eye. Black-headed Gulls have two age groups, and attains adult plumage after one year when it moults into adult winter plumage. Young birds just out of the nest are finely patterned on the upperparts in ginger and brown and show a black tail band. First winter and first summer birds retain the wing and tail markings of the juvenile bird, but show grey on the mantle and in the first summer, a hood with a variable amount of white mixed in with the brown. Just after the bird is one year old it moults into adult winter plumage.

Voice
Strident, down slurred call. Can be very noisy at colonies.

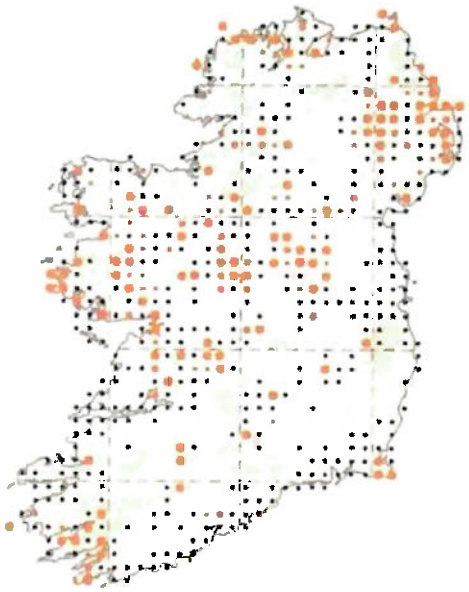
Diet
Feeds on insects especially in arable fields. Will also exploit domestic and fisheries waste.

Breeding
Breeds both on the coast and inland where they will often nest in colonies. Usually, nests on the ground in wetland areas, such as bogs and marshes and will also use man made lakes. Numbers breeding inland have declined dramatically, probably due to predation by the American Mink, which is an able swimmer and is able to access previously inaccessible nesting areas. The largest colonies in Ireland are in Northern Ireland on Lough Neagh. Colonies in the Republic are not widespread, the largest are found inland in Counties Galway, Monaghan and Mayo and at coastal sites in Counties Wexford and Donegal

Wintering
Irish birds are augmented by wintering birds from northern and eastern Europe and are widespread on both on the coast and inland.

Monitored by
Wintering birds are monitored through the Irish Wetland Bird Survey. Breeding seabirds are monitored through breeding seabird surveys carried out every 15-20 years.

Widespread resident. The gull most likely to be seen inland. Breeding on major inland lakes.



Breeding Distribution

- Non-breeding
- Possible
- Probable
- Confirmed

10.1 Characteristics

The Black-headed Gull is a small gull, slightly smaller than a Common Gull (Larus canus). Adults are pale grey above with white below and are easily told apart from other common gull species by the thick white leading edge to the upper surface of the outer wing, which can be seen at some distance. Pointed wings, and a short tail and head in proportion to the body, along with a long neck, give a distinctive profile compared to other gulls. Adults have red legs and in summer plumage a dark brown hood on the head. In the winter, the hood is absent and is replaced by a dark spot behind the eye.

10.2 Range in Ireland

The Black-headed Gull is a widespread Palaearctic species, ranging from Western Europe to Japan. In Ireland, this species can be found along all coasts, with significant numbers arriving from mainland Europe in winter. Though once a common bird, it now exists at much lower numbers across much of its Irish range and has experienced closely recorded declines in the recent past (Boland & Crowe 2012). This species now breeds sparsely across the midlands, though more prominent breeding sites in the Republic can be found at large lakes in the west in counties Galway and Mayo. Coastal sites in counties Wexford and Donegal are also important for this species breeding population.

10.3 Conservation status

Though significant populations exist elsewhere in the Palaearctic, Black-headed Gulls have been placed on the Red-list of Birds of Conservation Concern in Ireland since 2007, owing to a rapidly declining and localised breeding population (Lynas et al. 2007; Colhoun & Cummins 2013). The European population of this species is regarded as Secure, despite declines in several countries (BirdLife International 2004). The aggregate global population of this species has been assessed as Least Concern (BirdLife International 2012).

10.4 Population trend

Winter populations of this species are augmented by wintering birds from northern and eastern Europe (Wernham et al. 2002). Though once a common and widespread species with a considerable resident population, numbers breeding inland have declined dramatically. This is probably due to predation by the American Mink which, as an able swimmer, can access previously inaccessible nesting areas. Though declines are difficult to estimate given the irregularity of surveys and their wide distribution, some studies estimate that the species has experienced a 50% decline in overall mean and annual peak numbers (Boland & Crowe 2012). Other studies have identified a particular

decline in coastal breeding numbers (Mitchell et al. 2004). Of note, populations in the Dublin Bay area declined by almost 60% in just under a decade, from 1995 - 2004 (Merne et al. 2009).

10.5 Breeding ecology

Black-headed Gulls predominantly nest colonially, between April and July, often with other species of gulls and terns (Snow & Perrins 1998), preferring inland breeding sites over coastal locations. These include temporarily flooded, well-vegetated wetlands such as lake margins, river banks, lagoons, estuaries and tussocky marshes. This species is also known to use manmade structures and habitats as a nesting ground, such as gravel pits, sewage ponds and canals. Nests are ground-level and consist of rough vegetation on a shallow scrape on vegetation mats, reeds, grass and International 2014). Pairs will usually lay clutches of 2-3 eggs, which are incubated for 23-26 days. Though juvenile survival for this species is low at 0.447 (Balmer & Peach 1997), adult survival is extremely high at over 90% (Prévot-Julliard et al. 1998). Therefore, survival within the first two years for this species seems key to population stability.

10.6 Habitat requirements

Black-headed Gulls use a wide variety of wetlands, either on the coast or inland. These areas include the banks of slow-flowing rivers, lake edges, mudflats, tidal inshore waters, estuaries and lagoons, though may also be found in anthropogenic habitats such as parks, agricultural land, sewage ponds and landfills (Snow & Perrins 1998). In coastal areas this may further include inlets with sandy or muddy beaches, though rocky or exposed shores are avoided. Within these preferred habitats, this species is an opportunist, using a variety of food sources. During the breeding season, when natural food is abundant, aquatic and terrestrial invertebrates are preferred, small rodents and grain. During the winter when natural forage is scarce, Black-headed Gulls rely strongly on sources originating from humans, including refuse tips, fish discards and urban waste (BirdLife International 2014).

10.7 Site fidelity

Though the Black-headed Gull shows a seemingly low level of site fidelity given the wide suite of habitats occupied compared to other species and its opportunistic feeding behaviour, this species displays a strong preference for nesting near erect vegetation within its preferred habitat (BirdLife International 2014). In addition, decreases in population numbers as a result of ecosystem threats (including mink depredation) suggest that the species' willingness to change breeding habitat to avoid such stresses is lower than expected.

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.

10.10 Data sources

Data for this assessment were obtained from the most recent Irish Wetland Bird Survey (Boland & Crowe 2012) and Seabird 2000 (Mitchell et al. 2004), which was undertaken between 1998 & 2002 (Black-headed Gull records collected from '99 – '02).

Conservation Objectives for : Lough Corrib SPA [004042]

A179 Black-headed Gull *Chroicocephalus ridibundus*

To restore the favourable conservation condition of black-headed gull in Lough Corrib SPA, which is defined by the following list of attributes and targets:

Attribute	Measure	Target	Notes
Breeding population size	Number of Apparently Occupied Nests (AON)	Long-term population is stable or increasing	Black-headed gull colonies have been recorded at several locations in Lough Corrib SPA. The most recent SPA population estimate of 400 pairs from one site is based on a 2017 survey (NPWS unpublished data). This represents a short term decline of 51% from the 2010 population as estimated by McGreal (2011) and an acute long term decline since a 1983 survey, where Whilde (1983) estimated circa 3,000 breeding pairs. The attribute 'Apparently Occupied Nests', which equates to the number of breeding pairs, is based on standard survey methods (see Walsh et al., 1995)
Productivity rate	Number of fledged young per AON	Sufficient to maintain population	A lack of comprehensive Irish data precludes the identification of a minimum productivity rate for this relatively long-lived species at this SPA and indeed for black-headed gull at the national level. Walsh et al. (1995) sets out several methods to estimate the productivity rate for this species
Distribution: extent of available nesting options within the SPA	Numbers and spatial distribution	Sufficient availability of suitable nesting sites throughout the SPA to maintain the population	Black-headed gull is a colonial ground nesting bird. Whilde (1983) identified four major colonies (one sited in each of the two basins with two colonies located in the interconnecting narrow section of the lough) and summarised that this gull nested on small, rushy islands with one colony situated on a bracken dominated island. In 2010 McGreal (2011) noted that the SPA's breeding black-headed gull colonies were confined to just two islands (one in each basin). The 2017 survey identified just one colony located in the upper basin
Prey biomass available	Kilogrammes	Sufficient extent of biomass of available prey items across the site to help support the population	Black-headed gull is considered to have an opportunistic foraging strategy and can switch habitat depending on prey availability. Aquatic and terrestrial insects as well as other invertebrates including earthworms can be important. Foraging habitat includes terrestrial, freshwater and marine areas. During the breeding season, black-headed gull can forage up to 18.5km away from the colony (Woodward et al., 2019)
Disturbance at the breeding site	Level of impact	Disturbance occurs at levels that do not significantly impact on black-headed gull at the breeding site	Black-headed gull is a colonial ground nesting bird. Whilde (1983) identified four major colonies (one sited in each of the two basins with two colonies located in the interconnecting narrow section of the lough) and summarised that this gull nested on small, rushy islands with one colony situated on a bracken dominated island. In 2010 McGreal (2011) noted that the SPA's breeding black-headed gull colonies were confined to just two islands (one in each basin). The 2017 survey identified just one colony located in the upper basin
Disturbance at areas ecologically connected to the colony	Level of impact	Disturbance occurs at levels that do not significantly impact on black-headed gull at the breeding site	Foraging habitat includes terrestrial, freshwater and marine areas. During the breeding season, black-headed gull can forage up to 18.5km away from the colony (Woodward et al., 2019)
Barriers to connectivity	Number; location; shape; area (hectares)	No significant increase	During the breeding season, black-headed gull can forage up to 18.5km away from the colony (Woodward et al., 2019)

COMMON TERN

Irish Name:	Geabhróg
Scientific name:	*Sterna hirundo*

Bird Family:	Terns

Status
Summer visitor from March to October to all Irish coasts.

Identification
Usually seen over the sea or over large inland lakes. Slender seabird with narrow, pointed wings, long forked tail and long, pointed bill. Grey above and white below, dark cap to head. Flight light and buoyant, can hover briefly over the sea before diving in. Very similar to Artic Tern (with which it breeds) and told apart by plumage and structure. Common Tern has a longer head and bill and slightly broader wings, which look central on the body. Adults have a orangey red bill, usually with a small dark tip. Underparts are whiter than Artic Tern and there is no contrast with cheek. The wing pattern is useful in separation, Common tern shows a dark wedge in the primaries which develops over the summer and a defuse bar to the trailing edge of the primaries. Common terns have shorter tail steamers, not extending beyond the wing tips. Adult winter plumage, like all terns is different from breeding plumage and can develop in the summer months. Has a white forehead, all dark bill and dark carpel bar. Also has distinctive juvenile plumage with gingery mantle, a dark secondary bar and dark carpel bar. Bill base is orange. Shows a diffuse trailing edge to the primaries. First and second summer plumages are rarely seen in Europe.

Voice
A noisy bird when breeding, giving a rapid series of quarrelsome calls.

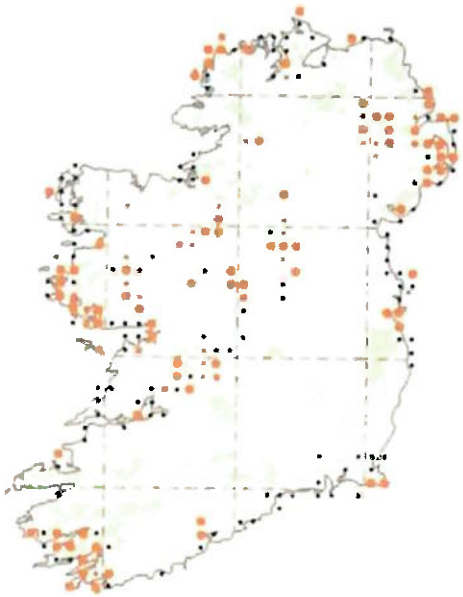
Diet
Chiefly fish.

Breeding
Nest colonially on the ground from August to October. Breeds on the coast, with larger colonies in Co. Dublin, Co. Wexford and Co. Galway. Also breeds inland on islets in freshwater lakes, notably in Co. Galway and in Co. Mayo.

Wintering
Winters in west and south Africa.

Monitored by
All-Ireland Tern Survey in 1995, and through breeding seabird surveys carried out every 15-20 years. Common Terns are also monitored annually at Rockabill and Lady's Island Lake.

Summer visitor, breeding on inshore islands and undisturbed beaches.



8.1 Characteristics

The Common Tern is a slender seabird with narrow, pointed wings, long forked tail and long, pointed bill. This species is grey above and white below with a black cap to head. Adults have an orange-red bill, usually with a small dark tip. It is very similar to the Arctic Tern (Sterna paradisaea) (with which it breeds) and is best told apart by subtleties in its plumage and morphology. For example, the Common Tern has longer legs and whiter underparts, while the Arctic Tern has a dark, blood red bill. Further, Common Terns have shorter tail steamers, not extending beyond the wing tips. The flight of this species is light and buoyant, hovering briefly over the water surface before plunge diving in. This species is usually seen over the sea or over large inland lakes.

8.2 Range in Ireland

A migratory seabird, this species has a circumpolar distribution, breeding in temperate and subarctic regions of Europe, North America and Asia. In Ireland it is present from March to October, wintering thereafter in West and Southern Africa. Irish breeding colonies of this species are limited to the islands of a few inland and coastal lakes and several important offshore islands. The most important mainland breeding colonies are located at Lady's Island Lake Co. Wexford, Loughs Mask, Conn and Carra Co. Mayo, Lough Corrib Co. Galway, Lough Egish Co. Monaghan and Lough Derg in the midlands. More than other species of tern present in Ireland, the Common Tern has a greater propensity to nest inland (Mitchell et al. 2004). Having said this, the majority of its colonies, and the bulk of the population, are located on coastal islands (Hannon et al. 1997).

8.3 Conservation status

The Common Tern is included on the Amber-list of Birds of Conservation Concern in Ireland due to its localised breeding population (Colhoun & Cummins 2013). The European population of this species has been evaluated as Secure as, despite fluctuations in some national populations, the overall European population remains stable (BirdLife International 2004). This species is also listed under Annex I of the EC Council Directive on the Conservation of Wild Birds (2009/147/EC) and, on a global scale, the IUCN have listed this species as being of Least Concern (BirdLife International 2012).

8.4 Population trend

Ten years ago, the breeding population of Common Terns in Ireland was estimated at 2485 pairs (Mitchell et al. 2004) but presently three colonies (Rockabill, Dublin Port and Lady's Island lake support in excess of 3000 pairs (BirdWatch

Ireland and National Parks and Wildlife Service data). Though the population has increased over the past 30 years, increasing threats through breeding disturbance and depredation have adversely affected this species. For example, though this species experienced a 21% reduction in the number of colonies from 1984 – 1995 (Hannon et al. 1997), the number of pairs in this period marginally increased, suggesting a concentration of more birds at fewer sites. With continued growth at the three abovementioned colonies, this factor has important conservation implications.

8.5 Breeding ecology

Common Terns nest on the ground either in solitary pairs or, more usually, colonially from April to October. Nests consist of a shallow depression on open ground near a vertical object to provide shelter and a landmark for chicks (BirdLife International 2014). These are usually found on shingle spits, low rocky islets and sand dunes, though nesting on flat rock surfaces (including artificial concrete surfaces) has also been noted (Snow & Perrins 1998; BirdWatch Ireland 2011; Becker & Ludwigs 2004). At inland sites, this species is also known to nest on islets of freshwater lakes. This species lays a single brood annually, in clutches of 2-3 eggs which are incubated for 21-22 days. Juvenile survival past the first year is very low (estimated at 0.47 (Becker & Ludwigs 2004)), potentially owing to high predation by larger gulls with which they often establish colonies. Some studies on Common Tern breeding suggest that pairs which hatch chicks earlier in the season achieve greater fledgling success, likely as a result of increased kleptoparasitism (stealing of forage food) by the other species at later stages in the breeding season (Arnold et al. 2004). Owing to substantial conservation measures on coastal breeding colonies on the east coast – including the provision of artificial nesting sites, reduction of predation pressures and installation of seasonal fencing – numbers of terns within these colonies have grown markedly (BirdWatch Ireland 2011; Merne 2004). These sites include Rockabill Island, Dublin Port, Kilcoole, Dalkey Island, Baltray and Lady's Island Lake.

8.6 Habitat requirements

This species requires relatively undisturbed areas of sand, shingle and rock. This is predominantly on coastal islands, close to rich marine feeding grounds though. However, in comparison to other species of tern found in Ireland, a significant part of the Common Tern's occupied habitat is located around islands on inland freshwater bodies (Hannon et al. 1997) where this species may feed on freshwater fish, though this proportion still only accounts for about 2-3% of its present population (S. Newton, pers. comm.). On mainland Europe (and increasingly with Irish populations) man made infrastructure supports a growing proportion of breeders, particularly around riparian sites (Becker & Ludwigs 2004). The diet of Common Terns is chiefly small fish and occasionally includes planktonic crustaceans and insects, though chicks are exclusively fed on fish (Becker & Ludwigs 2004). In marine habitats, these fish include Herring (Clupea harengus), Sprat (C. sprattus), sandeels (Ammodytes marinus and A. tobianus) and Sticklebacks (Gasterosteus aculeatus). Freshwater species include Roach (Rutilus rutilus), Bleak (Alburnus alburnus), Perch (Perca fluviatilis and P. flavescens), Ruffe (Gymnocephalus cernua), Trout (Salmo trutta), Minnows (Phoxinus spp.) and Smelt (Osmerus eperlanus).

8.7 Site fidelity

Common Terns exhibit strong site fidelity and return to the same nesting sites year after year following migration. Further, with the use and increasingly recognised effectiveness of artificial nesting structures and disturbance mitigation, the fidelity of this species to its current breeding locations is likely to remain high.

8.8 Sensitivity to development of wind energy

Common Terns have previously been identified by a pan-European assessment of wind energy potential as having "Evidence or indication of risk of impact" with wind turbines (European Commission 2011). Further, it is felt that the proportion of their life strategy spent flying duly increases their exposure to collision with turbines (Garthe & Hüppop 2004). A recent assessment of wind energy installations in Belgium showed that 27% of Common Tern flight in the vicinity of breeding colonies was at the rotor height of these turbines (16-50m), giving them a 1/911 chance of collision (Everaert & Stienen 2007). This probability is substantially higher than other tern species observed at the same site. Further, most fatalities occurred at turbines perpendicular to the flight path of feeding terns. In this example, Common Terns were the most affected species, resulting in the highest mortality in each of the 5 years for which records exist. This figure was estimated as being 4.4% of the entire breeding colony. The number of collisions with these turbines was directly related to the estimated colony size each year assessed (Everaert & Stienen 2007). Similar studies at an Irish coastal wind farm site, near Lady's Island Co. Wexford, however, found very limited collision

mortality as a result of wind farm operation, equating to two discovered Common Tern carcasses over a three year period (Daly 2004; Daly 2005; Adamson 2003). When carcass removal by scavengers was controlled for, no adverse effect was reported on bird colonies. Having said this, given the acute sensitivity of this species' breeding colonies to disturbance and habitat loss, construction of wind infrastructure is likely to exert significant pressure on Irish breeding sites. Additionally, power lines associated with wind energy developments have been shown to modify breeding and feeding patterns of Common Terns, though mortality due to power lines was low (Henderson et al. 1996).

8.9 Zone of Sensitivity

Given the requirement of this species to travel from breeding sites to the sea for feeding (e.g. at Lady's Island Lake) and the high likelihood of collision in flight as documented in other case studies (Everaert & Stienen 2007), a zone of sensitivity of 1000 m has been imposed around the mainland lakes identified as breeding sites for this species. Those breeding colonies located on the shores of inlands lakes may travel shorter distances while feeding but are conversely required to traverse large terrestrial areas when migrating. Though most individuals forage 5-10 km from breeding colonies, and occasionally feed up to 15 km from coastal nesting areas, most of this distance is travelled over water bodies.

8.10 Data sources Data for this species' distribution were obtained from the All-Ireland Tern Survey (1995), the Seabird 2000 survey which was undertaken between 1998 & 2002 (Common Tern records collected from '99-'01) and the most recent Bird Atlas for the UK and Ireland (Balmer et al. 2013).

Conservation Objectives for : Lough Corrib SPA [004042]

A193 **Common Tern *Sterna hirundo***

To restore the favourable conservation condition of common tern in Lough Corrib SPA, which is defined by the following list of attributes and targets:

Attribute	Measure	Target	Notes
Breeding population size	Number of Apparently Occupied Nests (AON)	Long-term population is stable or increasing	Common tern have nested across several locations within Lough Corrib SPA. The most recent SPA population estimate of 6 pairs from two sites is based on a 2017 survey (NPWS unpublished data). This equates to a short term decline of circa 73% since a 2007 survey (Hunt and Hefferman, 2007). Overall the population of common tern has declined over the short and long terms with 27 pairs estimated to be breeding in 1984 and 37 pairs in 1995 (Whilde, 1984; Hannon et al., 1997). The attribute 'Apparently Occupied Nests', which equates to the number of breeding pairs, is based on standard survey methods (see Walsh et al., 1995)
Productivity rate	Number of fledged young per AON	Sufficient to maintain population	A lack of comprehensive Irish data precludes the identification of a minimum productivity rate for this relatively long-lived species at this SPA and indeed for common tern at the national level. Walsh et al. (1995) sets out several methods to estimate the productivity rate for this species
Distribution: extent of available nesting options within the SPA	Numbers and spatial distribution	Sufficient availability of suitable nesting sites throughout the SPA to maintain the population	Common tern, a ground nesting bird, and breeds colonially usually on islands/islets and often with congener species and/or gulls. Hunt and Hefferman (2007) recorded common tern at four sites within Lough Corrib
Prey biomass available	Kilogrammes	Sufficient extent of biomass of available prey items across the site to help support the population	Common tern forages over open water (marine, freshwater, brackish) and its main prey are small fish up to 150 mm long; at times they can predominantly feed on crustaceans or insects (Arnold et al., 2020). During the breeding season, common tern can forage up to 30km away from the colony (Woodward et al., 2019)
Disturbance at the breeding site	Level of impact	Disturbance occurs at levels that do not significantly impact on common tern at the breeding site	Common tern, a ground nesting bird, breeds colonially usually on islands/islets and often with congener species and/or gulls. Hunt and Hefferman (2007) recorded common tern at four sites within Lough Corrib
Disturbance at areas ecologically connected to the colony	Level of impact	Disturbance occurs at levels that do not significantly impact on breeding common tern	During the breeding season, common tern can forage over open waters up to 30km away from the colony (Woodward et al., 2019)
Barriers to connectivity	Number, location, shape, area (hectares)	No significant increase	During the breeding season, common tern can forage over open waters up to 30km away from the colony (Woodward et al., 2019)

GREENLAND WHITE FRONTED GEESE

Irish Name:	Gé Bhánéadanach
Scientific name:	*Anser albifrons flavirostris*
Bird Family:	Geese

Status

Scarce winter visitor to wetlands in Wexford and western Ireland from October to April.

Identification

Medium-sized grey goose, with orange legs, a long orange-yellow bill with a prominent blaze around the base of the bill (adults).

Voice

High-pitched, musical in quality (not nasal). Usually disyllabic.

Diet

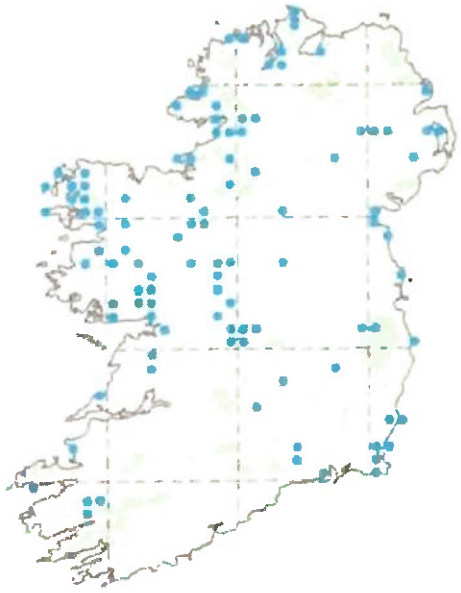
Grazes on a range of plant material taking roots, tubers, shoots and leaves. Grasses, clover, spilt grain, winter wheat and potatoes are popular foods. Forages over peat bogs, dune grassland, and occasionally salt marsh, with the use of agricultural grassland increasing in recent years.

Breeding
Breeds on lowland tundra, often by lakes and rivers. Nests are widely scattered, though loose colonies may be formed.

Wintering
Winters in Ireland and Scotland. Highly gregarious. Traditionally occurred in peatland areas, though now mostly seen feeding on intensively managed grasslands

Monitored by
National Parks and Wildlife Service/ Greenland White-fronted Goose Study Group.

Winter visitor with very localised distribution, occurring mostly (up to 9,000 birds) at the Wexford Slobs, with smaller numbers (usually low hundreds) elsewhere. Wexford (North & South Slobs, Tacumshin Lake & Cahore Marshes), Loughs Swilly & Foyle in County Donegal, Lough Gara in County Roscommon, Midland lakes (Loughs Derravarragh, Iron, Owel & Ennell) in County Westmeath, Little Brosna in County Offaly and River Suck Shannonbridge in County Roscommon are the most important sites.



13.1 Characteristics

The Greenland White-fronted Goose is a medium-sized grey-brown goose, with orange legs and an orange-yellow bill. Adults have a prominent blaze around the base of the bill and black barring on the belly. This species is similar to the larger Greylag Goose (Anser anser), though is distinguished from this by a white patch above the bill.

13.2 Range in Ireland

The Greater White-fronted Goose (Anser albifrons) has an extremely large range globally, extending throughout the Arctic while breeding and in various regions at lower latitudes during the winter, from China to Western Europe and coastal North America (BirdLife International 2014). The Irish and British migratory population originates from

Greenland and is regarded as a subspecies (A. a. flavirostris). In Ireland, this subspecies is a scarce winter visitor to a limited number of sites, between October and April. Whilst here, this species is highly gregarious and mainly gathers in three internationally important sites (at the Wexford Slobs, Lough Swilly and the Little Brosna Callows). Additionally, this species occurs at 3 sites, Lough Iron, Dunfanaghy New Lake and Cahore marshes, in nationally important numbers.

13.3 Conservation status

A large proportion (63%) of the global population of Greenland White-fronted Geese was counted in Ireland in spring 2014 (Fox et al. 2014). This subspecies is currently Amber-listed in Ireland as the majority of the internationally important population winters at less than ten sites (Colhoun & Cummins 2013).

13.4 Population trend

The population has experienced a marked decline, from an estimated 35,600 individuals in 1999 to 20,797 in spring 2014 (Fox et al. 2014). In Ireland, this equates to an average annual decline of 2.4% (Boland & Crowe 2012), though the substantial population found at the Wexford Slobs has undergone a much lower annual decline (0.9%). It is thought that this decline is a result of continued perilously poor productivity in its Greenland breeding grounds, as a result of environmental factors (Fox et al. 2006; Boyd & Fox 2008) and inter-specific competition (Kristiansen & Jarrett 2002).

13.5 Breeding ecology

This subspecies' breeding range is confined to western Greenland, where it nests in lowland tundra, often by lakes and rivers. While here, a single clutch is laid annually, although only a small proportion of birds may actually breed. This clutch consists of 5-6 eggs which are incubated for 27- 28 days. Nests – usually consisting of a mound of vegetation on sand or clay – are widely scattered, though loose colonies may be formed (Snow & Perrins 1998).

13.6 Habitat requirements In its wintering range,

Greenland White-fronted Geese require undisturbed foraging and roosting areas, and sites with multiple foraging areas to allow for local movements in response to disturbance (Stroud et al. 2012). Roost sites occur adjacent to salt marshes, on mud flats and on some inland freshwater lakes (BirdLife International 2014). It traditionally forages over peat bogs, dune grassland, and occasionally salt marshes though it is now increasingly found feeding on intensively managed grasslands (Mayes et al. 2009; Fox et al. 2006). This species grazes on a range of plant material, taking roots, tubers, shoots and leaves. In particular, grasses, clover, split grain, winter wheat and potatoes are preferred forage. More detailed investigations of White-fronted Goose feeding found that habitat preference is strongly linked to the availability of this preferred vegetation, in addition to environmental factors such as frost and snow cover (Owen 1971) and local drainage regimes (Mayes et al. 2009).

13.7 Site fidelity

The fact that this species returns to the same set of nationally and internationally important wintering sites annually, indicates strong site fidelity. Given the low reproductive output (Fox et al. 2006), the decline in numbers reaching the limited number of Irish wintering sites is likely to continue, increasing the importance of remaining sites. A longitudinal study of an isolated flock in Ireland revealed strong affinity to a wetland area during a decline towards, and subsequent to, the site becoming unsuitable for wintering individuals (Mayes et al. 2009).

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.

13.10 Data sources

Data for this assessment has been obtained from the Irish Wetland Bird Survey (Boland & Crowe 2012) and from a dedicated annual survey coordinated by the National Parks and Wildlife Service and the Greenland White-fronted Goose Study, the most recent of which was conducted in 2014 (Fox et al. 2014).

Conservation Objectives for : Lough Corrib SPA [004042]

A395 Greenland White-fronted Goose *Anser albifrons flavirostris*

To restore the favourable conservation condition of Greenland white-fronted goose in Lough Corrib SPA, which is defined by the following list of attributes and targets:

Attribute	Measure	Target	Notes
Winter population trend	Percentage change in number of individuals	Long term winter population trend is stable or increasing	The national population of Greenland white-fronted goose has declined by 13% between 1985 and 2018 (NPWS, 2019). During the baseline assessments to inform SPA designation, 160 geese were estimated to be using this SPA (5 year mean of peak counts for baseline period 1994/95 to 1998/99; note this data relates to individuals occurring within the SPA only, as opposed to all individuals associated with the SPA; see NPWS, 2013). This count includes geese from two discrete flocks; one that uses the southern end of the SPA and one that irregularly uses islands on the north-east side. Both of these flocks declined significantly (55-63%) from the baseline period to 2011/12 (Burke et al., 2018). In recent years, a total of 15 geese were determined to be using the SPA, with no geese from the northern flock recorded within the SPA (5 year mean of peak counts 2016/17 to 2020/21; see Fox et al., 2017-2021). Thus, the SPA population has declined 91% since the baseline period
Winter spatial distribution	Hectares, time and intensity of use	Sufficient number of locations, area, and availability (in terms of timing and intensity of use) of suitable habitat to support the population target	Distribution encapsulates the number of locations and area of potentially suitable habitat for the wintering population and its availability for use. The suitability and availability of habitat areas are likely to vary throughout the season, for example, due to variation in land management practices or the abundance of resources available (due to natural variation and other factors). This will affect the spatio-temporal patterns of use of the habitats by the wintering population
Disturbance at wintering site	Intensity, frequency, timing and duration	The intensity, frequency, timing and duration of disturbance occurs at levels that do not significantly impact the achievement of targets for population trend and spatial distribution	The impact of any significant disturbance (direct or indirect) to the over-wintering population will ultimately affect the achievement of targets for population trend and/or spatial distribution. Disturbance contributes to increased energetic expenditure which can result in increased likelihood of over-winter mortality or reduced fitness (if energy expenditure is greater than energy gain) and, in turn, negatively impact population trends (see, for example, Madsen and Fox, 1995). Factors such as intensity, frequency, timing and duration of a (direct or indirect) disturbance source must be taken into account to determine the potential impact upon the targets for population trend and spatial distribution
Barriers to connectivity and site use	Number, location, shape and hectares	No significant impact on the wintering population's access to the SPA or other ecologically important sites outside the SPA	Barriers limiting the population's access to this SPA or ecologically important sites outside the SPA will ultimately affect the achievement of targets for population trend and/or spatial distribution. Factors such as the number, location, shape and area of potential barriers must be taken into account to determine their potential impact. Access to ecologically important sites outside the SPA must also be considered as a single SPA may not satisfy all the ecological requirements of the wintering population, and it may require access to other SPAs or sites for certain activities, such as foraging when preferred foraging areas are unavailable due to disturbance, extensive flooding, or other factors

Forage spatial distribution, extent and abundance	Location, hectares, and forage biomass	Sufficient number of locations, area of suitable habitat and available forage biomass to support the population target	This species is a grazer, feeding on a wide range of vegetation. Key forage materials include roots, tubers (such as potatoes), shoots (such as winter wheat), stolons, rhizomes, leaves (such as grasses), and seed such as (spilled) grain. Key habitats include peat bogs (including raised bogs and blanket bogs), grasslands (such as wet grassland, callows, semi-improved grassland, and intensive grassland), arable stubble, winter cereal fields, coastal grasslands, and occasionally salt marsh. In general, the foraging distance of over-wintering Greenland white-fronted goose from night roosts is estimated at 5 to 8km (Scottish Natural Heritage, 2016), although this will vary depending on site and landscape
Roost spatial distribution and extent	Location and hectares of roosting habitat	Sufficient number of locations, area and availability of suitable roosting habitat to support the population target	Overnight roosting habitat mainly consists of permanent waterbodies, such as lakes, estuaries, bays, and other open waterbodies. When roosting in waterbodies, this species can roost on above-water features such as sandbanks. Roosting is a critical ecological requirement for the over-wintering population. Daytime roosting is also a common behaviour, where birds minimise activity levels to conserve energy, while benefitting from the vigilance of other flock members. A lack of sufficient and suitable roosting habitats can result in increased mortality risk, whether indirectly (e.g. via increased energy expenditure travelling to/from roost sites) or directly (e.g. via increased predation risk), or reduction in site use; this would ultimately affect the achievement of targets for population trend and/or spatial distribution
Supporting habitat: area and quality	Hectares and quality	Sufficient area of utilisable habitat available in ecologically important sites outside the SPA	The wintering population can make extensive use of suitable habitats in important areas outside the SPA, for foraging and roosting. The extent, availability and quality of these supporting habitats may be of importance for the resilience of the SPA population. Suitable supporting habitats include those highlighted in the attributes for foraging and roosting habitat

CORMORANT

Irish Name:	Broigheall
Scientific name:	*Phalacrocorax carbo*
Bird Family:	Cormorants

Status

Resident, some immigration during the winter

Identification

Large, mainly all dark seabird, often stands with wings out stretched drying. Long body and neck, long strong hooked bill. Dark webbed feet. Swims low in the water with bill raised. Often seen inland, unlike the similar looking Shag, where it breeds in trees. Adult breeding bird is black with a green, bronze and blue gloss to its plumage, white feathering and yellow bare flesh at the base of the bill and a white thigh patch. Cormorant lacks crest, instead having a sloping forehead which gives it a wedge shaped profile. Adult in non-breeding plumage lacks white thigh patch. Juvenile bird has very pale, even white, underparts and dark brown upperparts. Sub-adults have a variable amount of white in the underparts.

Voice

Deep guteral call when at the colony.

Diet

Fish.

Breeding

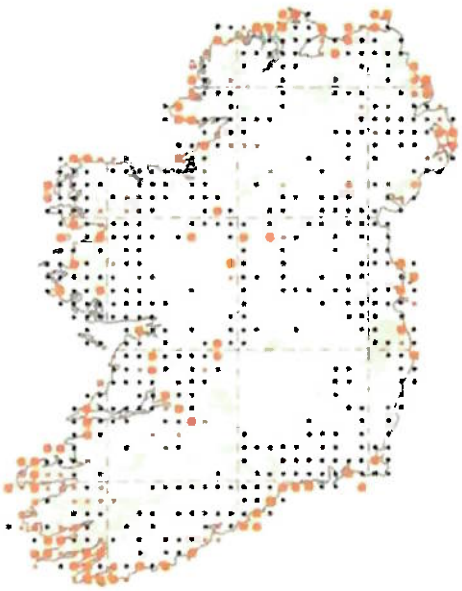
Breeds in colonies mainly around the coast of Ireland, with some birds breeding inland. Most of the larger coastal colonies in Ireland are on the south and north west coasts with big colonies also in Co. Dublin. Birds on the coast breed on cliffs whilst those inland, in trees.

Wintering

Winters at sea and inland

Monitored by
Breeding seabirds are monitored through seabird surveys carried out every 15-20 years.

Common resident either at sea or on inland lakes and rivers.



WHOOPER SWAN

Irish Name:	Eala Ghlórach
Scientific name:	*Cygnus cygnus*
Bird Family:	Swans

Status
Winter visitor to wetlands throughout Ireland from October to April.

Identification
Similar to Bewick's Swan, but larger, with longer neck. Yellow and black bill, with the yellow projecting below the nostril.

Voice
Vocal bugling or honking.

Diet
Aquatic vegetation, but they are commonly found grazing on agricultural grasslands and fields where there is spilled grain, as well as potatoes from cultivated land.

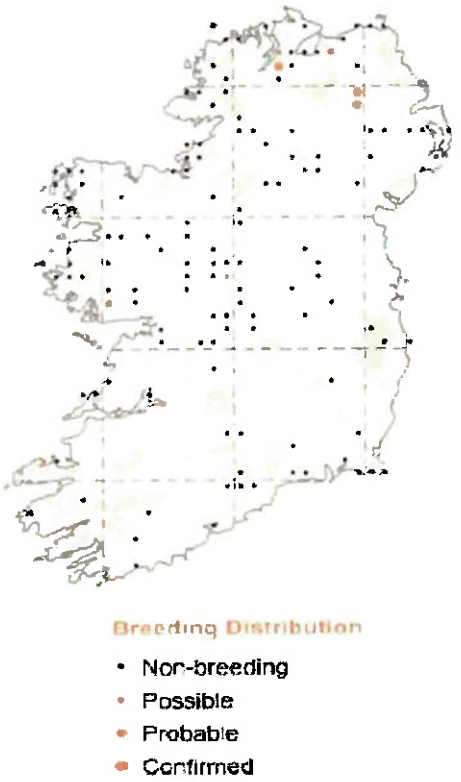
Breeding
The Whooper Swans that are present in Ireland each winter nest in Iceland during the summer. Each year a small number of Whoopers stay in Ireland for the summer and there have been occasional breeding records on lakes in the midlands and north-west.

Wintering
Most on lowland open farmland around inland wetlands, regularly seen while feeding on grasslands and stubble.

Monitored by

Irish Wetland Bird Survey (I-WeBS), and a special swan census is carried out every five years, most recently in 2020. The census takes place in January and aims to count and gather data on every Whooper Swan in Ireland. The census is coordinated in the Republic of Ireland by our I-WeBS team.

Breeding grounds in Iceland and Northern Europe. Relatively widespread winter migrant, especially north and west of a line between Limerick and Dublin. Lough Swilly (Donegal), Lough Foyle (Donegal/Derry), Wexford Harbour & Slobs, Lough Gara (Sligo) and Donegal Bay all support greatest numbers (350- >2,000 birds).



14.1 Characteristics

The Whooper Swan is a very large and conspicuous bird. Adults are uniformly white and have a yellow and black bill, showing more yellow than black, with the yellow generally projecting below the nostril towards the bill-tip. Whooper Swans are larger than the Bewick's Swan (Cygnus columbianus) – the other yellow-billed swan that occurs in Ireland - with a longer neck and longer bill-profile. Whoopers can be distinguished from Ireland's resident Mute Swans (Cygnus olor) as they lack the knob and orange colour of the latter, and the necks of the yellow-billed swans tend to be held more erect than the graceful S-bend formed by the Mute Swan.

14.2 Range in Ireland

Whooper Swans have an extensive international distribution, ranging from Iceland across the majority of the Palearctic to eastern Russia. In Ireland, these birds are winter visitors to wetlands throughout the country from October, peaking in November, December and January before departing by April (Boland & Crowe 2012). Of the five distinct populations of Whooper Swans globally, it is exclusively the Icelandic-breeding population that winters in Ireland (Robinson et al. 2004). Whilst in Ireland, this species is relatively widespread, occurring in as many as 270 sites, especially north and west of a line between Limerick and Dublin. Important sites within this distribution are Loughs Erne, Foyle, Swilly, Oughter and Iron, Wexford Harbour and Slobs and the Callows of the Shannon, Brosna, Suck and Blackwater rivers (Boland et al. 2010). Most recent surveys have suggested a general shift in this species' winter distribution to the southeast (Hall et al. 2012).

14.3 Conservation status

Whooper Swans are currently Amber-listed in Ireland due to the hosting of more than 20% of the European wintering population, the majority of which winter at ten or less sites (Colhoun & Cummins 2013). Furthermore, this species relies on a very small breeding population internationally. Consequently, this species is listed under Annex I of the EC

Council Directive on the Conservation of Wild Birds (2009/147/EC). BirdLife International has, however, assessed the European population of this species as Secure owing to its extensive range and large numbers which have experienced a recent increase (BirdLife International 2004). Similarly, this species has been listed as Least Concern by (BirdLife International 2012).

14.4 Population trend

Despite some declines in Balkan populations of Whooper Swans, aggregate European populations of this species are increasing (BirdLife International 2004). Within Ireland, numbers of this species have increased at a mean rate of 2.6% annually since 2001 (Boland & Crowe 2012), from 14,079 in 2005 (Worden et al. 2009) to 14,981 in 2010 (Boland et al. 2010), and the island of Ireland now supports more than 50% of the flyway population of the Icelandic breeding population (Boland & Crowe 2012; Hall et al. 2012). Of this most recent count, 10,452 birds were counted in the Republic of Ireland (Hall et al. 2012). Despite some flux in the importance of specific overwintering sites, there has been no significant change in the number of internationally-important sites on the island of Ireland (n = 14) (Boland et al. 2010). Of the numerous sites at which this species occurs in Ireland, 16 are now of national importance (Boland & Crowe 2012). Previous surveys did note, however, that these increasing numbers (8%) are found in a decreasing number (-9%) of sites (Worden et al. 2009).

14.5 Breeding ecology

The Whooper Swan breeds in open shallow water, by coastal inlets, estuaries and rivers of Iceland and north-eastern Europe. The population occurring in Ireland breeds exclusively in Iceland (Boland & Crowe 2012). This species lays a single clutch each year of 4-5 eggs, which are incubated for 31-42 days (Brazil 2003). Though estimates of juvenile mortality are unavailable, adult survival in this species is estimated at 0.801 (Brazil 2003).

14.6 Habitat requirements

This species winters at lakes, rivers, marshes, lagoons and sheltered inlets across Ireland and is increasingly found in lowland open farmland, grassland and stubble. A recent survey indicated that the use of improved dry pasture by this species has increased markedly since previous surveys (2005 and 2000), while occupation of lakes and rivers has dropped in the same period (Boland et al. 2010). Indeed, the majority of observations in recent surveys have positioned Whooper Swans in pasture and arable agricultural land (Worden et al. 2009; Boland et al. 2010). The diet of Whooper Swans was formerly restricted to aquatic vegetation within 1m of the surface, but this species is increasingly recorded grazing on grass in pasture and spilt grain, as well as roots, shoots, leaves, rhizomes and tubers of tillage land (Boland et al. 2010).

14.7 Site fidelity

Given the growing threat to migratory birds internationally and the increasing population of this species in Ireland, the importance of nationally- and internationally-important sites is generally growing (Worden et al. 2009). However, the recent adaptation to farmland of varying types indicates that this species has a reasonably broad habitat preference (Boland et al. 2010). In addition, the recently observed flux of sites indicates that this species may not remain loyal to specific areas of suitable habitat (Boland & Crowe 2012; Boland et al. 2010).

14.8 Sensitivity to development of wind energy

In general, this species has been identified as being at particular risk of disturbance displacement and collision as a result of wind energy development (Langston & Pullan 2003). In particular, exclusion from habitat around wind turbines has been identified (Larsen & Clausen 2002), in some cases up to 300 m from wind energy installations.

(Percival 2003). Observations of swan nonbreeding activity from 8 European studies have given a mean minimum distance of 150 m from the base of wind turbines (Hötker et al. 2006), while other studies have shown a reduction of 1-2.5% in available habitat through disturbance displacement (Larsen & Clausen 1998). Whooper Swans have the highest recorded migratory flight height of any species of bird, at up to 8km above sea level (Elkins 1983). However, while moving between roosting and feeding sites, most flocks travel at between 5 and 30 m, putting this species at a much higher risk of collision with medium and large turbines, especially when the size and reduced manoeuvrability of this species is considered (Larsen & Clausen 2002). Though Whooper Swans can avoid turbines and have been known to habituate to these (especially resident birds) their risk of collision is much greater than that of other species. In addition to collisions with turbines themselves, swans have a high observed collision rate with overhead power

lines, which may be associated with these installations (Langston & Pullan 2003). Despite this, observed collision rates for Whooper Swans have remained low around the wind energy installations of Europe (Hötker et al. 2006). It is therefore claimed that Whooper Swans are most susceptible to collision with medium sized turbines (10 – 50 m blade height) in the low light conditions of mornings and evenings during winter (Larsen & Clausen 2002). There may also be seasonal variation in this exposure, as flight times have been shown to vary across over-wintering periods (Larsen & Clausen 2002).

14.9 Zone of Sensitivity

Given the high risk of collision with wind turbines in comparison to other species and the observed disturbance to occupied habitat up to 300 m (Percival 2003), Whooper Swans have been assigned a zone of sensitivity of radius 600 m around occupied I-WeBS subsites. A more conservative approach has been taken in this instance given the international importance of the Irish distribution of this species.

14.10 Data sources

Data for this assessment was obtained from the Irish Wetland Bird Survey (I-WeBS) (Boland & Crowe 2012), and the International Swan Census of January 2010 (Boland et al. 2010; Hall et al. 2012). IWeBS is co-ordinated by BirdWatch Ireland and funded by the National Parks and Wildlife Service of the Department of the Arts, Heritage and the Gaeltacht. The International Migratory Swan Census is organised every five years and is carefully co-ordinated over one weekend in January in Ireland by the I-WeBS Office and the Irish Whooper Swan Study Group, in Britain by the Wildfowl and Wetlands Trust (WWT) and in Iceland by the Icelandic Institute of Natural History, with overall co-ordination by WWT and the Wetlands International/ IUCN SSC Swan Specialist Group. BirdLife International, 2004.

KINGFISHER

Irish Name:	Cruidín
Scientific name:	*Alcedo atthis*
Bird Family:	Kingfisher

Status
Resident on Irish streams, rivers and canals.

Identification
Very distinctive when seen well with its brightly-coloured plumage. The underparts are a bright orange-red, while the wings and back of the head are dark blue. The back, rump and tail are a bright, almost "electric" blue and usually draw attention to a flying bird. Despite these bright colours, can be easily overlooked perched motionless on a branch beside a stream or river on the look-out for fish. During the breeding season, females have a small red patch at the base of the bill, which is not shown by adult males.

Voice
A shill whistled "chee-kee", frequently repeated. It is usually one first signs that a Kingfisher is present along a stream or river.

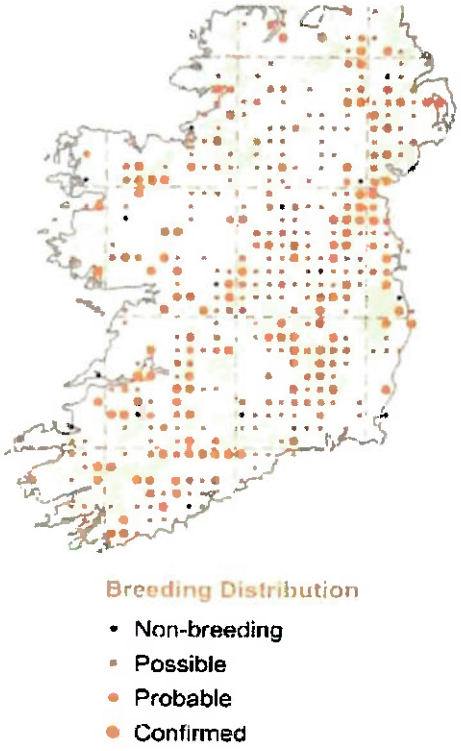
Diet
Various species of small fish (Stickleback, Minnow, and Chub) and larger aquatic insects caught by plunge-diving from a perch or while hovering.

Breeding
Kingfishers breed in tunnels dug in vertical banks along streams and rivers.

Wintering
A very sedentary species, Kingfishers rarely move from their territories. However, some may move to lakes and coasts during extended spells of poor weather.

Monitored by Waterways Bird Survey.

Widespread in Ireland, mainly sedentary but young disperse after fledging.



Reference No 38 : 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.

Reference Number 39 : Bat Conservation Ireland Wind Turbine/Wind Farm Development Bat Survey Guidelines Version No. 2.8 December 2012

Wind turbines and bats Wind turbines are a known risk to bats (Arnett et al. 2008, Baerwald et al. 2008, Betts 2006, Cryan and Brown 2007, Johnson et al. 2003, Johnson and Strickland 2004, Zagmajster et al. 2007) and the UNEP/EUROBATS Secretariat published guidelines on bats and wind farm projects (Rodrigues et al. 2008) to ensure bats are considered as part of development proposals.

Although further worldwide research on bat/turbine interactions needs to be undertaken, studies to date in Europe and the U.S.A. (Kunz et al. 2007, Arnett et al. 2008, Horn et al. 2008, Rydell et al. 2010), have shown that bat mortality due to wind turbines is a serious issue. Bats are known to be killed either through a fatal change in pressure within the lungs (Baerwald et al 2008) or through collision with rotor blades (Rollins et al. 2012). There is no evidence to suggest that the Irish context is unique in avoiding such a conflict.

To date, ten bat species have been recorded in Ireland and all, apart from one, Leisler's bat Nyctalus leisleri, are normally low fliers e.g.<10m above ground level and as such are considered to be at a lower risk from turbine impacts. However, pipistrelle species have been observed to investigate new landscape structures such as turbine masts. **Data from European wind turbine related mortality includes high numbers of pipistrelle species of which approximately 50% occur outside the migratory season.**

Leisler's bat is classified as a high risk species in relation to wind turbines as it is a high flier (Carlin and Mitchell-Jones 2009) which travels considerable distances (up to 13.4km has been recorded in Ireland, Shiel et al. 1999) between roosts and foraging areas. The species has evolved for fast flight in excess of 40km/h (Dietz et al. 2007) and is less manoeuvrable as a consequence. It therefore avoids cluttered environments by keeping above the tree canopy normally flying between 10m and 70m above the ground (Russ 1999) but the species has been known to reach heights of 500m (Bruderer and Popa-Lisseanu 2005). Flying at such heights potentially brings it into direct risk of collision with wind turbines.

BATLAS 2020 – A Bat Distribution Survey

Final Report 2016-2018

Pickett, S., Aughney T., Roche N. & Langton, S.

Table 1: Total number of records for BATLAS 2020 Target Bat Species and Non Target Bat Species (2015-2019 dataset).

Target Bat Species	No. of Records (% of total survey sites)	Non-Target Bat Species	No. of Records
Common pipistrelle	1,977 (55%)	Brown long-eared bat	134
Soprano pipistrelle	2,465 (68%)	Natterer's bat	78
Leisler's bat	1,304 (36%)	Whiskered bat	34
Daubenton's bat	1,105 (31%)	Nathusius' pipistrelle	55
		Lesser horseshoe bat	14

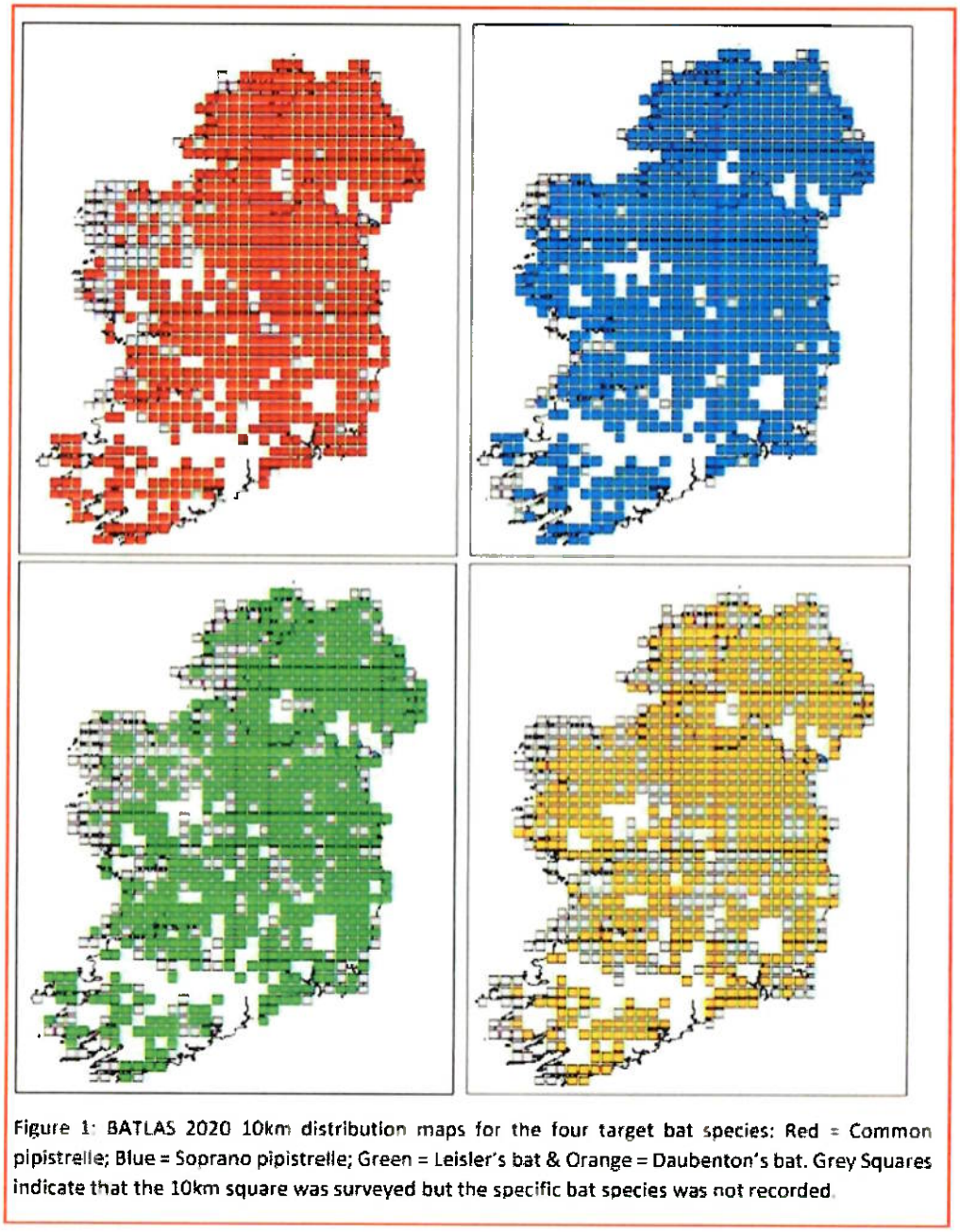


Figure 1: BATLAS 2020 10km distribution maps for the four target bat species: Red = Common pipistrelle; Blue = Soprano pipistrelle; Green = Leisler's bat & Orange = Daubenton's bat. Grey Squares indicate that the 10km square was surveyed but the specific bat species was not recorded.

Reference Number 40 : 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 No 38 : ***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."[2]

Startling costs to insect and bird populations

There are over three hunded studies compiled by National Wind Watch on the adverse effects in a range of animals, birds, bats, and insects (see here*). For instance, cortisol levels have been found to increase in geese and ground dwelling animals*[3] *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.*[4]

'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."*[5]

Cattle farmers have laid blame for mass deaths and other issues on wind turbines,[6] *including the electrical currents induced by them through the ground.*[7] *Equestrian property owners have reported their horses dwelling at the far reaches of their pastures to escape the effects of the massive turning blades.*[8] *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.[9] *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.[10] *See* Bat Apocalypse*.*

Still, this article has merely grazed the scope of environmental harm these massive industrial warm farms are causing to wildlife (and, of course, people).[11] *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 Number 39: 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 Number 40: Post construction bird and bat monitoring at wind farms in Victoria Ver. 1.0 Public report 13th Wind Wildlife Research Meeting 2020. Symbolix

1.2.1 Cumulative estimated mortality rates

We present a table in Section 4.6 of the estimated annual mortality per turbine for each species. This is limited to the species found at three or more sites, as we cannot reliably report combined results for species found at only one or two sites.

• Turbine size influences the mortality estimate, due to differing 'fall zones' for carcasses (Hull and Muir 2010). We estimated per turbine mortality for two size classes.

– Small (SML) turbines have rotor diameter of less than or equal to 103m. Anything larger was classed as Large (LRG).

– At time of writing there were 544 small class turbines and 220 large class turbines in Victoria (Appendix A).

• Between 7 and 10.8 bat mortalities occur per turbine per year in Western Victoria. The rate is not significantly different for different sizes (Section 4.5.1)

• For birds, significantly more mortalities occur at larger turbines. For small turbines, between 3.4 and 4.1 bird mortalities occur per turbine per year. For large turbines, the

range varies between 5 and 6.7 per turbine per year.

• Our study suggests that mortalities are higher for White-striped Freetail Bats than any other bat or bird species. Between four to six White-striped Freetails are struck per turbine, and they were discovered at every site in the study. This implies that turbines in Western Victoria strike around as many White-striped Freetails as all birds combined.

Table 5: Twenty-five most documented species during carcass searches (at included sites)

Common name	No. found	No. sites
White-striped Freetail Bat	229	10
Gould's Wattled Bat	77	8
Australian Magpie	69	10
Unidentified Bird	45	7
Nankeen Kestrel	41	8
Raven sp.	35	7
Wedge-tailed Eagle	33	7
Eastern False Pipistrelle	33	5
European Skylark	33	3
Brown Falcon	26	7
Large Forest Bat	16	6
Lesser Long-eared Bat	15	<3
Little Forest Bat	13	6
Unidentified Bat	11	6
Southern Freetail Bat	10	4
Southern Bent-wing Bat	8	<3
European Goldfinch	7	5
Common Starling	7	5
Welcome Swallow	6	4
Chocolate Wattled Bat	6	4
Red-rumped Parrot	5	<3
Grey-headed Flying-fox	4	<3
House Sparrow	4	<3
Magpie-lark	4	<3
Southern Forest Bat	4	<3

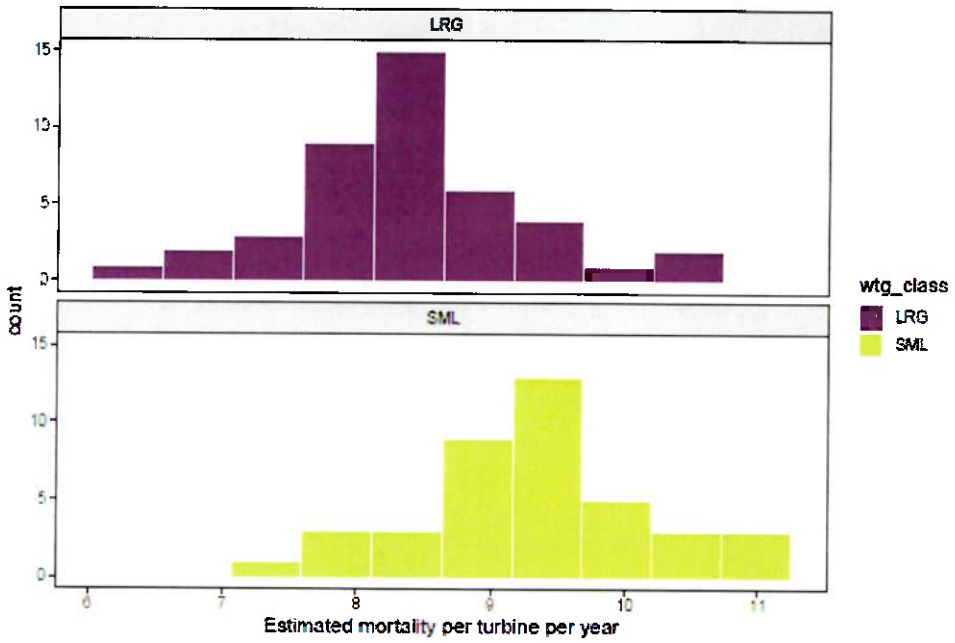


Figure 11: Credible Distribution of Bat Mortalities per turbine year

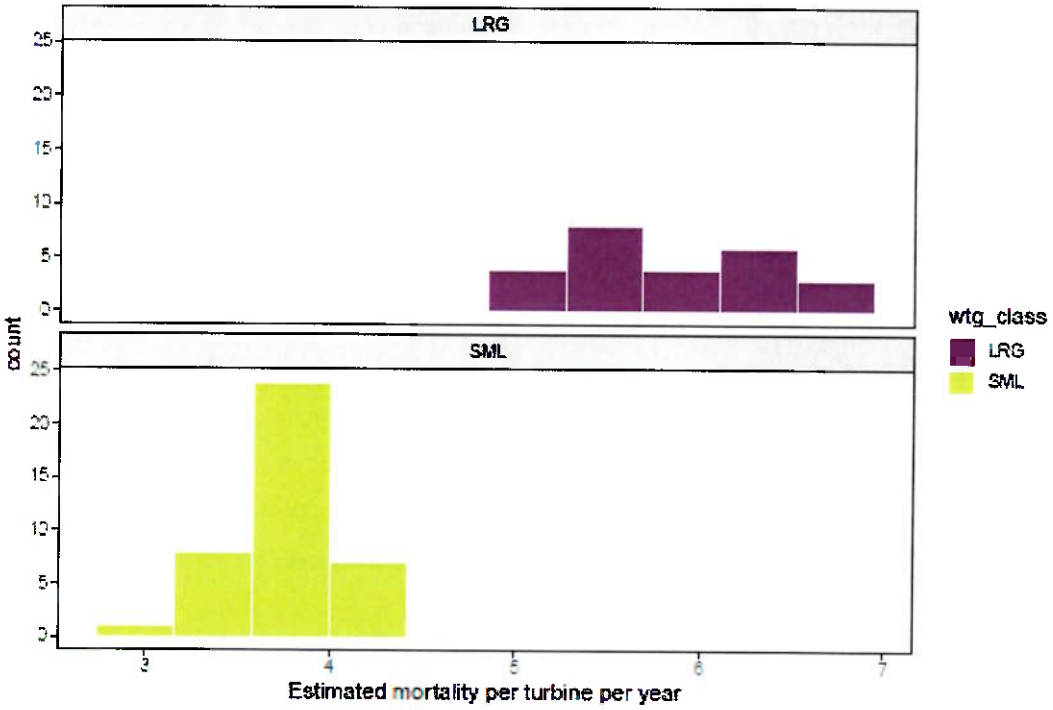


Figure 12: Credible Distribution of Bird Mortalities per turbine year

Reference Number 41 : 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."

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Lights: "Lights on wind structures or associated infrastructure may directly or indirectly contribute to increased bat activity."

Olfaction: "Recent work using paired thermal video and acoustic recording at Meteorological tower sites documented swarming activity concentrated at various focal points on the Meteriological tower structure, including mechanical anemometers, wind vanes, the top of the tower, and aircraft marker balls."

Reference Number 42 : Bats and onshore wind turbines: Survey, Assessment and Mitigation, version August 2021, NatureScot, Natural England, Natural Resources Wales, RenewableUK, 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 Number 43 : Conservation: Tracking bats around wind turbines. M. Teague O'Mara, Current Biology 33, R136–R158, February 27, 2023 2022 Elsevier Inc. . https://doi.org/10.1016/j.cub.2022.12.048

Alternative energy is essential for a green future but comes at a high risk for animals. New research shows that forest-based wind turbines may create an ecological trap for bats that typically are repelled by wind turbines.
Like many other tree-roosting migratory bats, common noctules are particularly vulnerable to wind turbine mortality. Common noctules migrate and forage at altitudes commonly occupied by wind turbines. They are the most commonly killed bat species at wind turbine facilities in Germany, and like many bat species worldwide, their populations are declining rapidly. Common noctules will roost in bat boxes, but prefer natural tree cavities such as woodpecker holes for roosting during the day. By placing GPS loggers on common noctule bats that roosted near wind turbine fields in Germany, Reusch and colleagues tracked individual bats over time. This allowed them to test how these bats interacted with wind turbine habitats in and out of forests, both at an individual and population level. Typically, surveys that track bat activity rely on acoustic detectors that record echolocation calls that can then be identified to species or a group of species and give a measure of occupancy and activity for the area. Miniaturized GPS tracking pushes beyond an anonymous, population-level view to understand how individuals arrived at a site, and how the site was selected and used.
Reusch and colleagues found that per night common noctules flew 16 km, covering an area of 11 ± 34 km2, and spent roughly half their time commuting across farmland and meadows to forests where they feed on a wide range of moths, beetles and other insects.

Reference Number 44: Conservation: Tracking bats around wind turbines. O'Mara, M.T., 2022, Current Biology, https://doi.org/10.1016/j.cub.2022.12.048

"Flying animals face the highest risk from wind turbines, as birds and bats seek out the same conditions that make wind generation profitable. These energetically advantageous conditions allow animals to fly cheaply on uplifting winds and thermals or on prevailing winds. The placement of wind turbines in such profitable wind conditions may dramatically endanger migration, commuting and foraging pathways. Preference for these habitats makes bats particularly vulnerable to turbine related mortality, and efforts in . North America have focussed on why and how bats are attracted to wind turbines at night.....This conflict has resulted in millions of bats killed by wind turbines every

year worldwide, including over 300,000 in Germany alone .... Common noctules flew 16km per night covering an area of 11+- 34km2".

Reference Number 45: 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 Number 46 : 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 Number 47 : 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 Number 48 : 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."

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Olfaction: "Recent work using paired thermal video and acoustic recording at Meteorological tower sites documented swarming activity concentrated at various focal points on the Meteriological tower structure, including mechanical anemometers, wind vanes, the top of the tower, and aircraft marker balls."

Reference Number 49 : Bats and onshore wind turbines: Survey, Assessment and Mitigation, version August 2021, NatureScot, Natural England, Natural Resources Wales, RenewableUK, 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 Number 50: Conservation: Tracking bats around wind turbines. O'Mara, M.T., 2022, Current Biology, https://doi.org/10.1016/j.cub.2022.12.048

"Flying animals face the highest risk from wind turbines, as birds and bats seek out the same conditions that make wind generation profitable. These energetically advantageous conditions allow animals to fly cheaply on uplifting winds and thermals or on prevailing winds. The placement of wind turbines in such profitable wind conditions may dramatically endanger migration, commuting and foraging pathways. Preference for these habitats makes bats particularly vulnerable to turbine related mortality, and efforts in North America have focussed on why and how bats are attracted to wind turbines at night. This conflict has resulted in millions of bats killed by wind turbines every year

worldwide, including over 300,000 in Germany alone .... Common noctules flew 16km per night covering an area of 11+- 34km2".

Reference Number 51 : Wind turbine power and land cover effects on cumulative bat deaths. Moustakas, A., Georgiakis. P., Kret. E., Kapsalis. E., The science of the Total Environment. (May 2023)
"Wind turbines cause bird and bat mortalities which depend on the wind turbine and landscape features..... wind turbine power is the most significant factor associated to bat deaths.....wind turbines located within 5km buffer of natural land cover types have substantially higher deaths. More wind turbine power will result in more deaths. Wind turbines should not be licensed in areas where natural land cover at a radius of 5km exceeds 50%.

Reference Number 52 : 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 Number 53: 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 Number 54: Forest gaps around wind turbines attract bat species with high collision risk Julia S. Ellerbrok , Nina Farwig, Franziska Peter, Finn Rehling, Christian C. Voigt. Biological Conservation 288 (2023) 110347

The global demand for renewable energy has led to an expansion of wind energy production at forested sites. The deployment and operation of turbines requires the clearing of forest areas, resulting in significant habitat changes. To assess the consequences of these changes for forest-associated bats, we measured the acoustic activity of three foraging guilds at turbine clearings, adjacent forest edges, and above nearby closed forests. Open-space and edge-space foraging bats were more active at turbine clearings and forest edges than above closed forests. Similarly, narrow-space foraging bats tended to be more active at turbine clearings than above closed forests. Open-space and edge-space foraging bats are known to be at high risk of colliding with wind turbines and their increased activity at forest gaps around turbines may increase casualties for these guilds. Operation of wind turbines in forests may therefore require longer shutdown periods to prevent legally protected bats from colliding with turbines. Although this may impair the energy yield of wind turbines in forests, such preventive conservation measures will ultimately contribute to a sustainable transition from fossil to renewable energy sources which factors in biodiversity conservation.

Temperate forests are important habitats for a wide range of species, among them bats. For example, 90 % of European bat species use forest structures at least temporarily for foraging and roosting (Dietz and Kiefer, 2014; Russo et al., 2016). Specifically, bats require tree cavities and standing deadwood for roosting as well as resource-rich foraging areas, which they use according to strata, structure, and vegetation density (Jung et al., 2012; Müller et al., 2013; Law et al., 2016). When forests are partially cleared for wind turbines, bats can be affected in several ways depending on their foraging and flight behaviour (Denzinger and Schnitzler, 2013; Aldridge and Rautenbach, 1987). Open-space foraging bats are long-range echolocators with pointed wings foraging mostly in spaces with few or no obstacles (Denzinger and Schnitzler, 2013).

They hunt above treetops and in larger clearings, while they avoid dense vegetation and small clearings (Voigt and Holderied, 2012). Thus, open-space foraging bats may explore and use forest gaps associated with wind turbines in forests. Edge-space foraging bats are mid-range echolocators, which are specialized on hunting prey close to background objects (Denzinger and Schnitzler, 2013). Hence, they are often found at forest edges (Kirkpatrick et al., 2017), which are created when forest patches are clear-cut for wind turbines. Finally, narrow-space foraging bats are short-range echolocators with rounded wings that facilitate foraging in forest understorey (Denzinger and Schnitzler, 2013). Although narrow-space foragers can fly outside of forests (Heim et al., 2018), they mostly occur in the forest interior and might therefore suffer from the creation of forest gaps for wind turbines. In conclusion, open-space and edge-space but not necessarily narrow-space foraging bats can be expected to increase their activity where forest gaps are created for wind turbines.

Fatalities of bats after collisions with wind turbines are a known global problem (O'Shea et al., 2016; Thaxter et al., 2017). Bat casualties at wind turbines are not equally distributed across species.

In Europe, for example, 95 % of bats found dead under wind turbines belonged to 6 out of 11 assessed genera (Nyctalus, Vespertilio, Pipistrellus, Hypsugo, Miniopterus, Tadarida; Dürr, 2022). Accordingly, bat species from these genera are commonly recognized as high-collision risk species (Rodrigues et al., 2014), which is associated with their ability to fly at the operation range of wind turbines (Reusch et al., 2022, 2023; Roeleke et al., 2016; Roemer et al., 2017).

Noticeably, all bat species recognized as high-collision risk species at wind turbines are members of the open-space or edge-space foraging guild, while bat species of the narrow-space foraging guild are usually considered to be at low risk of colliding with wind turbines (Rodrigues et al., 2014). Consequently, deployment of wind turbines at forested sites might lead to more casualties at wind turbines if bat species of high-collision risk are attracted to the open and edge habitats which were created for the deployment and operation of wind turbines. Besides, bats may also respond to the operation of wind turbines. Indeed, past studied confirmed that wind turbines repel certain bat species in open landscapes (Barr´e et al., 2018; Leroux et al., 2022) and in forests (Ellerbrok et al., 2022; Reusch et al. 2023; Gaultier et al., 2023)

Reference Number 55: 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 Number 56 : 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 No. 57: 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, BenitezLopez ´ et al. (2010) omitted the few studies not showing the negative effects of infrastructure. Their models however showed that a large number of studies reporting neutral or positive responses to infrastructure would be needed to reverse their results.

Marques et al. (2021) included 71 studies in their review and found that approximately 40 % of studied bird taxa showed displacement from onshore and offshore wind power development. They suggested improvements for study design, for example, by encouraging observations to be made before the construction of a wind power development. Scholl ¨ and Nopp-Mayr (2021) reviewed 27 studies of birds, bats, and mammals in woodland ecosystems. They concluded that displacement distances (or distance thresholds) varied temporally and spatially, even within species. They also called for the improvement of study design and suggested that BACI (before-after-control-impact) studies should be mandatory for approval and decisions related to wind power development.

Number of cases, i.e., taxa or functional groups, for which displacement distances were presented in the published studies. Classified as displacement/no displacement

Taxa/functional group	***Displacement***	***No displacement***	***Sum***
Birds			
Cranes	*3*	*0*	*3*
Gallinaceous birds	*11*	*7*	*18*
Owls	*2*	*0*	*2*
Passerines	*16*	*16*	*32*
Raptors	***24***	***6***	***30***
Waders	***8***	***11***	***19***
Waterfowl	***6***	***1***	***7***
Several	*3*	*2*	*5*
Sum	***73***	***43***	***116***
Bats	***21***	***8***	***29***
Terrestrial mammals			
Canids	*1*	*1*	*2*
Cervids	*8*	*1*	*9*
Small mammals	*1*	*3*	*4*
Sum	***10***	***5***	***15***
Total	***104***	***56***	***160***

All three cases on cranes were classified as displaced by wind power development. Two studies focused on migrating whooping cranes (Grus americana, Ellis et al., 2022; Pearse et al., 2021). They showed 20 times more activity outside the 5000 m distance from wind turbines compared to the area inside (Pearse et al., 2021). The same displacement distance was observed when the birds looked for a stopover site to forage in the same area in the United States Great Plains (Ellis et al., 2022). GPS marked overwintering sandhill crane (Grus canadensis) showed potential indication of avoidance behaviour <10km distance, although this was suggested to be the result of habitat selection rather than displacement.

We classified eleven out of 18 cases of gallinaceous birds in the displacement category, the median distance being up to 5000 m. Birds were found to reduce lekking near wind power development (LeBeau et al., 2017a; Winder et al., 2015; Zwart et al., 2015), the longest distance being >5000 m for the decreased lek persistence of greater prairie-chicken males (Tympanuchus cupido pinnatus, Winder et al., 2015). Greater prairie-chicken males near turbines spent less time in non-breeding behaviours than those farther away, possibly to compensate for the effects of noise disturbance (Smith et al., 2016). On the other hand, greater prairie-chicken females could nest even within a small wind power development area, but as they selected nest sites >700 m from wind power roads (Harrison et al., 2017), we classified the case as displacement.

Noise was also assumed to disturb capercaillie (Tetrao urogallus) and reduce the success rate and time invested in breeding up to over 800 m (Taubmann et al., 2021). The species showed population declines because of reduced habitat suitability near wind power development (Gonzalez ´ et al., 2016), and there was no indication that habituation occurred eight years after construction (Coppes et al., 2020a). Chick survival in Columbian sharp-tailed grouse (Tympanuchus phasianellus columbianus) decreased by 50 % when there were ≥10 wind turbines within 2100 m of the nest (Proett et al., 2022). A potential reason for this was suggested to be increased predation and noise disturbance, which hindered the passing of alarm sounds to chicks by brood females (Proett et al., 2022). Summer habitat selection of greater osage-grouse (Centrocercus urophasianus) decreased with the increase of surface disturbance ≤1200 m from wind power development, although there was no direct effect on the nest site selection or the survival of females (LeBeau et al., 2017b). Seven gallinaceous bird cases were classified as no displacement, two focusing on the breeding or habitat selection of greater prairie-chicken (McNew et al., 2014; Raynor et al., 2019). The lack of responses in these studies was suggested to be connected with the habitat, i.e. the avoidance of non-grassland areas instead of the displacement from wind power development. The lack of displacement in red grouse (Lagopus lagopus scoticus) was assumed to result from methodology, i.e. a shortterm (three-year) study on a single site after wind power development was operational (Douglas et al., 2011).

Even positive associations with wind turbines were found for common pheasant (Phasianus colchicus, Łopucki et al., 2017) and red grouse (Lagopus lagopus scoticus, Douglas et al., 2011). The suggested reasons for this association were linked to species and habitat through a reduced number of predatory birds and a general affinity for tracks as a source of grit, which is important for digestion (Douglas et al., 2011; Łopucki et al., 2017). Also the short duration of study on a single site was suggested to be a reason for no displacement in Douglas et al. (2011).

Only two cases addressed owls. Both showed that the birds abandoned their territories and nests up to 5000 m from wind power development (Husby and Pearson, 2022; Lopez-Peinado ´ et al., 2020). The owls were suggested to be sensitive to noise and disturbance, and open areas created by wind power development were assumed to be poor hunting habitats.

Passerines showed both displacement and no displacement in 16 cases. The median displacement distance was 500 m and was observed as avoidance behaviour and reduced bird densities (Fern´ andez-Bellon et al., 2019; Pearce-Higgins et al., 2009; Shaffer and Buhl, 2016; Stevens et al., 2013), a reduced number of breeding birds (Leddy et al., 1999; Pearce-Higgins et al., 2009), and reduced nest density (Song et al., 2021). The displacement extended up to 4500 m in a study of the endangered Dupont's lark (Chersophilus duponti) in Spain, where even local extinctions were suggested to occur in the presence of wind farms (Gomez-Catasús ´ et al., 2018). Nighttime lights and the rotation of turbines were suggested to disturb birds and have adverse effects on communication (Gomez-Catasús ´ et al., 2018, 2022; Leddy et al., 1999). It was also observed that habitat change and reduced forest cover resulted in a large reduction of safe habitats for forest-dwelling passerines (Fernandez-Bellon ´ et al., 2019; Shaffer and Buhl, 2016). In Garcia et al 2015, decreasing population trends were observed among 12 of 15 breeding passerine species during construction, but the species were observed to return to their old nesting sites when construction was completed. We nevertheless classified Garcia et al. (2015) in the "displacement" category, since displacement was observed during the construction period. Also no displacement was shown in 16 cases of passerines. In Hale et al. (2014), breeding grassland passerines were not observed to react to turbines, partially due to the difficulty of isolating the effect of turbine distance from other factors, such as barbed wire fences, covarying with distance. However, their conclusion was criticized by Johnson (2016), who claimed that the conclusion was based on inappropriate statistical analysis of data and that two of the three studied species might in fact show displacement. In Shaffer and Buhl (2016), the vesper sparrow (Pooecetes gramineus) was the only passerine species that did not respond to wind turbines, suggested reason being related to the species and habitat conditions, i.e. its life-history characteristic as the first species to occupy disturbed areas.

For the nest-site selection of the grasshopper sparrow (Ammodramus savannarum), vegetation (i.e. habitat conditions) was assumed to play a more important role than distance from turbines, and snake predation causing failure to nesting was greater close to wooded edges than near wind turbines (Hatchett et al., 2013). In Stevens et al.

(2013), three out of four passerine species showed no displacement from wind turbines, and the difference between species was assumed to be in their species-specific predator evasion strategies.

Social species such as Sprague's pipit (Anthus spragueii), savannah sparrows (Passerculus sandwichensis), and meadowlarks (Sturnella sp.) were known to use open areas, and a high number of individuals was suggested to help in the detection of predators. In contrast, Le Conte's sparrow (Ammodramus leconteii) was known to hide in thick vegetation and was observed to show displacement (Stevens et al., 2013).

In Devereux et al. (2008), corvids and Eurasian skylark (Alauda arvensis) did not show displacement and were indeed more likely to occur close to turbines than farther away. Potential reasons were suggested to be the small sampling size (methodological reason), but also higher food availability (habitat conditions) near turbines.

We found displacement in 24 cases of raptors . The median distance was 500 m, ranging from 100 m for Montagu's harrier (Circus pygargus, Schaub et al., 2020) and the golden eagle (Aquila chrysaetos, Fielding et al., 2021, 2022) to 4000 m for the white-tailed eagle (Haliaeetus albicilla, Balotari-Chiebao et al., 2016a). Displacement was represented as changes in abundance (Campedelli et al., 2014; Garwin et al., 2011) and flight behaviour near turbines (Cabrera-Cruz and Villegas-Patraca, 2016; Hull and Muir, 2013; Johnston et al., 2014; Santos et al., 2021, 2022), which were assumed to increase the birds' energy usage (Cabrera-Cruz and Villegas-Patraca, 2016). Functional habitat loss (Campedelli et al., 2014; Marques et al., 2019), and reduced breeding success were also observed (Dahl et al., 2012; Balotari-Chiebao et al., 2016a).

Time could influence the results: Raptor abundances declined immediately after installation (Farfan ' et al., 2009) but showed some recovery, although not to the preconstruction level, 6.5 years later (Farf' an et al., 2017). Displacement was not found in six raptor cases, in which distances up to 1000 and 5000 m (median 1000 m) were studied. Due to the lack of displacement, young white-tailed eagles were observed flying into the wind turbine areas, exposing them to the risk of collision (Dahl et al., 2013; Krone and Treu, 2018). The flying behaviour was observed to vary between individual eagles and in relation to food availability (Krone and Treu, 2018).

Individuals of three Buteo hawk species did not show displacement from wind turbines regarding the selection of their nesting territories, but as rotor speed increased, avoidance flights increased, thereby mitigating collisions (Watson et al., 2018). As the avoidance flights occurred in the immediate vicinity of turbine blades, we did not classify them as displacement. Montagu's harrier (Circus pygargus, was expected to choose its nesting site according to the potential of vegetation covering the nests rather than the distance to disturbing features such as wind turbines (Hernandez-Pliego ' et al., 2015). In Campedelli et al. (2014), the sparrowhawk (Accipiter nisus) was the only species of seven raptors showing no significant difference in observations between pre- and post-construction. The result was not discussed. Hawks, eagles, and falcons did not display avoidance behavior around wind turbines, suggesting that their displacement might be species- and site-specific (Smith et al., 2017).

Waders were the only bird group in which we found no displacement more often than displacement (11 vs. 8 cases, respectively). Displacement effects were manifested as decreased bird density and breeding bird abundance, the median distance being 500 m from wind turbines (Pearce-Higgins et al., 2009; Sansom et al., 2016; Shaffer and Buhl, 2016). Bai et al. (2021) showed that shoreline bird groups (all four cases classified as waders in this study) avoided crossing closely spaced (200 m) turbines. However, their abundance showed no significant change in the study area compared with the control.

Eleven cases of waders showed no displacement, median studied distance across the cases being 1000 m. The longest studied distance reached beyond 5000 m for the little egret (Egretta garzetta) in China, where bird abundance was not influenced (Xu et al., 2021). The abundance of little egrets depended on the habitat conditions, i.e. on the land use type suitable for feeding rather than the distance to the wind farm (Xu et al., 2021). Similarly, no evidence was found for golden plovers (Pluvialis apricaria) avoiding wind turbines in the UK (Douglas et al., 2011) or the USA (Pluvialis dominica, Homoya et al., 2017). These results contradicted those of Pearce-Higgins et al. (2009) and were assumed to be partially due to a single study location and the lack of an assessment before the construction of turbines (Douglas et al., 2011). Also weather conditions between the two survey years were expected to at least partly explain the observed population increase of the golden plover (Douglas et al., 2011). An interesting observation was made for killdeer (Charadrius vociferous), which not only exhibited high tolerance to turbines but also increased in density near them, as turbines were assumed to provide gravel substrates for nesting (Shaffer and Buhl, 2016). Four wetland species were not observed to avoid wind turbines, but the result was thought to arise largely from the small sample size and short duration (three years) of the study, which did not cover potential lag effects on the species (Niemuth et al., 2013).

Six cases of waterfowl showed displacement, the median distance being 500 m from wind turbines. The greatest distance was 1300 m (classified as "up to 5000 m") for the Chinese spot-billed duck (Anas zonorhyncha) and mallard (Anas platyrhynchos, Zhao et al., 2020). Displacement was often shown as changes in the selection of resting and feeding areas (Fijn et al., 2012; Harrison et al., 2018; Larsen and Madsen, 2000; Zhao et al., 2020). To avoid the wind turbines, the birds had to fly farther, which was assumed to require more energy (Madsen and Boertmann, 2008). The associated infrastructure and fragmentation of habitats caused more displacement than the turbines themselves (Larsen and Madsen, 2000). The distance from small wind turbines decreased in 8–10 years for pink-footed geese (Anser brachyrhynchus, Madsen and Boertmann, 2008), and Bewick's swans (Cygnus columbianus bewickii), which were found to feed closer to the wind turbines according to food availability (Fijn et al., 2012). The oldest study of waterfowl, by Meek et al. (1993), indicated that the only species to respond negatively was the red-throated diver (Gavia stellata). The reason for its decline was however uncertain in the study. The only case for waterfowl showing no displacement was also presented in Meek et al. (1993) as an aggregated result for ducks. It was notable that most studies of waterfowl were conducted using wind turbines with tower heights of <50m.

Three studies of several bird groups showed displacement, and two no displacement, with the studied distances up to 100, 500 m, or 1000 m. Displacement was expressed as reduced abundance and flight rates during a 6.5-year post-construction period (Farfan ´ et al., 2017), a reduction in avian activity during construction (Pande et al., 2013), and changes in aerial space and flight course (Therkildsen et al., 2021). Minderman et al. (2012) did not observe displacement in terms of bird activity related to small turbines (<50m m tower height) and assumed that turbine presence did not affect habitat use, or because displacement occurred at a different spatial scale than what was studied. There was only one study focusing on tall (even above 200 m) wind turbines. It showed that small forest birds (45 species) were sensitive to forest structure, season, and rotor diameter, but not to the proximity of wind turbines (Rehling et al., 2023). We therefore classified the study as showing no displacement. Nevertheless, the study showed that the height and number of turbines, along with rotor length, reduced bird abundance and richness (Rehling et al., 2023).

The vulnerability of bird populations to wind power development can be high especially among long-lived species (Fielding et al., 2021). For example, owls and raptors have slow maturation and reproduction rates (Farf" an et al., 2009; Garwin et al., 2011). If displacement influences their abundance during the breeding season (Lopez-Peinado ´ et al., 2020), increases the abandonment of nests (Husby and Pearson, 2022), or decreases the success of breeding (Balotari-Chiebao et al., 2016a,b), and these effects occur with increased collisions (e.g., Husby and Pearson, 2022), population effects are inevitable. Habituation to wind turbines has rarely been observed in raptors, suggesting that they do not adjust easily to the presence of a wind farm, and population changes may therefore be permanent (Campedelli et al., 2014 and the references therein).

Bats showed displacement in 21 cases out of 29, the median displacement distance being 1000 m, which was also the maximum distance surveyed (Fig. 3). Apart from the studies by Minderman et al. (2012, 2017) on small wind turbines (<50m tower height) other studies were conducted on turbines taller than 50 m, extending even to over 200 m (Ellerbrok et al., 2022). None of the bat studies included observations before wind power development.

Bat responses were strongly confounded by their foraging environment (forest, edge, open) and the echolocation range of the species (short, mid, long). Especially forest species (which are also short-term ecolocators, e.g., Myotis sp., Barbastella barbastellus) showed displacement, which was expressed as reduced abundance and activity around turbines (Apoznanski ´ et al., 2018; Barr´e et al., 2018; Ellerbrok et al., 2022; Leroux et al., 2022; Gaultier et al., 2023). Loss in habitat quality due to greater amount of open areas (Gaultier et al., 2023), noise (Ellerbrok et al., 2022) and red aviation lights were suggested as reasons for displacement (Barr´e et al., 2018). Displacement was observed in their optimal foraging habitats such as hedgerows (Barr´e et al., 2018) and forests (Gaultier et al., 2023), while the response could be the opposite (i.e., attraction) in less optimal open habitats (Leroux et al., 2022). Reduced activity near turbines resulted in a loss of foraging habitat, which in a tropical biodiversity hotspot was considered to threaten bat conservation (Millon et al., 2018). An interesting observation was made in Reusch et al. (2022), where 70 % of common noctule bats (Nyctalus noctula) showed avoidance behavior toward wind turbines, but when attraction was found, it occurred toward large turbines more than small turbines.

Displacement was not observed in eight cases, the studied distances being up to 1000 m. Edge-space foragers (and mid-range echolocators) Pipistrellus pipistrellus (Ellerbrok et al., 2022) and P. kuhlii/nathusii (Barr´e et al., 2018; Leroux et al., 2022) showed no response to wind turbines in forest landscapes. The lack of responses in Pipistrellus pipistrellus in Ellerbrok et al. (2022) contrasted with the observation by Barr´e et al. (2018) and Minderman et al. (2017), who observed displacement in an open landscape. It was suggested that forest clearing for wind turbines would create ideal foraging habitats for edge-space foragers (Ellerbrok et al., 2022). Regarding the lack of response in P. kuhlii/nathusii, a potential explanation was the contrasting behavior (avoidance vs. attractiveness) of the species

within this bat group due to their different migratory status (Barr'e et al., 2018; Leroux et al., 2022). Open space foragers were observed to be attracted to wind turbines in open areas (Leroux et al., 2022) or during certain seasons (Ellerbrok et al., 2022). However, the suggested reasons for this attraction were inconsistent (Ellerbrok et al., 2022).

Bats display a mixture of displacement and attraction, of which displacement occurs at longer distances and attraction around turbines (Millon et al., 2015; Reusch et al., 2022). The maximum observed displacement distance was 1000 m, but this might be an underestimate, since longer distances were not studied (Barr'e et al., 2018). Displacement seems to vary, depending on the preferred foraging habitat (forests or hedgerows vs. open habitats), echolocation range, and migratory pattern, but in general, the mechanisms leading to displacement remain largely unknown (Barr'e et al., 2018). Many studies report negative population effects, and even extinctions have been anticipated if wind power development continues to increase (Friedenberg and Frick, 2021). Despite initial population declines and changes in species diversity due to habitat change and displacement, some bat populations can recover, as shown in a study of 22 tropical bat species in Mexico (Briones-Salas et al., 2017).

Terrestrial mammals

There were only two studies of canids, showing displacement for the red fox (Vulpes vulpes) up to 700 m in Poland (Łopucki et al., 2017) but not significantly for the coyote (Canix lastrans), studied to almost 10,000 m in Nebraska, USA (Smith et al., 2017). Displacement for the fox was assumed to be an indirect effect of wind power development and result from lower prey availability, especially of the hare, near wind turbines (Łopucki et al., 2017) (Fig. 3). Bird carcasses killed by wind turbines were proposed to attract the foxes, but there were no observations of bird remains to support this (Łopucki et al., 2017). Coyote was assumed to have habituated to the wind turbines by the time of the study, which was started eight years after the wind turbines became fully operational (Smith et al., 2017).

Of the nine studies of cervids, six were undertaken of the semidomestic reindeer (Rangifer tarandus), all showing displacement. Three studies were carried out in the same area but on different occasions in Sweden (Skarin and Alam, 2017; Skarin et al., 2015, 2018). Displacement from 100 m to the access road (Colman et al., 2013) up to 15,000 m from the wind farm (Skarin and Alam, 2017) was observed. According to Colman et al. (2013), the distribution of the reindeer was more related to habitat quality than wind power development. Displacement nevertheless occurred especially during the construction phase (Colman et al., 2013; Skarin et al., 2015), although it was observed also during operation (Skarin and Alam, 2017). Calving time was most sensitive for the reindeer (Skarin et al., 2018; Tsegaye et al., 2017). The noise generated by wind turbines was assumed to disturb the interaction between calves and mothers and negatively affect the reindeer's ability to hear predators (Skarin et al., 2018). As a consequence, displacement during operation occurred farther away than during construction (Skarin et al., 2018). Tsegaye et al. (2017) did not observe a change in the spatial use of areas near wind power development outside calving time. A high seasonal and annual variation in displacement was also observed by Eftestol et al. (2023), and the reasons were assumed to be linked not only to natural movement patterns but also to herding activities, indicating human interference with the displacement.

Concerning wild cervids, the European roe deer (Capreolus capreolus) avoided wind farm interiors and proximity to turbines up to 600–700 m, potentially due to the difficulty of hearing or sensing their predators (Łopucki et al., 2017). The pronghorn (Antilocapra americana) showed behavioral changes during migration by avoiding turbines and moving more quickly near them, which was assumed to influence their foraging success or the availability of specific routes in the long run (Milligan et al., 2023). The Rocky Mountain elk (Cervus elaphus) was not adversely affected by wind power development, as evidenced by its home range, studied up to a distance of over 5000 m (Walter et al., 2006). The suggested reason was despite disturbance and habitat loss, riparian habitats that were critical seasonal habitats for the elk, were not altered by construction (Walter et al., 2006).

Of the four studies of small mammals, only European hare (Lepus europaeus) showed displacement up to 700 m (Łopucki et al., 2017), whereas three studies focusing on small rodents, shrews, hedgehogs, and hamsters did not show displacement (de Lucas et al., 2005; Łopucki and Mroz, ´ 2016; Łopucki and Perzanowski, 2018). Large temporal variation of populations and difference in temporal trajectories between places (de Lucas et al., 2005), and behavioural and physiological characteristics (Łopucki and Mroz, ´ 2016; Łopucki and Perzanowski, 2018) which were not monitored, were suggested to be reasons for the lack of responses. Also, the hamster was known to live near various types of human infrastructure, including settlements (Łopucki and Perzanowski, 2018).

In our review two thirds of 160 cases show displacement, and there is large variation in the displacement distances within and among taxa. Concerning especially cranes, owls, semi-domestic reindeer and gallinaceous birds the effects of wind power development can extend for several kilometers, suggesting a significant loss of functional habitat for these species. For flying species such as raptors and bats, displacement and collisions create a double-edged sword that causes population decline regardless of whether displacement occurs. "

Reference Number 58 : Examples of onshore baseline surveys for bats (adapted from the UNEP/EUROBATS guidelines, Rodrigues *et al.* 2015)

• Identification of important maternity, hibernation and swarming sites based on signs of bats and/or presence and abundance of recorded bats.
• Bat detector surveys on the ground — use of automated detectors to the define bat activity index (number of bat contacts per hour) and habitat use, potentially supplemented with manual surveys (walked transects, vantage-point surveys) and other observational techniques (thermal/infra-red cameras).
• Activity surveys at height — use of automated detectors to define the bat activity index (number of bat contacts per hour).
• Potential need for above-canopy activity surveys and advanced techniques such as trapping and radio-telemetry in woodlands.
• Collection of environmental data (temperature, precipitation, wind speeds).

Main types of impacts on bats (drawn from the UNEP/EUROBATS guidelines)

• Collision and barotrauma — the fatal interaction between bats in flight and wind turbine structures.
• Habitat loss and degradation — the removal of, fragmentation or damage to supporting habitats.
• Disturbance and displacement at roost sites — activities in and around roost sites such as habitat removal or the presence of maintenance vehicles and personnel can result in changes in temperature, humidity, light, noise and vibration within the roost, with a consequent reduction in use or reproductive capacity.
• Loss of flight corridors and roost sites — the physical or functional loss of flight corridors and roosting sites.

Table 5-4 Types of impacts on bats during the project's life cycle for onshore wind energy developments

Types of impacts	Project phase				
	Pre-construction	Construction	Operation	Decommissioning	Repowering
Habitat loss and degradation	X	X	X	X	X
Disturbance and displacement at roost sites	X	X	X	X	X
Habitat fragmentation		X	X	X	
Collision			X	X	
Barrier effect			X	X	
Barotrauma			X	X	
Loss or shifting of flight corridors and roost sites		X	X	X	
Increased availability of invertebrate prey, and thus increased collision risk, due to night illumination			X	X	
Indirect effects		X	X	X	X

Once the wind turbines are in operation, mortality due to collision or barotrauma are considered to be the most significant effects, but the risk differs between species.
Disturbance and displacement could occur at any stage of a project's life cycle, with barrier effects occurring during operation and repowering. These likely significant effects could result in changes in behaviour including attraction (Behr *et al.* 2018; Foo *et al.* 2017), spatial shift of flight corridors, and the exclusion of bats from foraging habitats they would otherwise use (Barré *et al.* 2018). Attraction could result in higher collision risk (Rydell *et al.* 2010a; Voigt *et al.* 2018). However, Millon *et al.* (2018) considered displacement itself to be an important impact to consider, and Barré *et al.* (2018) have recently quantified this effect across a number of wind farms. The assessment of disturbance, displacement and barrier effects should be considered on a case-by-case basis, taking into account the size of the plan or project, the bat species known to be present, their habitat use, and the importance of the supporting habitat to the favourable conservation status of the population, particularly in the light of existing threats and the site's conservation objectives.

Factors for the design of baseline data collection methods and the assessment of significance, in relation to bats

Biological

• Collision risk, to a large extent defined by foraging characteristics, echolocation type and the flight behaviour of species (Denzinger and Schnitzler, 2013; Roemer *et al.*, 2017).
• Annual life cycle stage, i.e. active, hibernating, breeding, migrating, swarming.
• The presence of hibernation and maternity roosts.
• Population vulnerability, based on collision risk and the status of species affected (an example can be found in Scottish Natural Heritage *et al.*, 2019).

Environmental

• The presence of habitats within 200m of a plan or project likely to be used by bats during their life cycle, e.g. forests (especially mature broad-leaved forests), trees, hedgerow networks, wetlands, waterbodies, watercourses and mountain passes
• Confined areas where bats forage or roost, and/or the potential for narrow bat migration or commuting routes.
• Large river corridors that may serve as migration routes.
• Habitat types at a landscape scale, e.g. the presence of broadleaved woodland within 1.5 km of wind energy developments in Great Britain appeared to reduce risk to all species combined (and soprano pipistrelles analysed separately), but the total area of coniferous woodland was only associated with an increased risk to noctules (Mathews *et al.*, 2016). The responses are therefore species- and habitat-dependent. Depending on the species in question and their habitat associations, the presence/absence of a suitable habitat could be used as a way of 'ruling in' areas potentially suitable for wind energy developments rather than for identifying areas likely to be problematic (Mathews *et al.*, 2016).
• Wind speed and direction, temperature and relative humidity are known to be significantly correlated with both bat activity and mortality (Amorim *et al.* 2012; Mathews *et al.* 2016; and others cited in Rodrigues, 2015). These environmental variables may be among those used to determine the level of risk a proposed site is likely to have on bats.

Plan or project design

• Turbine number and rotor swept area.
• Turbine size, which can influence the distance over which displacement occurs [Barré *et al.* (2018) and Minderman *et al.*, (2012; 2017)].

Collision risk for European (incl. Mediterranean) species from wind turbines in open habitats(derived from Rodrigues, 2015)

High risk	Medium risk	Low risk
***Nyctalus* spp.**	*Eptesicus* spp.	*Myotis* spp.
***Pipistrellus* spp.**	*Barbastella* spp.	*Plecotus* spp.
Vespertilio murinus	*Myotis dasycneme*[2]	*Rhinolophus* spp.
Hypsugo savii		
Miniopterus schreibersii[1]		
Tadarida teniotis		

[1] *Miniopterus schreibersii* is the only Annex II species in the high-risk category

The annual life cycle of bat species must also be taken into account as the magnitude and significance of an effect can vary depending on the time of year (Table 5-6). The timing of annual life cycle stages varies between species and populations of the same species in different Member States. It is therefore prudent to refer to national guidance in relation to bats and wind energy developments, where this is available, or to the UNEP/EUROBATS guidelines (Rodrigues *et al.* 2015) if there is no national guidance. A comprehensive list of national guidance documents is provided in Appendix E.

The degree of risk associated with impacts on bats in relation to their annual life cycle(drawn in part from Rodrigues et al. 2015)

Likely significant effect	Breeding season	Hibernation season	Spring/autumn
Construction			
Habitat loss and degradation	Low to high, depending on proximity to roosts	High, depending on proximity to roosts	Low (particularly for migrating bats travelling long distances)
Loss of roost sites	Potentially high or very high	Potentially high or very high	Potentially high (e.g. loss of mating roosts)
Turbine operation			
Collision/fatalities	Low to high, depending on the species	Low	High to very high
Loss or shifting of flight corridors	Medium	Low	Low. Migration likely to occur on a broad front, but cumulative effects need to be considered

Key challenges in assessing the significance of effects on bats

All effects

• Limited evidence regarding the effects of small wind turbines, e.g. those with a hub height less than 18 m above ground level.
• Limited evidence regarding the behaviour of bats around turbines (Natural England, 201485 and Mathews *et al.* 2016). Some evidence of attraction has been reported (Behr et. al., 2015), particularly in the presence of red light (Voigt *et al.* 2018).
• In a British wind park, bat activity showed extremely high variability, both within and between years (Mathews *et al.*, 2016).

Collision

• There is no way to predict bat fatalities prior to construction with current approaches focused on site-specific surveys rather than multi-site studies, which makes it difficult to identify risk factors (Mathews *et al.*, 2016). Arnett *et al.* (2016) identified improving the predictability of bat fatalities as a key area for future research.
• It remains unclear whether pre-construction acoustic data are able to adequately predict post-construction fatality (Arnett *et al.*, 2013), and whether current environmental impact assessments fail to reduce the risk of bat casualties on wind farms (Lintott *et al.* 2016).
• It is possible that there are additional high-risk periods in the annual life cycle of bats, but that they remain undetected because of a focus on late summer/autumn, a period coinciding with both autumn migration and the beginning of the presumed mating period in many of the studied species (Rydell *et al.*, 2010; Rodrigues *et al.*, 2015).
• Search protocols might not identify all casualties, though techniques are improving, particularly with the use of dogs86. Injuries that allow bats to travel out of the typical search area before dying ('cryptic deaths') may mean bat mortality estimates are generally underestimated(Barclay *et al.*, 2017). Fatalities from turbines with greater nacelle/rotor heights may also fall outside the search area and be missed (Weber *et al.* 2018).
• There is some evidence of sex- and age-specific vulnerability to collision (Lehnert *et al.* 2014) but this has not been found in all studies (Barclay *et al.*, 2017, Mathews *et al.* 2016). The predicted effects on local populations depend heavily on the age and sex structure of casualties, so this is an important data gap.
• There are limited mortality estimates for wind energy developments located along migratory flyways (Rydell *et al.*, 2001a)
• The effects of mortality on populations is extremely poorly understood (Weber *et al.* 2018, amongst others)

Disturbance and displacement

• There is limited empirical data on the significance of disturbance and displacement, except in relation to the disturbance of roost sites.
• The extent to which wind farms may displace foraging bats is uncertain but may be important for a broad range of species, and may result in effects on species not considered to be at high risk of mortality (Barré *et al.* 2018).

Barrier effect

• The cumulative barrier effect on long-distance migrants of avoiding multiple obstacles along the course of their migration route remains unstudied.

Habitat loss and degradation

• The extent of functionally linked land that lies beyond the borders of a Natura 2000 site and is necessary to maintain or restore the favourable conservation status of a species is unknown and varies between species (e.g. Apoznański *et al.* 2018). As noted, however, the majority of species vulnerable to collision risk are not Annex II species.

Loss of flight corridors and roost sites

- Empirical data on the significance of the loss of flight corridors is limited.
- Wind turbines may influence populations outside their national borders through effects on migrating bats (Voigt *et al.*, 2012; Lehnert *et al.*, 2014).
- Connectivity between breeding and wintering areas may be weakened as the increasing cumulative density of wind energy developments disrupts national and transboundary migratory routes (Berkhout *et al.*,2013).

Key recommendations for assessing the significance of effects on bats

- Define clear significance criteria that are aligned with the conservation objectives for the bats concerned, are context specific (case-by-case) and are scientifically underpinned.
- Ensure availability of data, notably in relation to bat populations, their activities, their roost sites, etc. to inform plan-level assessments or detailed project-specific surveys and assessment.
- Invest in research in order to cover the knowledge gaps, as listed in Box 5-8.
- Benefit from the increased availability of post-development monitoring reports to improve the evidence base.

Table 5-7 Possible mitigation measures for bats (A: avoidance; R: reduction)

	Collision and barotrauma	Habitat loss and degradation	Disturbance and displacement at roost sites	Loss of flight corridors (barrier effects) and roost sites
Micrositing: Turbine arrangement and location	A/R	A/R	A/R	A/R
Infrastructure design: Turbine number and technical specifications	R		R	R
Scheduling: Avoiding, reducing or phasing construction activities during ecologically sensitive periods			A/R	
Curtailment and cut-in speeds: Turbine operation timing	R			R
Deterrents: Acoustic and visual measures	A/R			R

Reference Number 59 :

Consolidating the State of Knowledge: A Synoptical Review of Wind Energy's Wildlife Effects. Eva Schuster · Lea Bulling · Johann Köppel.Received: 10 August 2014 / Accepted: 10 April 2015 / Published online: 26 April 2015 © Springer Science+Business Media New York 2015

Table 1 Predominant hypotheses on wind energy-induced effects on bats based on Köppel et al. (2014 amended)

Hypothesis	Plausible/supported	Implausible/not-supported
Increased mortality due to high flight activity		
Increase in temperature enhances bat activity/fatality (up to 21 °C)	Arnett et al. (2006[o], 2007)[o], Baerwald and Barclay (2011)*; Behr et al. (2011)[o], Brinkmann et al. (2011)[o], Grodsky et al. (2012)*, Hein et al. (2011b)[o], Kerns et al. (2005)[o]: Meyersdale, and Redell et al. (2006)[o]	Arnett et al. (2006)[o] (>44 m); Horn et al. (2008)*: but in combination with wind speed; Kerns et al. (2005)[o]: Mountaineer
Decrease in wind speed leads to a higher bat activity/fatality	Arnett et al. (2006[o], 2008[n]), Baerwald et al. (2009)*, Baerwald and Barclay (2011)*, Behr et al. (2007*, 2011[o]), Brinkmann et al. (2011)[o], Hein et al. (2011b)[o], Horn et al. (2008)*, Kerns et al. (2005)[o], and Redell et al. (2006)[o]	Arnett et al. (2007)[o]: highest at moderate wind (8 m/s) and high temperature; Grodsky et al. (2012)*, Hein et al. (2011b)[o]: low-frequency bats
High bat fatality/activity in times of high air pressure	Kerns et al. (2005)[o] (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)[o], Brinkmann et al. (2011)[o], and Kerns et al. (2005)[o]	
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)[o]: also sunrise; Behr et al. (2007)*, Brinkmann et al. (2011)[o], Hein et al. (2011b)[o]: 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[o], 2008)[n], Behr et al. (2007)* (July–Oct), Brinkmann et al. (2006)[o], Brinkmann et al. (2011)[o]: July/August; Cryan and Brown (2007)*, Doty and Martin (2012)*: southern hemisphere; Grodsky et al. (2012)*, Hein et al. (2011b)[o], Jain (2005)[o], Johnson et al. (2003*, 2004)*, Redell et al. (2006)[o], and Rydell et al. (2010b)[n]	
Increased mortality due to flight behavior		
Migratory species particularly at risk	Arnett et al. (2008)[n], Baerwald et al. (2009)*, Cryan and Brown (2007)*, Cryan and Barclay (2009)[n], Grodsky et al. (2012)*, Johnson et al. (2003*, 2004*), and Kunz et al. (2007)[n]	Ahlén (2003)[o], Brinkmann et al. (2006)[o], Behr et al. (2007)*, Hull and Cawthen (2013)*, Rydell et al. (2010a)[n], and Voigt et al. (2012)*
Use of echolocation during flight, reaction time insufficient	Grodsky et al. (2011)*, Kunz et al. (2007)[n], Long et al. (2009)[o], and Rydell et al. (2010a)[n]	
Increased risk for sub-adults (e.g., lower flight ability)	Fiedler et al. (2007)[o] (sub-adults and juveniles)	Arnett et al. (2008)[n], Grodsky et al. (2012)*, Hull and Cawthen (2013)*, Johnson et al. (2004)*, Kerns et al. (2005)[o], and Rydell et al. (2010a)[n]

Bats approach turbines while mating, feeding, or swarming	Arnett et al. (2008[k], 2011b[o]), Behr et al. (2007)*, Cryan and Brown (2007)*, Cryan (2008)[p], 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)[o], and Rydell et al. (2010a)[q]	Baerwald and Barclay (2011)* (mating)
Open-air foragers with narrow wings more exposed to collision	Ahlén (2003)[o], Doty and Martin (2012)*, Hull and Cawthen (2013)*, and Rydell et al. (2010a[r], 2010b[n])	
Increased mortality due to attraction		
Investigating turbines as possible tree-roosts increases collisions risk	Ahlén (2003)[o], Cryan and Brown (2007)*, Cryan (2008)[p], Cryan and Barclay (2009)[p], Cryan et al. (2014)*, Hull and Cawthen (2013)*, and Kunz et al. (2007)[s]	
Attraction due to increased prey availability	Ahlén (2003)[o], Ahlén et al. (2009)*, Arnett et al (2011b)[o], Grodsky et al. (2012)*, Horn et al. (2008)*, Kunz et al. (2007)[b], and Rydell et al. (2010b)[n]	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)[k], Baerwald and Barclay (2011)*, Horn et al. (2008)*, Johnson et al. (2003)*, and Kerns et al. (2005)[o]
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)[o], 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)[a], Pearce-Higgins et al. (2012)*, and Steinborn et al. (2011)[o]	Pearce-Higgins et al. (2012)*, and Steinborn et al. (2011)[o]
Facility-caused effects		
Increased turbine height increases effects (displacement, collision risk)	Hötker (2006)[o] (displacement of resting birds)	Barclay et al. (2007)*, Everaert (2014)*, Hötker (2006)[o] (breeding birds), Pearce-Higgins et al. (2012)*, and Stewart et al. (2007)[p]
Spatial turbine layout limits effects on birds if arranged in lines or small clusters	Larsen and Madsen (2000)*	
Operation effects		
Resting species show avoidance behavior near turbines	Devereux et al. (2008)* (common pheasant), Fijn et al. (2012)*, Hötker et al. (2005)[o], Steinborn et al. (2011)[o], 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)[o], and Steinborn and Reichenbach (2012)*
Wind farms cause no effects on breeding success	Reichenbach and Steinborn (2006)[o]	
Decrease in comfort behavior of some species near turbines	Steinborn et al. (2011)[o]	
Birds adapt to wind farms and show signs of habituation	Madsen and Boertmann (2008)*	Hötker et al. (2005)[o] and Rydell et al. (2012)[b]
Enhanced effects due to species characteristics		
Resting birds are more sensitive to wind turbines than breeding birds (avoidance)	Hötker et al. (2005)[o], Reichenbach and Steinborn (2006)[o], and Steinborn et al. (2011)[o]	
Collision risk is species-specific	Drewitt and Langston (2006)[a], Everaert (2014)*, Grunkorn et al. (2009)*, Gue et al. (2013)*, and Morinha et al. (2014)*	
Minor risk of collision for species that spend most of the time on the ground (in particular *Galliformes*)/outside the rotor swept zone	Brennan et al. (2009)[w], Gue et al. (2013)*, LeBeau et al. (2014)*, Pruett et al. (2009b)*, Sandercock et al. (2013)[o], and Winder et al. (2013)*	Falkdalen Lindahl et al. (2013)[w]
Species show no avoidance behavior during flight	Pearce-Higgins et al. (2009)* and Steinborn et al. (2011)[o]	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)[o]
Species that commute between two habitats (e. g., resting and foraging) are at higher collision and displacement risk	Drewitt and Langston (2006)[a], Hötker et al. (2005)[o], Langgemach and Dürr (2013)[o], 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)[o] 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)[o]	

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)[h]
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[o], 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)[o], 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)[o], Katzner et al. (2012)*, Muños Gallego et al. (2011)[ψ], and Orloff and Flannery (1992)[δ]	
Low flight altitude with low air temperature increases collision risk	Barrios and Rodríguez (2004)*, Camiña (2011)[ψ], and Katzner et al. (2012)*	
Raptors drawn to wind farm due to low vegetation cover/open landscapes (favorable hunting ground) increases collision risk	Bellebaum et al. (2013)*, Dürr (2009)[o], 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)[o]	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)[o]	

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)[o]
Attraction due to increase in food availability/change in food distribution increases collision risk	Dürr (2009)[δ], Camiña (2011)[w], and Smallwood et al. (2007)*: borrowing owl	Hoover (2002)[ϕ]
Inattentiveness during foraging increases risk of collision	Orloff and Flannery (1992)[o] and Smallwood et al. (2009)*	
Inattentiveness due to interaction behavior increases risk of collision	Dahl et al. (2013)*, May et al. (2010[o], 2011[o]), Smallwood et al. (2009)*	
Higher risk of collision for adults than sub-adults	Bellebaum et al. (2013)*, Bevanger et al. (2010)[δ], Camiña (2011)[w]: Northern Spain; in Dahl et al. (2013), and May et al. (2010[o], 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)[n]
Indirect effects from wind energy development		
Decrease in breeding attempts/ success due to turbine-induced adult collision risk	Bellebaum et al. (2013)*, Bevanger et al (2010)[δ]: territorial shift, Dahl et al. (2012)*, and Martínez-Abraín et al. (2012)*	
Displacement during operation	Garvin et al. (2011)* and de Lucas et al. (2004)* (except *Falco tinnunculus*)	Dahl et al. (2013)*, Hull and Muir (2013)*, and Madders and Whitfield (2006)[n]

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)°, Hüppop et al. (2004*, 2006*), and van de Laar (2007)◊: gas platform	
	Majority: nocturnal migrants (esp. songbirds, ducks)	Aumüller et al. (2011)*, Christensen et al. (2004)◊, Hill et al. (2014)°, 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 Fägelvind (2011)°, 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)◊	
	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)° (onshore study); Pettersson and Fägelvind (2011)°, and Reichenbach and Grünkorn (2011)°	
	Near coastlines	Burger et al. (2012)*, Hüppop et al. (2004*, 2006*), Kahlert et al. (2011)°, 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 Fägelvind (2011)°	
	Time of the day and year	Hüppop et al. (2004)*: afternoon, 2. half of night and spring, and Pettersson and Fägelvind (2011)°: 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 Fägelvind (2011)°: fly above fog
	Rapid change in weather conditions (precipitation, headwind, strong winds)	Aumüller et al. (2011)*, Hüppop et al. (2004*, 2006*), Pettersson and Fägelvind (2011)°, and Reichenbach and Grünkorn (2011)◊	
Attraction to artificial light sources	Adverse weather condition with low visibility	Aumüller et al. (2011)*, Blew et al. (2013b)ᵛ, Hill et al. (2014)°, Hüppop et al. (2006)*, and van de Laar (2007)◊: gas platform	Kahlert et al. (2011)° (periods of low visibility very infrequent)
	Permanent/intense light	Blew et al. (2013a)ᵛ, Hüppop et al. (2006)*, and van de Laar (2007)◊: gas platform	

Decrease of potential collision risk			
Avoidance behavior	Species-specific	Furness et al. (2013)*, Mateos et al. (2011)[Ψ], Petersen et al. (2006)[δ], and Plonczkier and Simms (2012)*	
	Weather dependent	Aumüller et al. (2011)*, Coppack et al. (2011)[Ψ], Hüppop et al. (2006)*, and Reichenbach and Grünkorn (2011)[Ψ]	Pettersson (2005)[δ]
	Horizontal/vertical/between turbines	Desholm and Kahlert (2005)*, Kahlert et al. (2011)[δ], and Plonczkier and Simms (2012)*	
	Macro-/micro-avoidance	Christensen et al. (2004)[δ], Desholm and Kahlert (2005)*, Furness et al. (2013)*, Hill et al. (2014)[δ], Petersen et al. (2006)[δ], and Pettersson and Fägelvind (2011)[δ]	
	Increased micro-avoidance at operating wind turbines	Hill et al. (2014)[δ]	
Habituation	Over the years	Plonczkier and Simms (2012)*	

Table 5 Predominant hypotheses on wind energy-induced effects on marine mammals

Hypothesis	Plausible/supported	Implausible/not-supported
Habitat change		
Increase in prey availability due to exclusion of fishery	Scheidat et al. (2011)*, SMRU (2009)[ω], and Simmonds and Dolman (2008)[Ψ]	
Increase in habitat quality due to artificial reef-effect	Gill (2005)[β], 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)[β]	
Collision with floating or submerged structures	Gill (2005)[β] and Simmonds and Brown (2010)[β]	Russell et al. (2014)*
Disorientation due to change of magnetic fields	Gill (2005)[β], 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)[β], and Simms and Ross (2000)[β]	
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)*, Nedwell et al. (2007)◊, Nehls and Betke (2011)◊, and Thompson et al. (2010)*	
Mother-calf-separation/ disturbance	Dähne et al. (2014b)ψ, and Kastelein (2013a)ψ	
Increased vessel activity causing stress/disturbance and risk of strikes	Carstensen et al. (2006)*, Gordon (2012)ψ, Nedwell and Howell (2004)□, SMRU (2009)○, Simmonds and Dolman (2008)ψ, and Simmonds and Brown (2010)δ	
Tendency to return after piling	Brandt et al. (2009)○, Haelters and Vanermen (2013)ψ, Nehls and Betke (2011)◊, Scheidat et al. (2011)*, Tougaard et al. (2006b)○: Horns Rev, and Wahl et al. (2013)ψ	Tougaard et al. (2006a)○: 2 years
Disperse of sediment causing re-suspension of potentially polluted sediment and turbidity	Carstensen et al. (2006)*, Gill (2005)δ, and Simmonds and Dolman (2008)ψ	
During operation		
Masking causing disruption of usual behavior	Koschinski et al. (2003)*: harbor seals; Lucke (2008)○: at very short distance	Gordon (2012)ψ, Haelters and Vanermen (2013)ψ, Koshinski et al. (2003)*: harbor porpoises, Lucke (2008)○, Nehls and Betke (2011)○, and Tougaard et al. (2009b)*
Avoidance of wind farm area/ change of behavior due to noise emission and vibration	Simmonds and Dolman (2008)ψand Tougaard et al. (2009b)*: porpoises at very short distance/seals likely	Dähne et al. (2014a)◊, McConnell et al. (2012)○, Nedwell et al. (2007)◊, and Scheidat et al. (2011)*
During decommissioning		
Habitat loss due to removal of structure	Gill (2005)δ, and Gordon (2012)ψ	
Injury or behavioral response due to noise emission (e.g., explosion, cutting)	Gordon et al. (2007)○, Lucke et al. (2009)*, Prior and McMath (2008)ψ, SMRU (2009)○, and Simmonds and Dolman (2008)ψ	
Increased vessel activity causing stress/disturbance and risk of strikes	Nedwell and Howell (2004)□, and Simmonds and Brown (2010)δ	
Disperse of sediment causing re-suspension of potentially polluted sediment and turbidity	Carstensen et al. (2006)*, Gill (2005)δ, and Simmonds and Dolman (2008)ψ	

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

Reference Number 60 : 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 Number 61 : 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 No. 62: 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 No. 63: 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 Number 64 : Flight height patterns of a critically endangered insectivorous bat, impacted by wind turbine collision. May 2025. Amanda Bush, Lindy Lumsden, Thomas A. A. Prowse.
DOI: 10.1101/2025.05.23.655017

Harnessing wind energy, using wind turbines, is a prominent form of renewable energy production. There are, however, biodiversity impacts, including collisions by birds and bats with rotating blades. High levels of mortalities can cause localised and species-level population declines, which is especially significant for threatened species. The height at which species fly is a key collision risk factor. In this study we investigated the flight height patterns of a critically endangered bat to inform mitigations to reduce impacts. Methods We captured and GPS tagged 244 Southern Bent-wing Bats (Miniopterus orianae bassanii) (14 to 19 g) in south-eastern Australia, in spring and late summer/early autumn. We retrieved 93 units, yielding 4,289 bat observations from an 18 to 21 day period in each season. The vertical measurement error of the GPS units at different heights and sampling intervals was investigated with drone test flights. A Bayesian state-space modelling approach was then developed to estimate flight height distributions while accounting for measurement error.

Our results suggest that the majority of bat activity occurs between ground level and 30 m altitude, at least in early spring and late summer/early autumn. However, the bats were recorded taking short flights above 60 m and at times even flew above 80 m (maximum model estimate was 92.7 m with a maximum 95% CI of 144.1 m) and demonstrated that they are capable of quick and frequent altitudinal changes from ground level to almost 40 m. Flight heights were on average higher when associated with trees in summer. Mean flight heights appear to be higher when associated with tree habitats in summer.

This study shows that the flight height distribution of small bats can be investigated using store-on-board GPS devices and illustrates a statistical approach that incorporates vertical measurement error. It provides the first insights into the flight heights of this small bat species, which can help inform a more complete flight height profile across different seasons and conditions with future improvements in GPS technology. Results suggest that, although the Southern Bent-wing Bat primarily flies at lower heights, it exceeds 30 m altitude at times, increasing the risk of mortalities due to wind turbine collision. Accurately determining the proportion of time that threatened species such as the Southern Bent-wing Bats spend within high-risk flight zones will provide the evidence base for implementing effective mitigation measures to reduce population-level impacts.

Reference No 65 : 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."

Chapter 8: Land Soils and Geology has been prepared by Hydro-Environmental Services (HES) and assesses the likely significant effects that the Proposed Project may have on land, soils and geology and sets out the mitigation measures proposed to avoid, reduce or offset any potential significant effects that are identified.

The land, soils and geology of the site have been characterised using a combination of desk study and site investigation data. Several walkover inspections of the site have been completed as well as peat probing, gouge coring, shear vane testing, trial pit excavations, and laboratory analysis of recovered soil samples.

The Proposed Project site consists predominantly of cutover bog comprising of bare peat fields separated by field drains. The existing topography of the Proposed Project site is relatively flat, ranging from approximately 50 to 62mOD. As a result of industrial peat extraction activities and associated drainage works the land and topography of the Proposed Project site has been significantly modified. Industrial peat extraction ceased at the Proposed Project site in June 2020. All stockpiles had been removed from the site by the end of 2024. The decommissioning works relating to the railway network within the Proposed Project site are in the process of being completed.

Based on the peat depth information for the Proposed Project site, peat depths vary between 0 and >6m with an average peat depth of 2m. The peat thickness at the proposed turbine locations ranges from 0.1 to >4.5m. Available site data indicates that at least 80% of the 15 no. proposed turbine locations have a peat depth of ≤3m. Peat depths exceeding 3m were recorded at only 2 no. turbine locations: T15 and T1. The greatest peat depths were recorded in the north of the Proposed Project site, with deep peat encountered at the proposed onsite 220kV substation location (5-5.5m). Where possible the deeper peat areas have been avoided by the Proposed Project layout. The peat deposits at the proposed site are underlain by glacial tills comprising of clay, silts, sands and occasional gravels. The glacial till deposits are underlain by limestone bedrock.

The Proposed Project will involve removal of peat and subsoils (spoil) for the construction of access roads, internal road network, internal cable network, hardstanding emplacement, turbine foundations, proposed onsite 220kV substation, crane hardstands, compounds and met mast foundations.

Estimated volumes of peat and spoil to be excavated are in the region of 438,449m3. Excavated peat and spoil will also be used for reinstatement and landscaping works as close to the extraction point as possible or stored within the proposed onsite borrow pits. Peat will also be stored in the proposed onsite designated peat deposition areas. The handling and storage of peat and spoil will be done in accordance with the Peat and Spoil Management Plan which is included as Appendix 4-3 to the EIAR.

Storage and handling of hydrocarbons/chemicals will be carried out using best practice methods. Measures to prevent peat and subsoil erosion during excavation and reinstatement will be undertaken to prevent water quality impacts.

A Peat Stability Risk Assessment was undertaken for the site (Appendix 8-1 to the EIAR), and demonstrates an acceptable margin of safety, i.e., the Proposed Project site is suitable for the Proposed Project and is considered to be at low risk of peat failure. A number of control measures are given in the peat stability assessment to manage all risks associated with peat instability.

The Proposed Project has a very small development footprint when compared to the overall area of the Proposed Project site (approx. 3%). Therefore, no significant effects on land will occur during the construction, operation or decommissioning phases of the Proposed Project.

The peat bog at the Proposed Project site is already degraded by the historical industrial peat extraction and drainage. For this reason, and with the implementation of the mitigation measures detailed in this EIAR and the best practice measures detailed in the Peat and Spoil Management Plan, no significant effects on peat and soils will occur during the construction, operation or decommissioning phases of the Proposed Project.

With the implementation of the mitigation measures outlined in this EIAR, no significant effects on the underlying limestone bedrock geology will occur during the construction, operation, or decommissioning phases of the Proposed Project.

An assessment of potential cumulative effects associated with the Proposed Project and other developments on land, soils and geology has been completed. The Land, Soils and Geology Assessment confirms there will be no significant negative cumulative effects on land, soil and geology as a result of the Proposed Project. The assessment found that the cumulative effect with the draft Cutaway Bog Decommissioning and Rehabilitation Plan (Appendix 2-4 to the EIAR) will result in an overall positive effect on the local land, soils and geological environment.

Reference Number 66 : Wake Modeling And Simulation Of A Real Scale Wind Turbine Using Large Eddy Simulation And Dynamic Adaptive Mesh Refinement. Leandro J.L. Stival, Joshua R. Brinkerhoff & Fernando O. De Andrade & João Marcelo Vedovotto. An Acad Bras Cienc **(2025)** 97(4): e20240875 DOI 10.1590/0001-3765202520240875 Anais da Academia Brasileira de Ciências | *Annals of the Brazilian Academy of Sciences* Printed ISSN 0001-3765 I Online ISSN 1678-2690 www.scielo.br/aabc | www.fb.com/aabcjournal

Table I. Parameters of the NREL 5MW Wind Turbine.

Parameter	Value
Number of rotor blades	3
Rotor Diameter	126 m
Rated Power	5.3 MW
Rated Wind Speed	11.4 m / s
Rated Rotational Speed	12.1 rpm
Blade Length	61.5 m

The inflow wind velocity profile was imposed at the inlet with a hub height velocity of $u = 8$m/s.

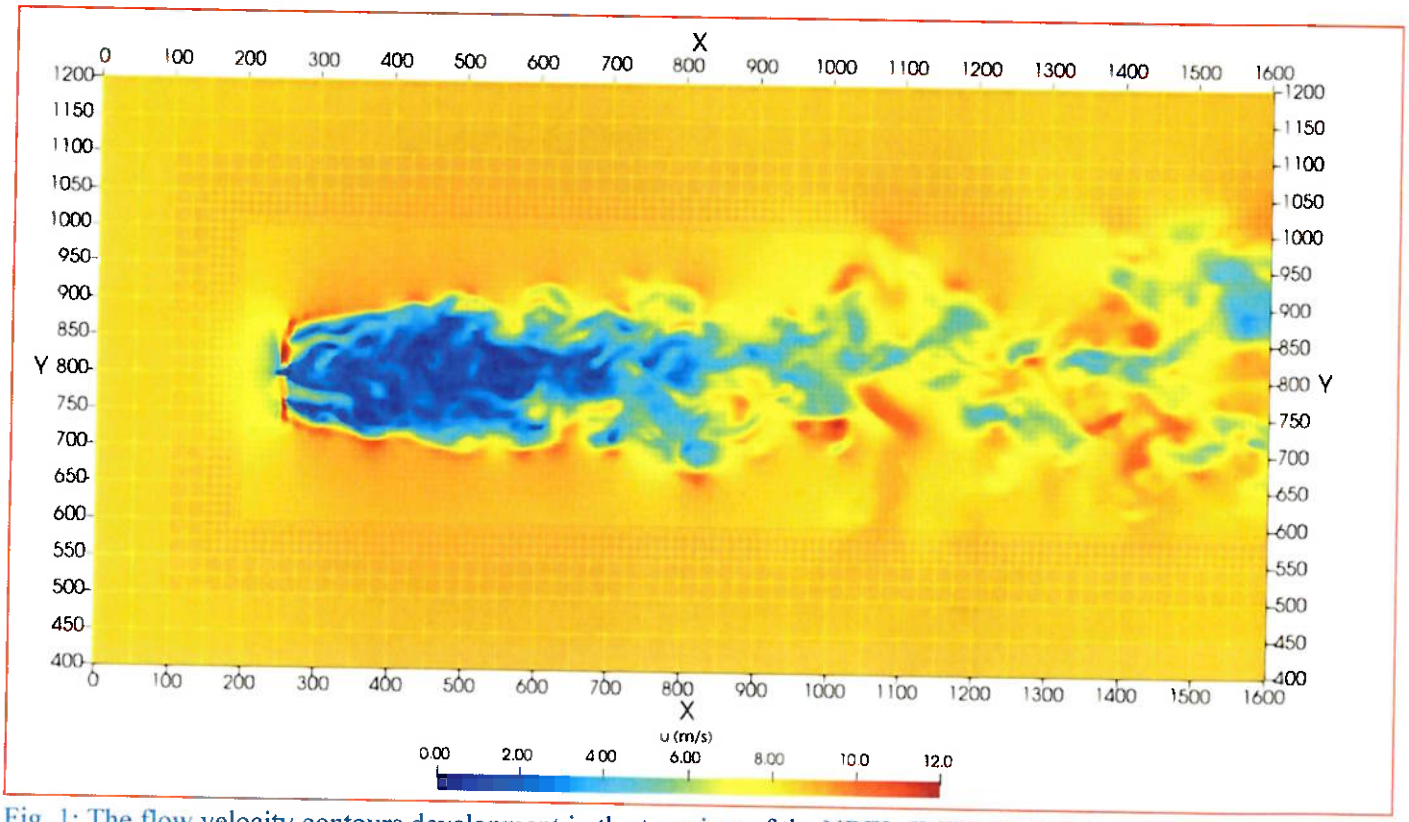


Fig. 1: The flow velocity contours development in the top view of the NREL 5MW wind turbine.
Response from ML: This is a view from above the turbine looking towards ground. The turbine is to the left & you can see the turbulence towards the right & extending beyond 1,600m downwind. Note it extends outside the diameter of the turbine.

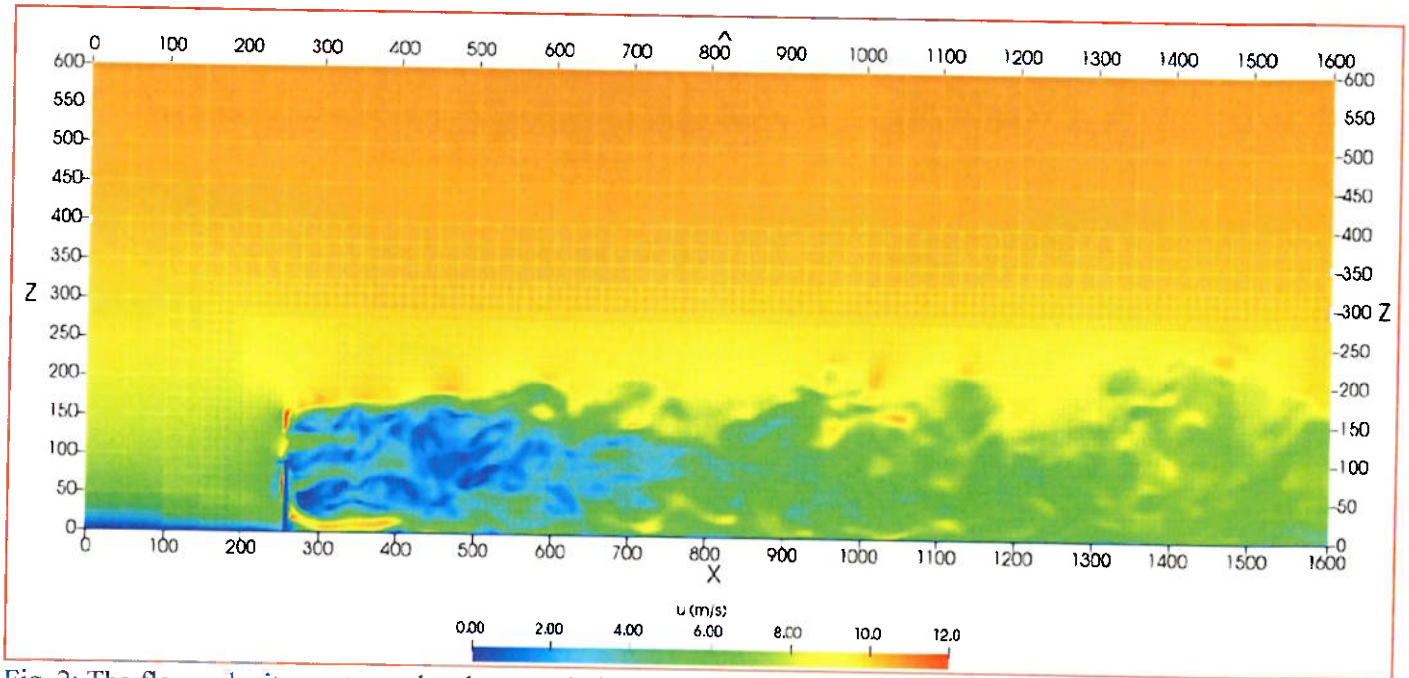


Fig. 2: The flow velocity contours development in lateral view of the NREL 5MW wind turbine.
Response from ML: This is a vertical view from the side the turbine. The turbine is to the left & you can see the turbulence towards the right & extending beyond 1,600m downwind. Note it extends above the diameter of the turbine.

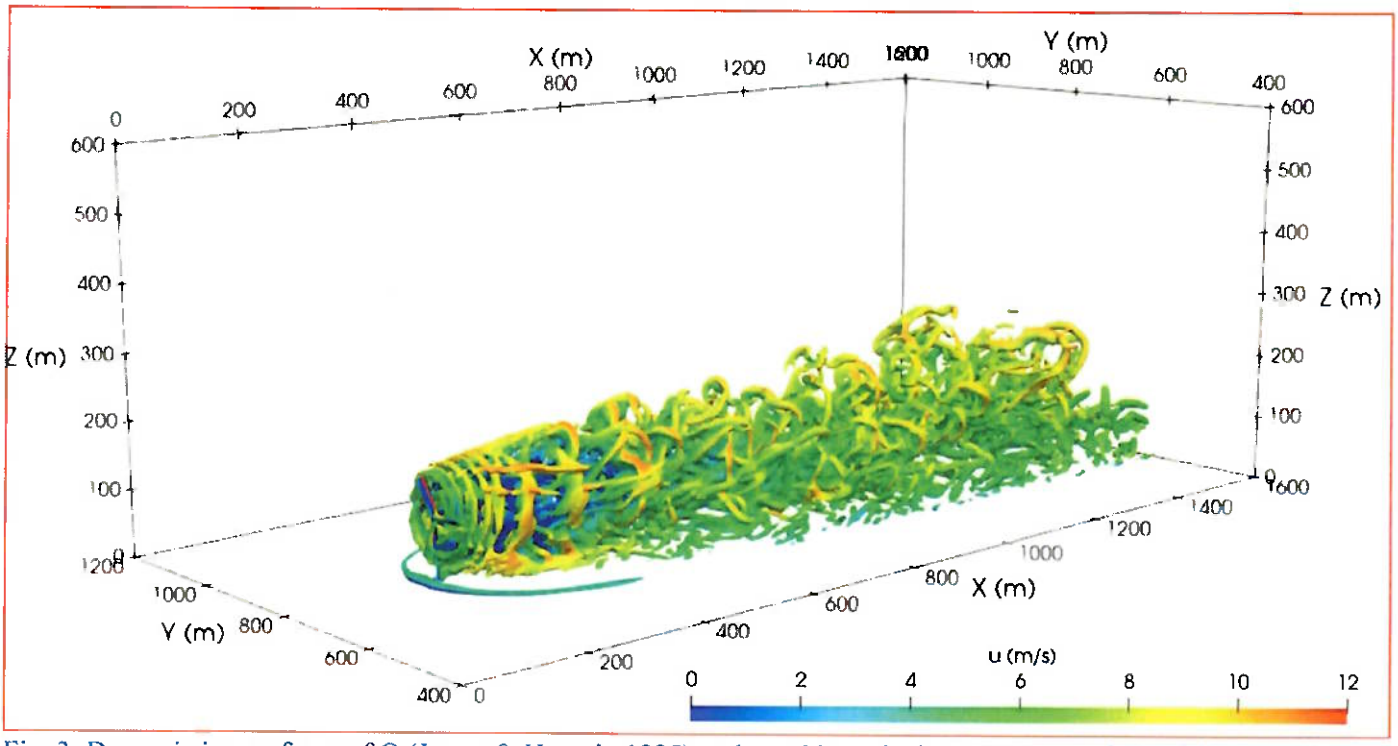


Fig. 3: Dynamic iso-surfaces of Q (Jeong & Hussain 1995), coloured by velocity around the wind turbine.

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?

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 bring 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.

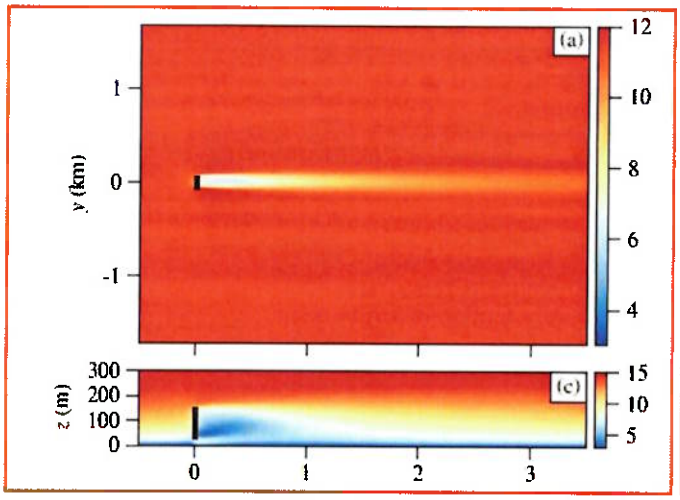


Fig. 4: One turbine & wake from above - top & side - bottom.

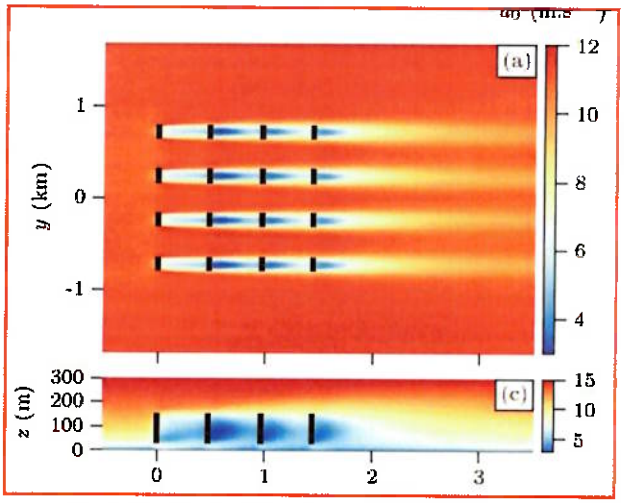


Fig. 5: Multiple turbines & wakes from above - top & side - bottom.

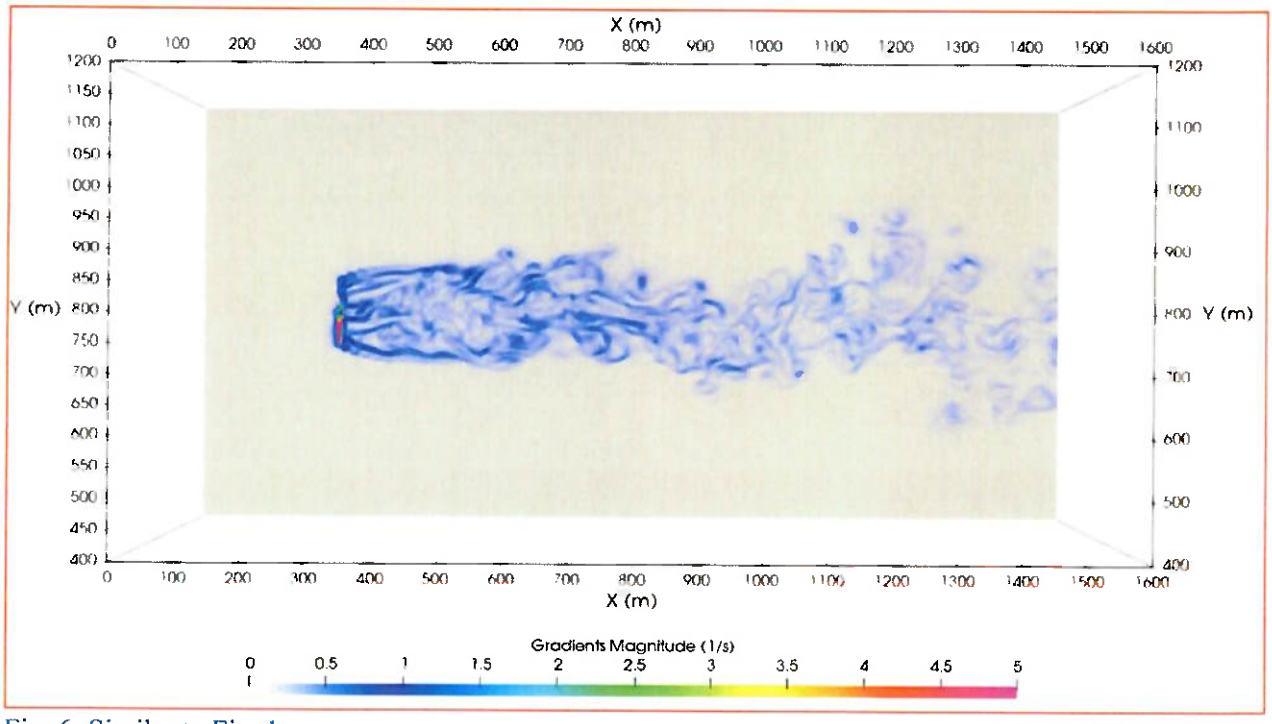


Fig. 6: Similar to Fig. 1.

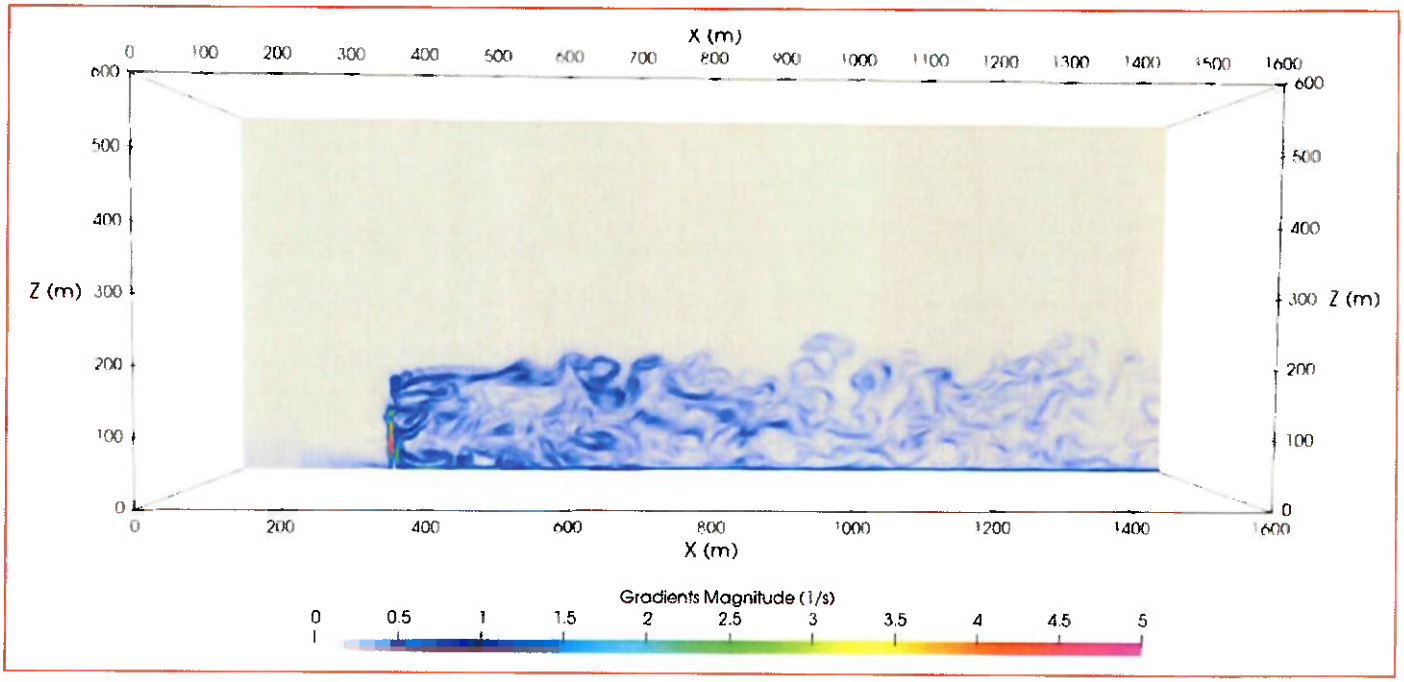


Fig. 6: Similar to Fig. 2: Vertical Contours of gradients of velocity of the overflow around the wind turbine.

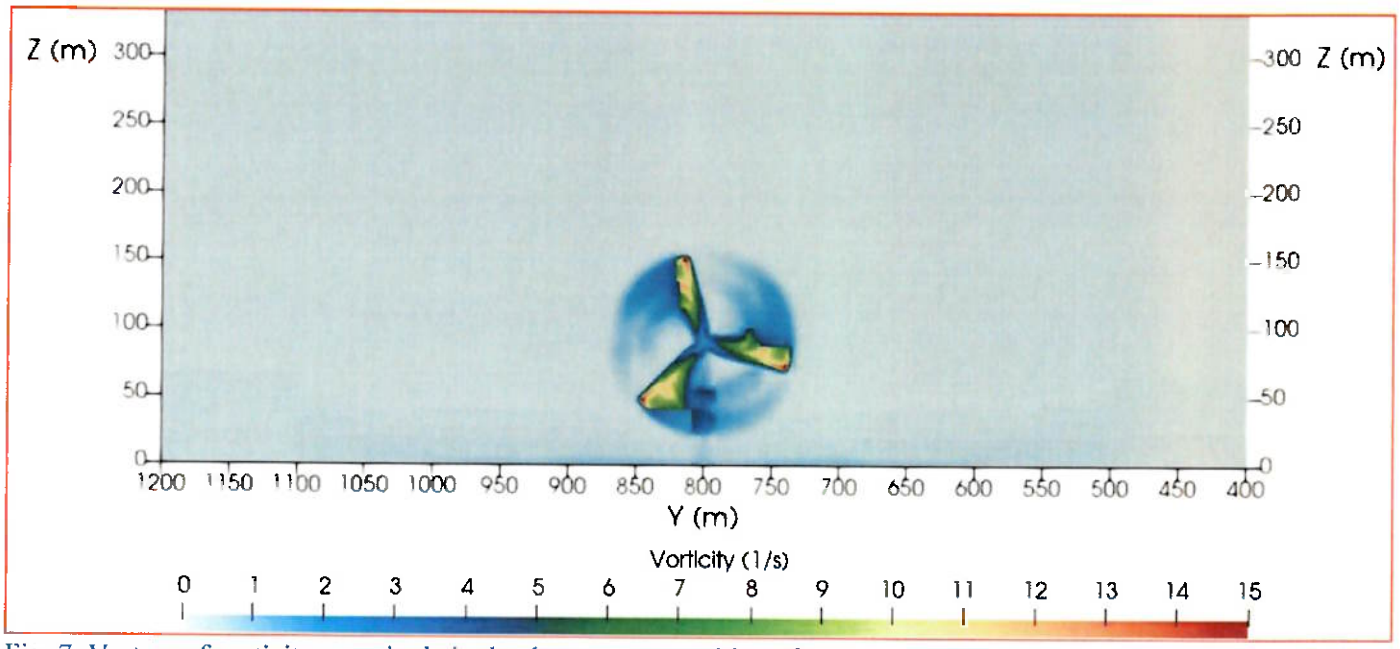


Fig. 7: Vectors of vorticity magnitude in the downstream position of the wind turbine. Insects are attracted to wind turbines & the bats follow the insects. The blade tip speed is c90metres per second. This is 324km/hr. In reality about 1.5 times the speed of a F1 motor racing car.
The 162m diameter would cover Croke Park from the outside of the Canal end to the outside of Hill 16.

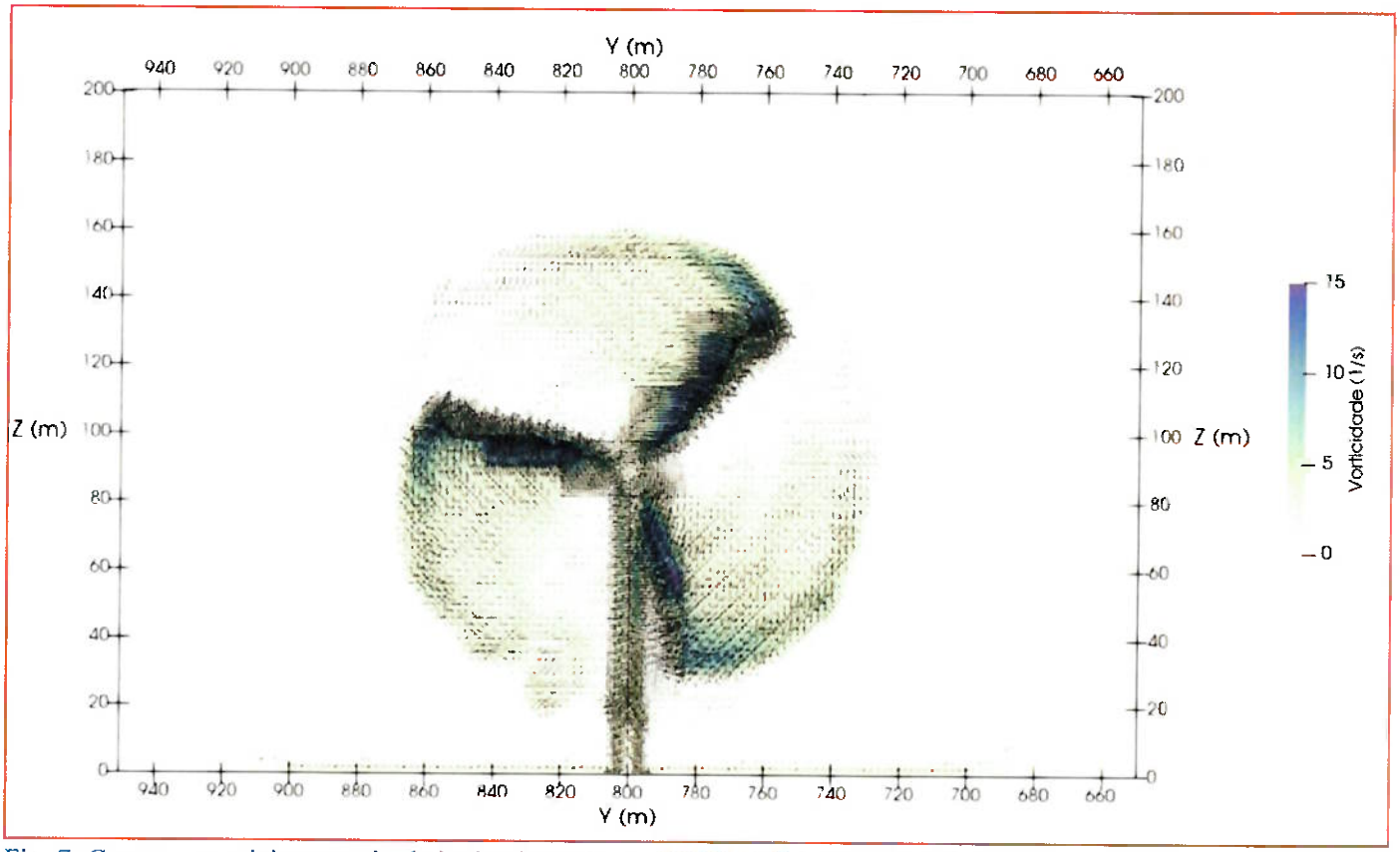


Fig. 7: Contours vorticity magnitude in the downstream position of the wind turbine.

Reference No 67 : Wind turbine noise generation and propagation through large eddy simulation and acoustic analogy. Giacomo Rismondo, Giovanni Petris, Marta Cianferra and Vincenzo Armenio. *J. Fluid Mech.* (2025), *vol.* 1024, A33, doi:10.1017/jfm.2025.10709

The analysis is representative of medium-sized turbines with low tip Mach number (~0.10). The fluid dynamic analysis revealed: a turbulent boundary layer over the blades, together with a trailing edge vortex sheet; a complex near-wake structure, including tip and root vortices; an intermediate wake with vortex instabilities triggering leap-frogging and vortex grouping mechanisms; and a far wake characterised by fully developed turbulence. Two primary

noise generation mechanisms were identified. The unsteady pressure field over the turbine surface generates tonal noise at the blade passing frequency and a high-frequency broadband noise, associated with the trailing edge vortex sheet (linear-noise contribution). The turbulent wake generates broadband low-frequency noise, driven by the complex fluid-dynamic processes outlined previously (nonlinear noise contribution). The linear part of the noise was found to dominate over the nonlinear one in the acoustic far field, while the opposite is true in the acoustic near field. As a composition of the two contributions to the noise, the directivity exhibits a non-symmetric dipole shape oriented along the flow direction, with lobes recovering symmetry moving from the near to the far field. Finally, analysis of the acoustic decay rates reveals that the linear term in the near field decays according to an $r^{-(n+1)}$ law within the rotor plane, where n is the number of blades, consistent with recent findings on the acoustics of rotating sources.

The near wake is influenced by the presence of the rotor itself and its geometrical properties; a three-dimensional complex flow is present, characterised by coherent periodic helicoidal vortex structures, namely the root and tip vortices; in the case of an isolated marine propeller, a strong rectilinear vortex is evident, namely the hub vortex. These vortex structures are connected through a thin vortex sheet released by the blades. The breakdown and instability of the hub and tip vortices, occurring in the intermediate wake, are responsible for the transition from the near to the far wake, with a considerable amount of turbulent kinetic energy detected at the outer radii. Finally, a fully composite turbulent wake develops in the far wake. Further downstream, a self-similar behaviour is detected with the mean streamwise velocity deficit profile collapsing into a single Gaussian distribution.

Several experimental and numerical investigations are present in the literature, exploiting the dynamics of rotor wake, as well as the instability mechanism responsible for the transition from near to far wake. Most of them used simplified methods such as actuator technique, which may give some information about the characteristics of the wake. Geometry-resolving simulations are more recent, and few of them have been carried out using eddy-resolving techniques, like large eddy simulation.

Rotor acoustics

The noise produced by rotors, especially wind turbines, is classified into three main groups, namely low-frequency noise, inflow turbulence noise and aerofoil self-noise. The rotation of blades produces the so-called thickness noise, characterised by a tonal spectrum, with peaks at the blade passing frequency (BPF) and its super-harmonics.
The rotating lifting surfaces, namely the loading noise source, contribute to BPF and broadband noise, the latter in the high-frequency range; this is because the transition from laminar to turbulent boundary layer and flow separation induce fluctuating pressures on the blade surface, as well as a thin vortex sheet radiating from the blade trailing edge. This noise-generation mechanism is known as trailing-edge noise and contributes to the acoustic signature over a wide range of frequencies (Lee *et al.* 2021). The noise emitted by the tip vortex influences both the low- and high-frequency regions of the spectrum and is not yet fully understood. The incoming turbulence, associated with the atmospheric boundary layer (ABL) or upwind wind turbines (in wind farm applications), produces a broadband noise. Depending on the characteristics of the turbulence, such as the time and length scales of the disturbances, the inflow turbulence noise mechanism contributes both to high- and low-frequency noise.
Experimental studies have contributed to the knowledge of noise generated by rotors. Specifically in the field of wind turbines, Debruijn, Stam & Dewolf (1984) performed acoustic measurements in small and medium wind energy conversion (WEC) systems, finding that the radiated noise is more affected by the rotational speed than the wind inflow velocity. Van der Borg & Vink (1994) carried out noise measurements on wind turbines, evaluating separately the contribution of tonal noise and that obtained with different blades on the same rotor, finding that changing blade geometry has a marginal effect on noise production. Oerlemans, Sijtsma & López (2007) performed acoustic field measurements for a three-blade wind turbine with a rotor diameter of 58 m, to characterise noise sources and to verify the dominance of trailing edge noise over other mechanisms. Ramachandran, Raman & Dougherty (2014) exploited the beamforming method to measure the aerodynamic noise sources in wind turbines, confirming that the trailing-edge noise source is dominant in the noise produced by the blade.

The fluid dynamic analysis showed the following features: a turbulent boundary layer develops over the blades together with a composite system of tip vortex, blade wake and root vortices in the near wake; the intermediate wake is characterised by destabilisation of the tip vortex and the mutual inductance mode triggering the leap-frogging mechanism; the fully turbulent wake populated by a number of turbulent structures is present in the far field. Our results agree with those of the relevant literature.

The contribution of the wake to the noise is significant in the low-frequency range $f < 4\,fT$. Among the vortical structures present in the wake, the role of vortex grouping has been highlighted: it causes the loss of tonal peaks, at the blade passing frequency, and generates low-frequency broadband noise.
The contribution to the noise originating from different regions has been investigated, considering two different configurations, the first composed of three different annular concentric regions, and the other composed of different sub-regions of the wake. The analysis of the first configuration confirmed that the trailing edge vortex system is the most important noise source, as regards the linear part of the noise; while the tip vortex system, together with its instability and evolution in the intermediate wake, is the dominant mechanism of the nonlinear noise source.

Reference No 68 : 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 No 69 : 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 2025, Vol. 11, No. 1, 2567100 Https://Doi.Org/10.1080/27658511.2025.2567100

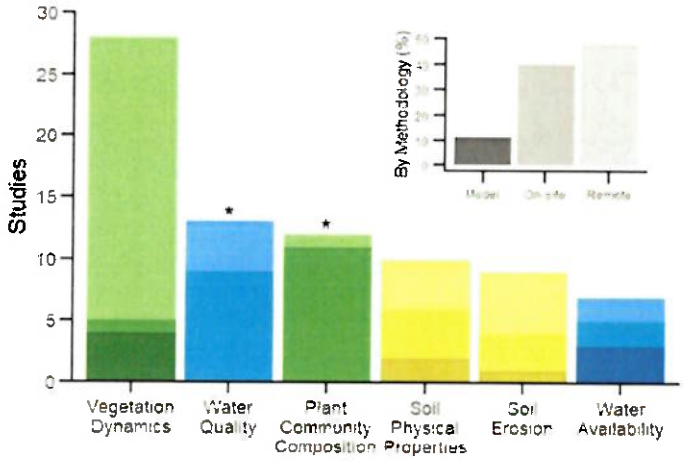


Figure 3. The number of empirical studies on the specific impacts of onshore wind energy on ecosystems. Each impact group is represented by a stack of bars, with different shades (dark, medium, and light) indicating the proportions of different methodologies used. The inset displays the overall proportions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

Reference Number 70 : Emerging evidence links wind power plants to changes in vegetation, soil, and hydrology. This may contribute to ecosystem degradation, which has been defined as '*[…] a persistent decline in the structure, function, and composition of an ecosystem compared to its former state*' (Society of Ecological Restoration, 2024).

Literature was retrieved on 25 July 2024, from Web of Science, Scopus, and ProQuest. For Tethys, a faceted search strategy was used to retrieve all references listed under land-based wind and linked to habitat change as a stressor and the physical environment as a receptor. The initial search yielded a total of 1477 references. All references were imported into the EndNote reference manager (The EndNote Team, 2013), and duplicates removed automatically.

Studies were excluded when they: (1) were not in English, (2) did not focus on onshore wind energy, (3) lacked relevance to vegetation, soil, or hydrology, (4) focused on wildlife disturbance, or (5) were not available as full text. This process resulted in 70 references meeting the criteria for inclusion. Following initial selection, a backward and forward reference search was conducted using the Web of Science citation map, identifying 18 additional studies that met the inclusion criteria. In total, 88 studies were included in this review.

Negative impacts on vegetation dynamics can result from vegetation clearings prior to construction, vehicle movement in construction areas (Christol et al., 2021), or wake effects caused by wind turbine blade movement (Diffendorfer et al., 2022; Li et al., 2016). For example, the development of wind power plants has been linked to deforestation (Balotari-Chiebáo & Byholm, 2024; Diffendorfer & Compton, 2014; Enevoldsen, 2018) and declines in overall native vegetation cover (Cetin et al., 2022; Guan, 2023; Turkovska et al., 2021). The associated vegetation loss can be substantial, with individual wind turbines contributing to the clearance of up to 3000 m2 of vegetation (Shen et al., 2017). On the project level, the vegetation loss could be as much as 25% of the whole project area (Balik et al., 2017).

Environmental impacts

Vegetation dynamics

Remote sensing studies have confirmed negative impacts on vegetation cover. Qin et al. (2022) found that 59% of 319 wind power plants across the United States exhibited reduced vegetation growth within their main operation area. Other researchers reported decreases in the Normalized Difference Vegetation Index (NDVI), indicating reduced vegetation cover and greenness after wind power plant construction in coastal regions (Aksoy et al., 2023), alpine ecosystems (Ma et al., 2023), and grasslands (Song et al., 2023; Tang et al., 2017). Xia and Zhou (2017) also found a decrease in NDVI after wind power plant construction, although their results were not statistically significant. Lastly, Diffendorfer et al. (2022) observed both increases and decreases in vegetation greenness within the growing season.

Plant community composition

Several studies have examined the impacts of onshore wind energy development on plant community composition. While Ji et al. (2023) documented an increase in species diversity around wind turbines in meadow grasslands, Fraga et al. (2009) found that species diversity was decreased inside the main operation area of a wind power plant within a blanket bog. A long-term study by Urziceanu et al. (2021) found that plots disturbed by wind turbines contained less than 40% of the inventoried rare, endemic, and threatened species of the characteristic steppe vegetation. Losses of endemic species as a result of wind power development were also recorded in mixed-grass prairies (Davis et al., 2018), mires with wet heath vegetation (Fagúndez, 2008), and deserts (Keehn & Feldman, 2018).

Soil erosion

When vegetation is cleared during the construction phase of a wind power plant, bare soil becomes susceptible to erosion from wind and rainfall (Nazir et al., 2020). Peatlands, when drained for safer wind turbine placement, pose a significant risk of carbon loss through erosion (Smith et al., 2014), which can be intensified by the drying of surface soils, depending on season and wind direction (Wang et al., 2023). Additionally, the construction of access roads for wind power plants can trigger peat slides, contributing to further soil loss (Dykes, 2022). In the Karaburun region of Turkey, researchers recorded a total loss of approximately 18,000 tons of soil organic carbon between 2000 and 2019, likely caused by wind energy development (Pekkan et al., 2021). When planning the siting of wind power plants in Chile, it was suggested that the associated soil erosion could increase soil loss by as much as 50% (Martí et al., 2023). Studies conducted in the Yunnan province of China imply that soil loss may even increase by over 1000% when accounting for factors like vegetation damage and rainfall (Ma et al., 2023).

Soil physical properties

Soil physical properties encompass factors such as soil texture, structure, density, temperature, and water- holding capacity (Sanchez, 2019). The construction of onshore wind power plants can alter soil physical properties through activities like excavation, road construction, and the building of related infrastructure (Christol et al., 2021). These

disruptions can cause the loss of native soils, topsoil disturbance, and microtopographic changes. They can also lead to soil compaction (Chen et al., 2019), which tended to be highest near wind turbines and decreased with distance (Xie et al., 2014). Furthermore, alterations in ground-level microclimate and soil temperature have been measured (Armstrong et al., 2016), along with changes in nutrient content (Chen et al., 2019; Luo et al., 2021) and soil salinity (Chen et al., 2019). Ji et al. (2023) also studied the influence of wind power plant operation on soil carbon content but found no significant impacts. The effects from decommissioning are expected to be similar to the ones from construction, which is why turbine pads and underground powerlines are often left in situ to minimize further soil disturbance (Welstead et al., 2013).

Water availability

Onshore wind energy development can affect an ecosystem's water availability via changes in microtopo-graphy and soil physical properties (Christol et al., 2021). Gunn et al. (2002) found that during the construction of an access road for a wind power plant in a peatland, the organic topsoil layer was 6L. SEIFERT ET AL. compacted, causing water to collect on the upslope side. The water availability can also be reduced actively by inserting ditches to regulate water flow and drain the soil for safer wind turbine placement, which is common practice in peatlands (Murray, 2012). Ditches can be inserted temporarily during construction to regulate surface runoff caused by earthwork activities and to prevent wind turbine pads from being uplifted, or permanently to regulate increased runoff caused by road construction (Stunell et al., 2009). It was suggested that the effects of drainage for wind energy development can far exceed conservative land use estimates and need to be backed up by continuous long-term studies on hydrological impacts (Ramchunder et al., 2009; Renou-Wilson & Farrell, 2009). In addition to drainage, some studies found impacts of wind power plants on local precipitation. Jawaheer et al. (2018) observed a decrease in precipitation one year after the construction of the Roches Noires wind power plant in Mauritius. Similarly, Pryor et al. (2018) found a decrease in summer precipitation caused by wind power plant operation, though the effect was not statistically significant. These findings are contradicted in a study by Fiedler and Bukovsky (2011), who used a regional climate model to demonstrate a significant increase in precipitation resulting from wind power plant operation.

Water quality

Studies on water quality have predominantly centered around wind power plants in peatlands, where peat degradation can contribute to reduced water quality by mobilizing metals and pollutants stored in the peat (Evans et al., 1999). The establishment of wind power plants was linked to increases in water turbidity and nutrient contents (Stunell et al., 2009), as well as dissolved organic carbon content (Ramchunder et al., 2009) in downstream aquatic habitats. The concentration of dissolved organic carbon and suspended sediments was higher in streams disturbed by wind power plants compared to undisturbed reference streams (Grieve & Gilvear, 2009; Heal et al., 2020; Lindsay & Bragg, 2005; van Niekerk, 2012; Waldron et al., 2009). At the Whitlee wind power plant in Scotland, researchers measured increased macronutrient concentrations (Zheng et al., 2018) and export rates (Murray, 2012) following wind power plant construction on peatland. Another study conducted on peatland reported significant impacts on pH and alkalinity (Millidine et al., 2015). However, studies conducted in a Karst environment found no impacts on groundwater quality (Valente et al., 2022).

Consideration of mitigation and restoration

The majority of studies (41 studies) focused exclusively on impacts, while fewer considered the subsequent need for mitigation (24 studies) or restoration (23 studies). This was especially apparent in empirical research, where more than half of the studies (35 out of 62 studies) focused exclusively on impacts, while only few acknowledged the subsequent need for mitigation (16 studies) or restoration (11 studies). In contrast, only 6 of the 26 non-empirical studies focused exclusively on impacts, while the majority addressed the need for mitigation (8 studies) or restoration (11 studies). Another emerging trend was the low concern for restoration in studies that analyzed vegetation impacts. The share of vegetation studies was 58% in the studies exclusively focusing on impacts, and 55% in those mentioning mitigation. This trend was reversed in the restoration group, where most studies concerned soil-related impacts (45%), but only 30% concerned impacts on vegetation, despite the overall dominance of vegetation studies in the reviewed literature. For hydrological studies, no clear trend was observed regarding their consideration of mitigation and restoration.

Discussion

Highlights

This literature review analyzed 88 studies on the impacts of onshore wind energy on vegetation, soil, and hydrology. Empirical studies were more common than non-empirical studies. They primarily focused on vegetation dynamics and highlighted both positive and negative effects, such as increased biomass in grasslands and deserts, but significant vegetation loss in forests. For impacts on soil and hydrology, empirical evidence remained limited. Few studies included direct field-based measurements of soil compacted, causing water to collect on the upslope side. The water availability can also be reduced actively by inserting ditches to regulate water flow and drain the soil for safer wind turbine placement, which is common practice in peatlands compaction or hydrological alterations, and only a small subset monitored long-term recovery. Moreover, most empirical research lacked standardized methods or site replication, making it difficult to generalize findings across studies. Importantly, nearly half of the studies focused solely on identifying impacts, while few acknowledged the subsequent need for mitigation or restoration. This trend was reversed for non- empirical studies. This imbalance highlights the need to more actively consider how environmental impacts can be mitigated and how degraded ecosystems can be restored in the context of onshore wind energy.

Note that the blades have to be cleaned of insect detritus. This involves detergents and power hoses. The contaminated fog created by such cleaning discharges & emerging particles from blades onto the soil & into the underground waterbody causing pollution to the nearby drinking water sources.

Reference No 71 : 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

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.

Reference Number 72 : 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).

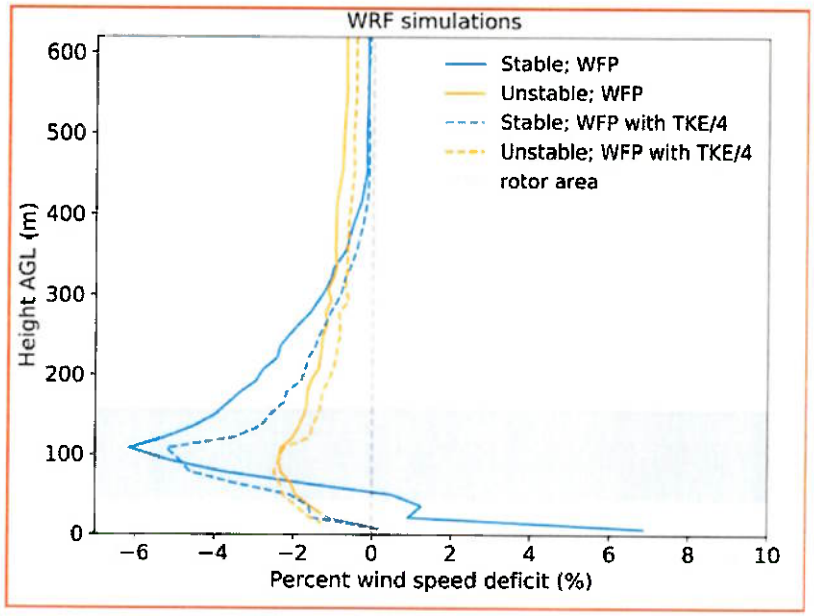
As for impacts on vegetation, ***our results showed decreased vegetation for most wind farms,*** *especially those large farms. However, positive and insignificant impacts were observed as well. The decreased vegetation is mainly caused by the construction of wind farms and the associated land cover 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 Number 73: 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 No 74 : 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 No 75 : *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 No 76 : 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 Number 77 : 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.

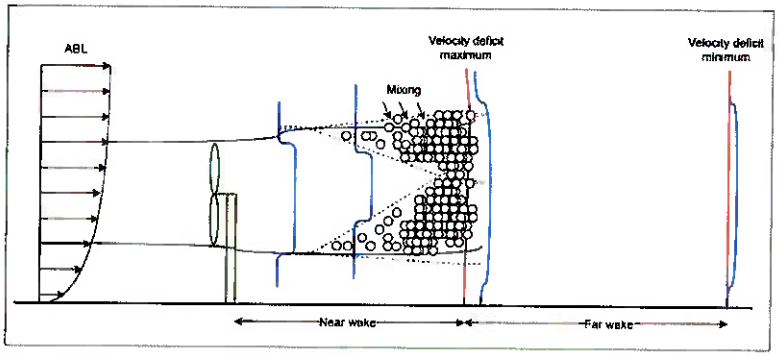


Figure 9. The velocity profile behind WT [85].

Due to the wake effect, the downstream WTs receive wind with lower speed and higher turbulence level, which reduces the energy yield . In Figure 10, uo is the direction of wind, T1 to T7 are WT locations, and it is clear that the downstream WTs receive modified wind; hence, it affects the energy yield.

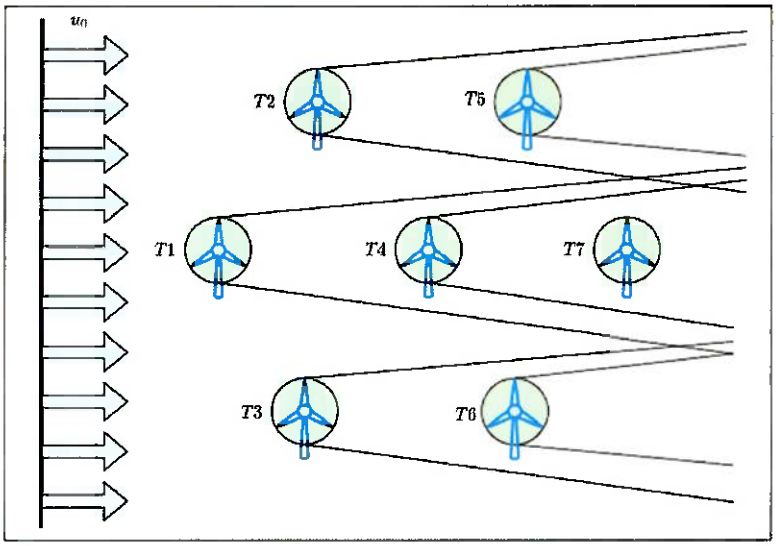


Figure 10. Wake effect in a wind farm (WF) [73].

The parameters that influence the wake effect are Wind Farm size and layout, number and size of WTs, wind speed and direction, and turbine blade design . General impacts of the wake generated by WTs are a mechanical failure, extra maintenance cost, and reduction in power.

Reference Number 78 : Eolization 2024 : A project on spatial auralization of wind farm noise Jules Colas, Loïc Alexandre. INTER-NOISE and NOISE-CON Congress and Conference Proceedings · October 2024 DOI: 10.3397/IN_2024_4225

Results: First, the results from the propagation simulations are briefly presented for the scenarios studied. In Fig. , the overall sound pressure level (OASPL) fields average over one rotation are plotted in the plane z = 2 m for the two cases. For a single wind turbine (Fig. 5a), the OASPL presents a dipolar shape which is characteristic of a wind turbine. Cross-wind extinction zones (on the line x = 1500 m) and an upwind shadow zone (x < 1000 m) are observed and a small focusing induced by the wake downwind (x > 2000 m) is also discernable. When two wind turbines are present (Fig. 5b) the same features are present but superimpose on each other. No additional refraction patterns that could be induced by the wake of the turbines are visible in this case. The average OASPL is typically low in wind turbine noise application and amplitude modulation (AM) must also be considered as it is responsible for annoyance at resident locations. Fig. 6a shows the AM field at z = 2 m for one wind turbine. AM is defined as the difference between minimum and maximum OASPL computed during one rotation of the rotor. For the single wind turbine case some classical features are again recovered with this method. In the cross-wind direction (x = 1500 m) high amplitude modulation is found due to the blade approaching and receding from the receiver. Upwind, at the limit of the shadow zone (x = 1000 m), AM also increases as already shown by various authors [11, 19]. AM also increases downwind (x > 3000 m) due to the wake effect [14, 20]. As sound sources move inside the wake the refraction pattern is modified and the amplification at the ground changes. The same features are present in the two wind turbine case (Fig. 6b) but AM decreases slightly downwind and crosswind because of the source superposition.

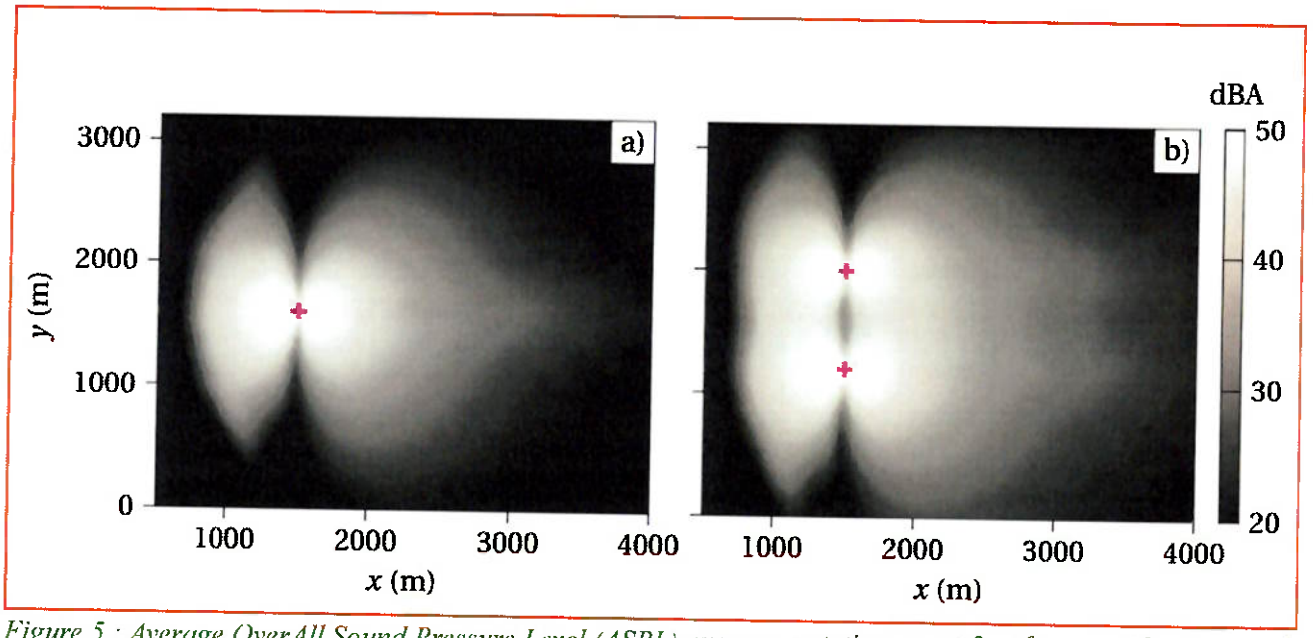


Figure 5 : Average OverAll Sound Pressure Level (ASPL) over one rotation at z = 2 m for a) single wind turbine case and b) two wind turbine cases. Wind turbine hub positions are indicated with crosses.

Note the upwind and downwind noise effects up to 50Dba for distances over 2km.

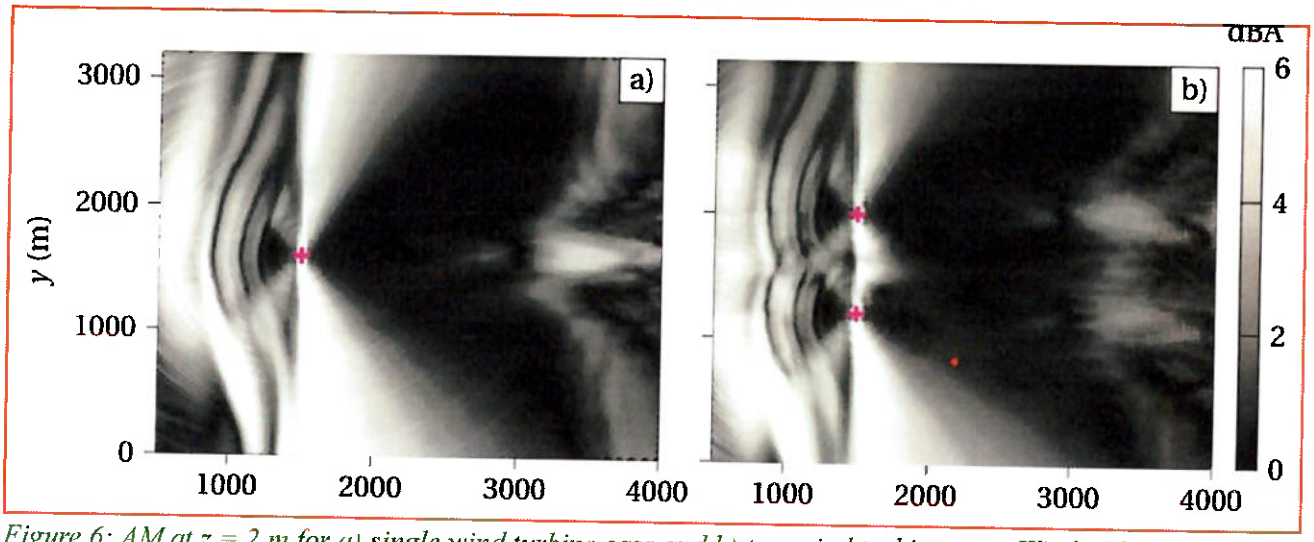
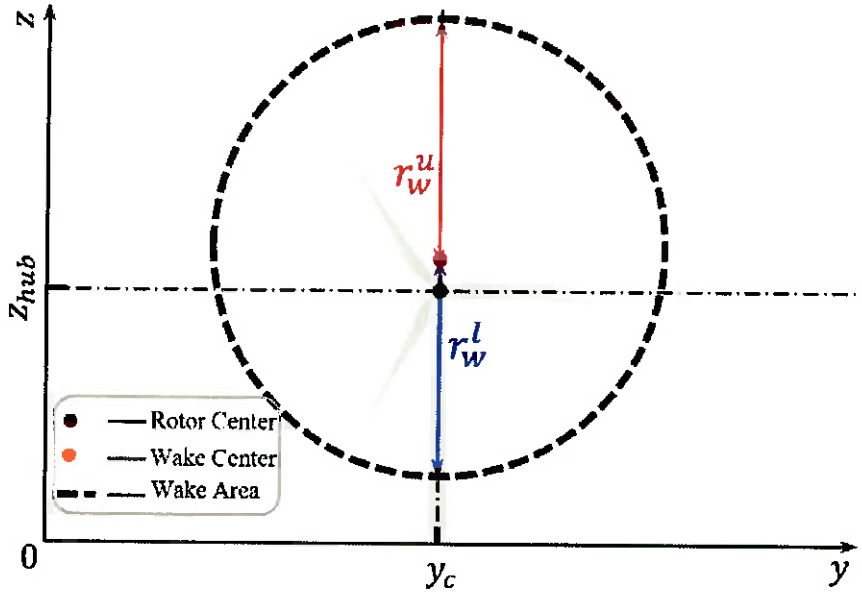


Figure 6: AM at z = 2 m for a) single wind turbine case and b) two wind turbine case. Wind turbine positions are indicated with crosses. and (x, y) = (2500 m,1600 m) for the two scenarios considered.

Reference Number 79 : 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 Number 80 : 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 Number 81 : Wind turbine impact on near-ground air temperature, Renewable Energy Volume 123, August 2018, David Moravec , Vojtěch Barták , Vladimír Puš , Jan Wild . https://doi.org/10.1016/j.renene.2018.02.091

"*Impacts on local climate are especially crucial in situations where allocating more turbines is justified by reducing carbon emissions, because these effects could have subsequent impacts on the carbon cycle in the affected area.* Wind farms can affect local climates in two main ways. The first is by extracting kinetic energy, which slows wind flow. The second is by further heightening turbulence flow downwind. Turbulence can be generated in the wake of rotors and also by the shear between the non-affected faster air layer below the turbine and the upper air layer slowed by the turbine .

The generated turbulence has a secondary effect by enhancing vertical mixing of air. Several studies showed that enhanced turbulence produced by wind farms has impact on heat and moisture exchange between the surface and the atmosphere. In stable atmospheric conditions, when a warm air layer is present above cooler air, increased turbulence results in a warming near the surface by transferring thermal energy from higher levels to the lower. On the other hand, when unstable atmospheric conditions are present, i.e. cool air lying above a warmer layer, enhanced turbulence leads to mixing the layers and provides a cooling effect on the ground. These impacts depend on the ratio of natural turbulence to turbulence generated by the wind turbine. The stability of atmospheric layers can also influence a wind farm's impacts. The effect of vertical mixing can be 10–15% stronger when a wind turbine is present in the atmospheric boundary layer."

"Theoretical models have been tested in wind tunnel experiments. The outcomes of these experiments have shown that the effect of the wake can be found up to a distance of 20 rotor diameters . A computational study has suggested this to be a shorter still distance of 15 diameters . Maximum turbulence has been found at a distance of 4–4.5 rotor diameters above rotor hub height in neutral cases of atmospheric layers and 3–6 diameters in stable cases. Heightened turbulence intensity is associated with strong shear of layers and turbulent kinetic energy produced by regional features or wind farm layout ."

The effect of the turbine: For every 1,000ft you ascend, the temperature drops approximately 3.5-5 degrees Fahrenheit.[1.94- 2.77 degrees Centigrade]..The proposed windfarm will reduce temperatures by a minimum of 4 degrees Centigrade & a maximum of 6 degrees Centigrade. The Meterological Maps indicate the effect on the Wake area. Basically pasture lands & crops will be dramatically affected as will carbon sequestration.

Reference Number 82 : 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 Number 83 : Observations of wind farm wake recovery at an operating wind farm Raghavendra Krishnamurthy1, Rob K. Newsom1, Colleen M. Kaul1, Stefano Letizia2, Mikhail Pekour1, Nicholas Hamilton2, Duli Chand1, Donna Flynn1, Nicola Bodini2, and Patrick Moriarty. Wind Energ. Sci., 10, 361–380, 2025 https://doi.org/10.5194/wes-10-361-2025 ©Author(s) 2025.

Wind turbine wakes, i.e., velocity deficits due to extraction of the kinetic energy from an operating wind turbine, are observed to extend several kilometers during stable atmospheric conditions both onshore and offshore (Hirth et al., 2012; Banta et al., 2015; Krishnamurthy et al., 2017; Fernando et al., 2019; Ahsbahs et al., 2020; Zhan et al., 2020). Wind farm wakes from a large cluster of wind turbines in mesoscale model simulations, and offshore observations **can reach over 50km downwind** under stable atmospheric conditions (Platis et al., 2018; Lundquist et al., 2019, Schneemann et al., 2020). Large-eddy simulations of large wind farms also show that wind farm wakes can alter the surface momentum and heat fluxes (Calaf et al., 2011). Wind farm wakes are known to impact the local meteorological conditions by, for instance, increasing or decreasing the temperature and enhancing turbulence downwind of a wind farm (Baidya Roy et al., 2004; Smith et al., 2013; Siedersleben et al., 2018; Miller and Keith, 2018, Bodini et al., 2021), although the intensity of the impact depends on atmospheric stability, local atmospheric processes, orientation of the wind farms, downwind distance, and the number and operative regimes of wind turbines.

In operational wind farms, intra-farm wakes can result in significant power losses, and it is important to understand the dissipation of wakes within a wind farm. The effect of a wind turbine is to decrease the mean velocity and increase the turbulent kinetic energy above the rotor layer (the layer from the bottom of the wind turbine blade tip to the top of the blade tip; Verhulst and Meneveau, 2014). The turbulent transport term in a steady-state filtered-energy equation includes the entrainment of the mean momentum due to turbulence and the entrainment of the turbulent kinetic energy due to fluctuating velocities (Allaerts and Meyers, 2017).
Today's wind turbines operate within the lowest 300m of the atmospheric boundary layer (ABL), and in offshore or stable atmospheric conditions the ABL can be lower than 300m (Shaw et al., 2022). Although wind farms operate within 300m above ground level, their impacts can be observed through the entire depth of the boundary layer. Therefore, to accurately assess such impacts, observations of mean and turbulent characteristics of wind and temperature should extend up to the top of the ABL.

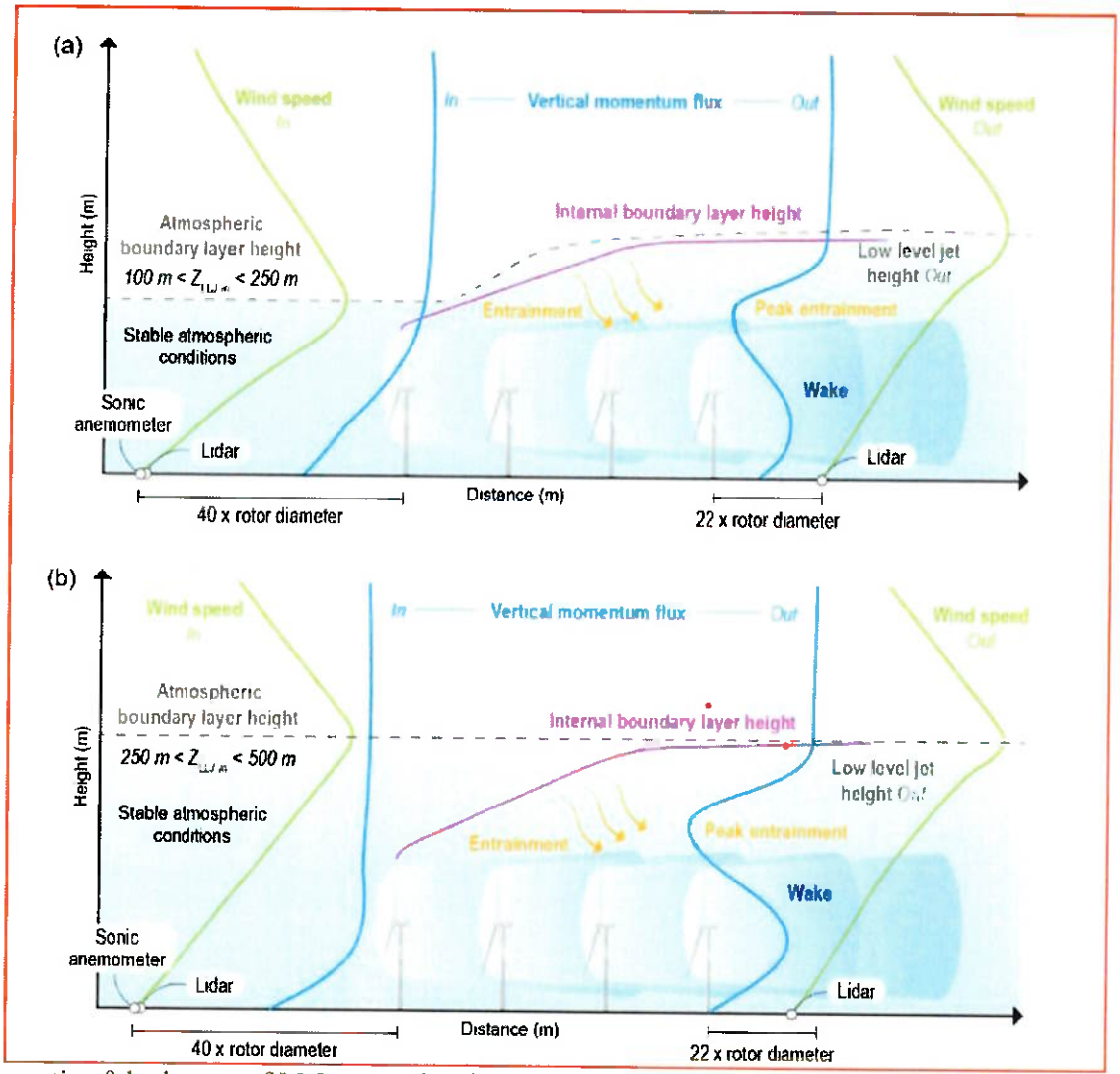


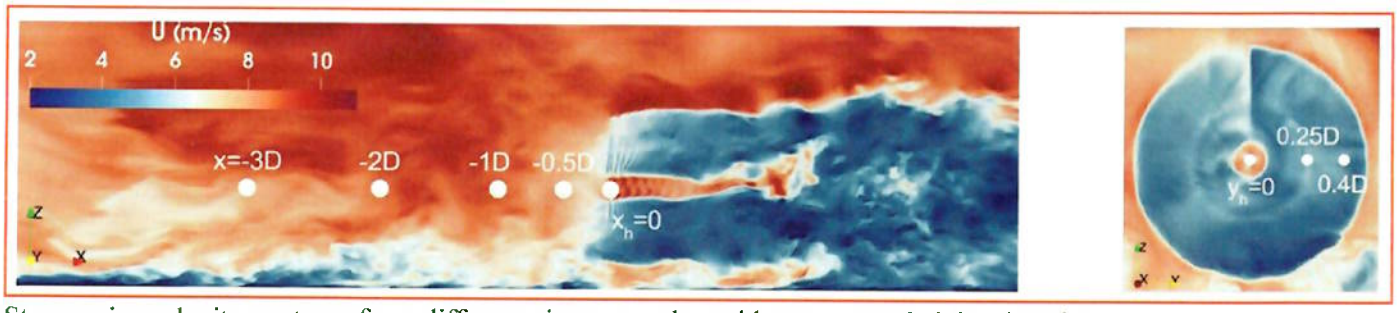
Figure: Schematic of the impact of LLJs on a wind farm boundary layer when (a) 100m<ZLLJ<250m and (b) 250m<ZLLJ<500m.

Note the Wake distance of 22 times rotor diameter which equates to 3.575km for a 162.5m diameter. Negative wind shear during non-LLJ cases show short wake propagation at 22 Rotor Diameters downwind of a wind turbine.

Reference Number 84 : Turbulence Distortion Matters in Predicting Inflow Turbulence Noise of Future Wind Turbines. Ozgur Yalcın, Andrea Piccolo, Riccardo Zamponi, Daniele Ragni, and Roberto Merino-Martinez. https://doi.org/10.5194/wes-2025-214. Preprint. Discussion started: 29 October 2025

Aerodynamic noise can be classified mainly into blade self-noise and inflow turbulence (IT) noise. Considering blade optimization and operational flow regimes, trailing edge (TE) noise is a dominant self-noise source, which inherently scatters in the mid-to-high frequency range (Oerlemans et al., 2007). On the other side, IT noise arises from the interaction between the incoming turbulent flow and the blade leading edges (LEs), predominantly emitting low-frequency noise (f <200 Hz, corresponding to acoustic wavelengths larger than blade chords and comparable to large WT rotor scales) (Lowson, 1993; Buck et al., 2016).

Recent developments, such as TE add-ons and active flow control mechanisms, have yielded notable reductions in TE noise (Zhou et al., 2022; Lahoz et al., 2024). However, increasing rotor sizes and hub heights of next-generation turbines shifts the noise spectrum to lower frequencies, thus amplifying the relevance of IT noise (Moller and Pedersen, 2011). This shift is particularly important considering that low-frequency sound waves propagate over longer distances and experience reduced air absorption and transmission losses by building materials. **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 Number 85 : Atmospheric stability effect on wind farm flow and performance. Marwa Souaiby and Fernando Porte-Agela, Phys. Fluids 37, 095152 (2025); doi: 10.1063/5.0280027. 11 September 2025

Large-eddy simulations are used to investigate how surface-layer stability (from strongly stable to strongly unstable) and free-atmosphere stratification influence wind farm flow and power output. Increased stability reduces turbulence intensity (TI), limiting wake recovery and decreasing power to downstream turbines. These effects are amplified under strong free-atmosphere stratification, which confines the internal boundary layer, suppresses vertical mixing, and reduces momentum entrainment, leading to stronger velocity deficits and greater power losses. Blockage effects, including entrance-region wind speed reduction, also intensify with increasing stratification—more so in the free atmosphere than in the surface layer. In strongly stratified cases with low Froude numbers (Fr_1:2), pronounced standing gravity waves form, accelerating the flow in the exit region and near wake, but slowing wake recovery further downstream due to reduced ambient TI. While wake recovery is generally delayed under stronger stratification, wind speed recovers more slowly than TI, particularly when freeatmosphere stratification is strong. Overall, the results highlight the need to consider both surface-layer and free-atmosphere stability when assessing wind farm aerodynamics and performance.

Reference Number 86 : How far the wake of a wind farm can persist for? Guodan Dong, Zhaobin Li, Jianhua Qin, Xiaolei Yang. Theoretical and Applied Mechanics Letters 12 (2022) 100314.

With the increased penetration of wind energy in our nation's energy portfolio, wind farms are placed in a way close to each other. Thus, their wakes have to be fully considered in the design and operation of a wind farm. In this study, we investigate the wake of a wind farm using large-eddy simulation with wind turbine rotor modelled by the actuator disk model. The simulated results show that the wake of a wind farm can persist for a long distance in its downstream. For the considered wind farm layout, the velocity in the wake recovers 95% of that of the undisturbed inflow at 55 rotor diameters downstream from its last row, suggesting that the wake of a wind farm should be fully considered in the optimal design and operation for its downstream wind farms.

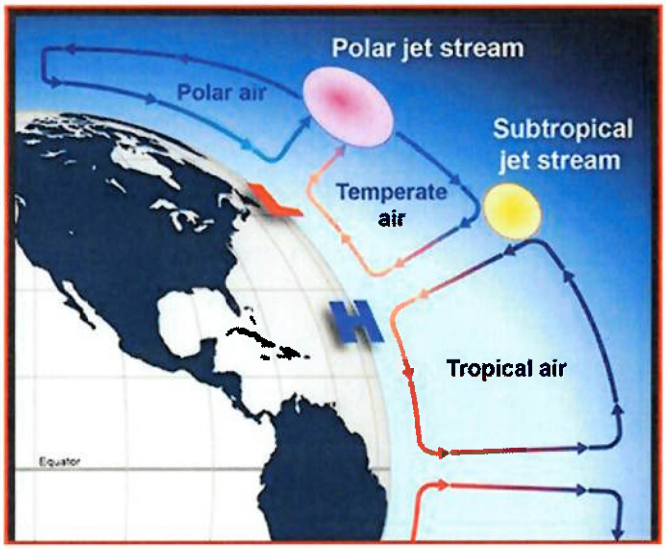
The simulated results show that the streamwise velocity recovers 95% of the undisturbed incoming wind speed at 55 *D* downstream of the last row of the wind farm. The influences of wind turbine wakes persist for a very long distance, which are still observed even at 165 *Diameters* downstream of the last row of the wind farm.

For a 162.5m rotor diameter wind turbine, 55D = 8.937km & 165D = 26.812km. Thus houses & farms are subject to property losses, agricultural output losses over these distances, temperature losses & heating costs without their consent.

Reference Number 87 : Climatic Impacts of Wind Power. Miller & Keith, Joule 2, 2618–2632 December 19, 2018. 2018 Elsevier Inc. https://doi.org/10.1016/j.joule.2018.09.009

Climatic impacts due to wind power extraction were first studied using general circulation models (GCMs). These studies found statistically significant climatic impacts within the wind farm, as well as long-distance teleconnections, with impacts outside the wind farm sometimes as large in magnitude as impacts inside the wind farm. Note that such impacts are unlike greenhouse gas (GHG)-driven warming, as in some cases wind power's climatic impacts might counteract such GHG warming—at least four studies have found that mid-latitude wind power extraction can cool the Arctic. However, these studies often used idealized or unrealistic distributions of turbines installed at unrealistic scales. Model simulations of geometrically simple, isolated wind farms at smaller scales of 3,000–300,000 km2 (10- to 1,000 times larger than today's wind farms) in windy locations found substantial reductions in wind speed and changes in atmospheric boundary layer (ABL) thickness, as well as differences in temperature, precipitation, and vertical atmospheric exchange.

In central USA, The warming is greatest in an N-S corridor near the center of the wind turbine array, perhaps because of an interaction between wind turbines and the nocturnal low level jet (LLJ). The LLJ is a fast nocturnal low-altitude wind (>12 m/ s at 0.5 km) common in the US Midwest, which occurs when the atmosphere decouples from surface friction, resulting in a steep vertical temperature gradient —meteorological conditions that might be sensitive to perturbations by wind turbines.



The climatic impacts of wind power may be unexpected, as wind turbines only redistribute heat within the atmosphere, and the 1.0 W m2 of heating resulting from kinetic energy dissipation in the lower atmosphere is only about 0.6% of the diurnally averaged radiative flux. ***But wind's climatic impacts are not caused by additional heating from the increased dissipation of kinetic energy. Impacts arise because turbine-atmosphere interactions alter surface-atmosphere fluxes, inducing climatic impacts that may be much larger than the direct impact of the dissipation alone.***

As wind turbines extract kinetic energy from the atmospheric flow and slow wind speeds, the vertical gradient in wind speed steepens, and downward entrainment increases. These interactions increase the mixing between air from above and air near the surface. The strength of these interactions depends on the meteorology and, in particular, the diurnal cycle of the atmospheric boundary layer(ABL).

Reference Number 88 : 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 [1], and Orsted presented an update of its long-term financial targets taking into account the blockage and wake effects [2], 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 [3].

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.**

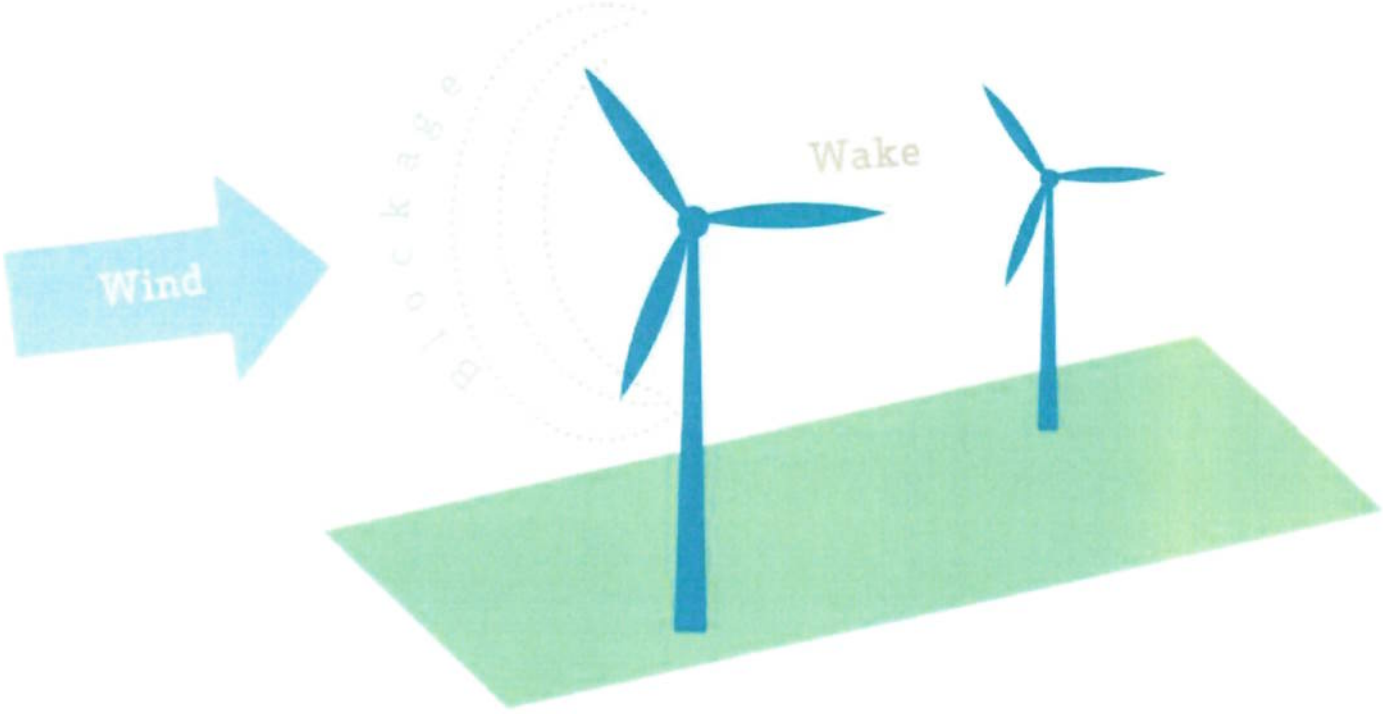
This effect can impact the efficiency and energy output of turbines located downwind, as they receive less kinetic energy from the wind. The increased turbulence within the wake can cause additional mechanical stress on these downstream turbines, potentially leading to higher maintenance needs and a 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.

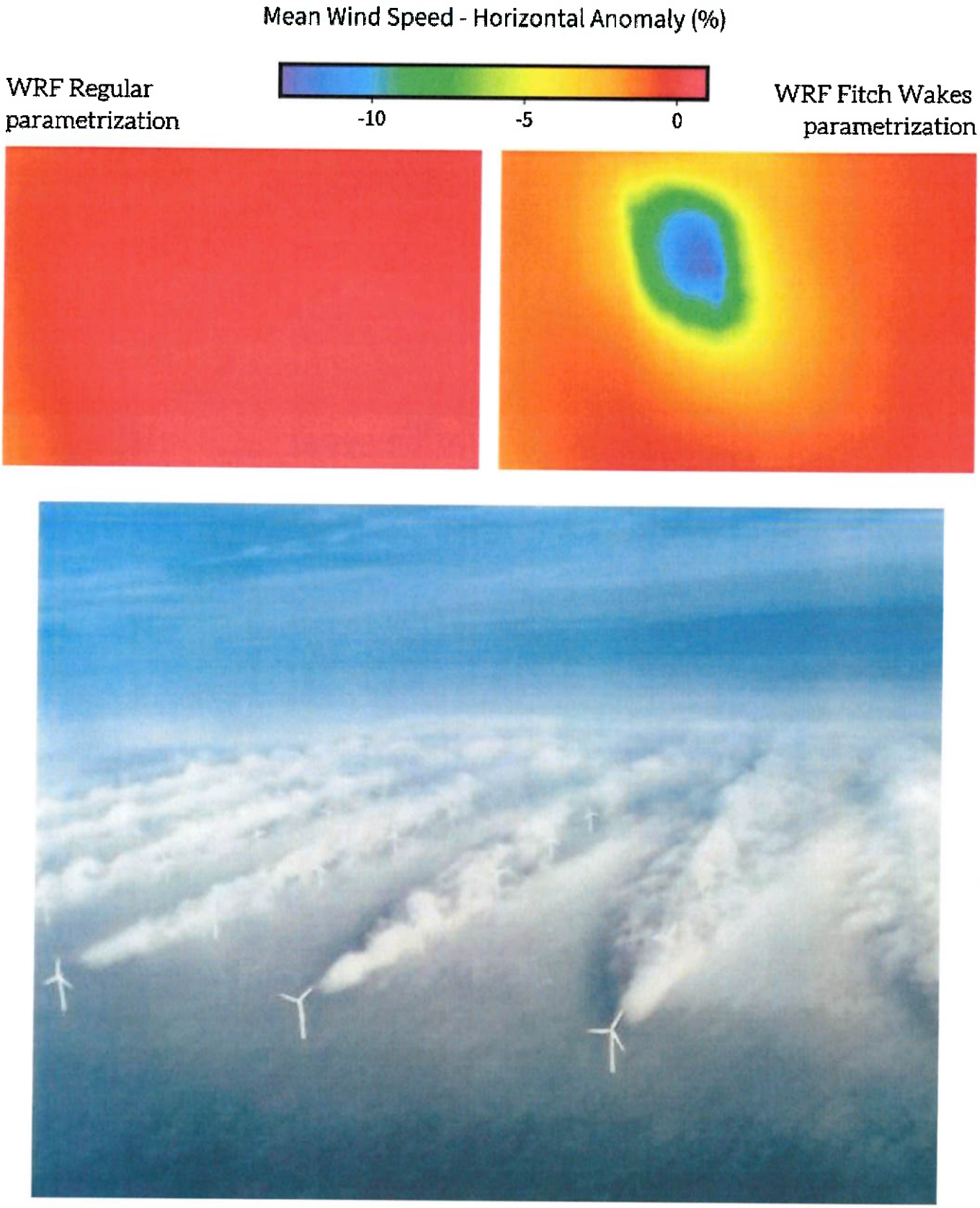


A scheme of the wake and blockage effect. The first turbine disrupts the airflow, so the second turbine will have a lower power output and more turbulence. The blockage produces a deceleration of the flow upstream of the turbine.

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 [4].

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 Number 89 : 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 Number 90 : 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 Number 91 :
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

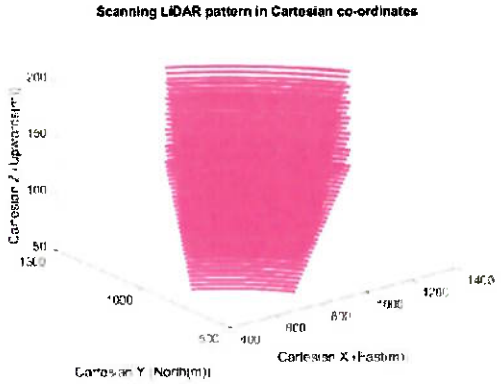


Figure A1: Scanning LiDAR pattern (Cartesian co-ordinates)

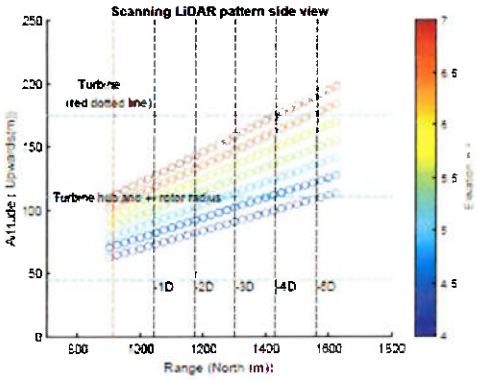


Figure A2: Scanning LiDAR pattern side view

Reference Number 92 :
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 Number 93 : 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 Number 94 : 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 Number 95 :
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 Number 96 :
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 Number 97 : Do terrestrial animals avoid areas close to turbines in functioning wind farms in agricultural landscapes? Rafał Łopucki & Daniel Klich & Sylwia Gielarek. Environ Monit Assess (2017) 189: 343 DOI 10.1007/s10661-017-6018-z

The reactions of animals were species specific. Herbivorous mammals (roe deer and European hare) avoided wind farm interiors and proximity to turbines. The common pheasant showed a positive reaction to wind turbine proximity. The red fox had the most neutral response to wind turbines. Although this species visited wind farm interiors less often than the control area, there was no relation between fox track density and turbine proximity.

Terrestrial animals can potentially be affected by wind power development in various ways (Lovich and Ennen 2013), but the empirical evidence suggests a lack of such effects during the operational phase of wind farms or a swift habituation of animals to the disturbance, thus suggesting a limited impact (Helldin et al. 2012; Lovich and Ennen 2013; Łopucki and Mróz 2016; Menzel and Pohlmeyer 1999; Walter et al. 2006; Winder et al. 2014a, b). For this reason, we would expect no effect (neither negative nor positive) of wind turbines on the studied species.

However, our study showed that wind farms can significantly alter habitat use of terrestrial animals not only during the construction phase (Helldin et al. 2012), but also during the operational phase.

In our study, terrestrial animals did indeed use the wind farm areas (tracks of all analyzed species were found close to turbines), which is in accordance with the published literature regarding the different animal species (Helldin et al. 2012; Lovich and Ennen 2013; Rabin et al. 2006; Winder et al. 2014a, b), but the frequency of use of areas near wind turbines was different than the use of land far away from turbines. Our results show that wind farm operations affect terrestrial animals both in wind farm interiors (among the turbines), as well as within at least a 700-m buffer zone around each wind farm. The reaction of the studied animals to wind farms, however, is specific and depends on the species.

Herbivorous mammals

Wind farm interiors were less intensively frequented by roe deer and European hare than control areas. Both species also showed a clear linear decrease of track density with decreasing distance to the turbine. Acoustic factors seem to be the most probable reason for the lower presence of these species in the wind farm areas and with decreasing distance to turbines. Permanent and high noise levels may be bothersome enough for these species to visit less frequently and spend less time there (resulting in lower track density) because the noise may cause metabolic stress and be harmful for animals (Du et al. 2010; Kight and Swaddle 2011). However, it is more likely that herbivorous mammals have difficulty perceiving sounds in noisy environments. Human related noise may restrict the habitat use and movement of species and represent a life-threatening hazard in predator-prey interactions, particularly regarding herbivorous mammals (Barber et al. 2010; Chan et al. 2010; Clevenger and Waltho 2005; Rabin et al. 2006). Both the roe deer and the European hare rely more on hearing than other senses, particularly to avoid danger (Molinari-Jobin et al. 2004) and, thus, are susceptible to such a noise effect. Both are also under high predatory pressure in the Carpathian region (Bombik et al. 2014; Kauhala and Kowalczyk 2011).

Herbivorous mammals generally increase their vigilance in environments that are under a high predatory pressure (Laundré et al. 2001; Wolff and Horn 2003). Avoidance of risky habitats is an important part of their anti-predatory strategy (Aulak and Babińska-Werka 1990; Bongi et al. 2008; Klich and Grudzień 2013) that may lead to some areas being depleted of prey due to vigilance rather than predation (Brown et al. 1999).

For roe deer and the European hare, the proximity of turbines may thus represent a risky habitat due to the animals' impaired ability to hear approaching predators. This phenomenon may be more likely during hours of darkness or low light, when both species are most active during winter (Chapman and Flux 2008; Pépin and Cargnelutti 1994; Wallach et al. 2010). Previous studies (Bergen 2002; Menzel and Pohlmeyer 1999) showed no significant difference in roe deer distribution or habitat use in areas with wind farms compared to reference areas without wind power. However, neither roe deer nor the European hare were under high predation pressure that could displace them to other habitats (Keuling et al. 2011; Ludwig et al. 2009).

Reference Number 98 : 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 Mala 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 Number 99 : 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 Number 100 :

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 101 : 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 Number 102 : Vibrational noise from wind energy-turbines negatively impacts earthworm abundance. 2021, Velilla, Estefania; Collinson, Eleanor; Bellato, Laura; Berg, Matty P.; Halfwerk, Wouter Published in: Oikos DOI: 10.1111/oik.08166. www.oikosjournal.org

Human activities often impact the sensory environment of organisms. Wind energy turbines are a fast-growing potential source of anthropogenic vibrational noise that can affect soil animals sensitive to vibrations and thereby alter soil community functioning. Larger soil animals, such as earthworms (macrofauna, > 1 cm in size), are particularly likely to be impacted by the low-frequency turbine waves that can travel through soils over large distances. Here we examine the effect of wind turbine-induced vibrational noise on the abundance of soil animals. We measured vibrational noise generated by seven different turbines located in organically-farmed crop fields in the Netherlands. Vibratory noise levels dropped by an average of 23 ± 7 Db over a distance of 200 m away from the wind turbines. Earthworm abundance showed a strong decrease with increasing vibratory noise. When comparing the nearest sampling points in proximity of the wind energy turbines with the points furthest away, abundance dropped on average by 40% across all seven fields. The abundance of small-sized soil animals (mesofauna, < 10 mm in size) differed between crop fields, but was not related to local noise levels. Our results suggest that anthropogenic vibratory noise levels can impact larger soil fauna, which has important consequences for soil functioning. Earthworms, for instance, are considered to be crucial ecosystem engineers and an impact on their abundance, survival and reproduction may have knock-on effects on important processes such as water filtration, nutrient cycling and carbon sequestration.

Animals rely on different sensory stimuli to acquire and process information from their environment. The ability to acquire this information is essential for an animal's reproductive success and survival (e.g. finding a mate and detecting a predator) (Dall et al. 2005, Dominoni et al. 2020). Activities tightly linked to human population growth are however interfering with environmental information processing of many animal species, with important population- and community-level consequences (Derryberry et al. 2020, Dominoni et al. 2020, Halfwerk 2020). Sensory pollutants, such as artificial light at night and traffic sounds have been shown to cause negative effects on animal behaviour and physiology, which can translate to reduced survival and reproduction, and ultimately to population declines (Barber et al. 2010, Kight and Swaddle 2011, Francis and Barber 2013).
Human activities are responsible for 50% of the earth's seismic noise levels (Lecocq et al. 2020), but the impact of this sensory pollutant on animals and their communities living in the soil remains largely unknown. ***However, vibrational noise of natural and anthropogenic sources has been shown to affect mating interactions, predator prey dynamics and competition in different species*** *(Caldwell et al. 2010, McNett et al. 2010, Roberts et al. 2016, Caorsi et al. 2019, Phillips et al. 2020, Velilla et al. 2020).* ***A major contributing source of anthropogenic vibrational noise comes from wind energy turbines, which are mainly found in rural or farming areas and sometimes cover a large land surface. The blades, the rotor and the shafts from wind turbines are supported by a tower that is usually anchored to a heavy concrete and steel rebar platform reaching up to nine meters in depth*** *(Stammler and Ceranna 2016). These platforms are needed to withstand the weight of the turbine, and although they may additionally reduce some of the vibrational noise created by the turbine, they induce vibrations in the soil, mostly in the low frequency range < 500 Hz (Stammler and Ceranna 2016). So far, we have little knowledge on how wind-turbine generated noise affects soil animals.*
The potential impact of noise on animals may depend on the overlap between an animal's body size and the spectral distribution of the vibrations that travel through the soil. Vibrations generated by wind energy turbines are typically low in frequency (< 500 Hz) and small-bodied animals (mesofauna, < 10 mm in size) might not be able to perceive, or even experience any strain from these low-frequency waves. Larger soil animals (macrofauna, > 1 cm in size), however, might be able to perceive low-frequency vibrations and can therefore be impacted by turbine noise through a perceptual mechanism. Among macrofauna, earthworms are particularly sensitive to low-frequency vibrations as they use vibrational cues to detect approaching predators (Catania 2008, Farina 2014). Earthworms are crucial ecosystem engineers (Jones et al. 1997) that are well known to influence soil structure, hydrology and nutrient quality as well as plant production (Clements et al. 1991, Van Groenigen et al. 2014, Bertrand et al. 2015). Vibratory noise from turbines may either mask, or mimic vibratory cues produced by approaching predators, such as moles, and earthworms may surface in response (Catania 2008, Dominoni et al. 2020). An increased perception of predation pressure, or decreased response to predatory cues could both lead to a decline in earthworm abundance in areas with high vibrational noise, consequently affecting soil structure, water infiltration, nutrient cycling, carbon sequestration and more (Blouin et al. 2013, Bertrand et al. 2015).
In the current study we assessed the effect of wind turbine-induced vibrational noise on earthworm abundance, and on the abundance of soil mesofauna. We hypothesized that vibrational noise would have a body-size dependent effect on soil animals and therefore expected a negative impact on earthworm abundance and no direct impact on the smaller mesofauna (although they could still be affected indirectly through an impact on earthworms). To test our predictions, we selected seven turbines stationed in agricultural fields in the Netherlands. We measured vibrational noise induced by wind turbines along a 14 transects and related these noise levels to earthworm and mesofauna abundance.

Earthworm abundance was negatively related to vibrational noise

We found that, on average, the number of earthworms decreased by 40% at the point furthest away from the turbines compared to the closest point to the turbines where we measured (128 m versus 8 m). Our results confirm that earthworm abundance decreased substantially as the amplitude of vibrational noise increased. The maximum amplitude difference over the range at which we surveyed earthworms was on average 13 Db. We therefore predict the impact of vibratory noise to be even bigger when measured over the whole transect, as vibrational noise levels near the base of the turbine are up to 30 Db higher than at our furthest sites (> 200 m from the turbine). We did not survey earthworm densities close to the turbine base as the composition of the soil differed substantially between the nearest points (2 m and 4 m) and remaining points of the transect. While we accounted for variation in soil compaction and crop type, neither of these factors was related to earthworm densities. Soil compaction and crop type also did not co-vary with distance to the wind turbines (Supporting information). Although vibration-specific receptors have not been described for any earthworm species, earthworms can detect tactile stimuli along their entire body (Laverack 1960), and tactile stimulation has been shown to induce activity in the segmental nerves (Laverack 1960, Mill and Knapp 1967). Earthworms also have distinct sensory cell bumps found along their body surface that contain multiciliate sensory cells (Langdon 1895, Knapp and Mill 1971, Gardner 1976, Mill 1982). A combination of sensory cell bumps and tactile sensitivity in earthworms, makes them a good candidate for vibration reception (Mitra 2009).

Sensory pollution consequences

Human-induced sensory pollutants can directly affect organisms through an impact on their perception, physiology and behavior (Brumm and Slabbekoorn 2005, Barber et al. 2010, Kight and Swaddle 2011, Naguib 2013, Velilla and Halfwerk 2019). It is possible that wind turbine-induced vibrational noise masks the vibrational cues of approaching foraging moles, making earthworms in noisy areas more prone to predation (Dominoni et al. 2020). Vibratory noise could also be misleading to earthworms (Dominoni et al. 2020), who may not be able to distinguish between vibratory cues coming from an approaching predator such as a mole, and the subterranean waves from the turbines. As matter of fact, earthworms are well known to be misled by other organisms, including humans who have developed so-called 'worm grunting' techniques that mimic soil vibrations from approaching moles (Catania 2008). Future studies should experimentally test which sensory mechanism is responsible for the patterns we revealed in this study. Alternatively, soil vibrations induced by wind turbines could alter the direct physical environment, e.g. through soil particle sorting or an impact on eartworm tunnel structures, thereby influencing water drainage and other abiotic conditions. Such physical impact should however also impact the mesofauna, which we did not report on our study. However it is clear that more data on the effects of vibrations on soil structure are needed, and vice versa.
Our findings suggest that noise could decrease earthworm densities, and ultimately modify the distribution of species that depend or interact with earthworms (Gutiérrez-López et al. 2010). In our study we did not find evidence for an effect of variation in earthworm abundance on the abundance of smaller soil animals. However, our measurements and observations were carried out in agricultural fields, possibly influencing the effects that earthworms would have under natural wild conditions, or in a different season. Further studies should examine the effect of vibrational noise on earthworm abundance in non-managed fields and its consequences on other soil organisms.
Earthworms play a crucial role in several soil processes including: soil formation, soil structure, water infiltration, nutrient cycling, carbon sequestration, climate regulation and primary production (Blouin et al. 2013, Bertrand et al. 2015). Furthermore, earthworms are known to play an important role in plant production (Baker et al. 2006, Blouin et al. 2013). Therefore, the negative relationship we find between wind turbine noise levels and earthworm abundance could potentially have cascading effects on other soil organisms and processes and should also draw attention to other sources of seismic noise (Lecocq et al. 2020).

Reference Number 103 : 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 Number 104 : How far are birds, bats, and terrestrial mammals displaced from onshore wind power development? – A systematic review Anne Tolvanen a, Henri Routavaara, Mika Jokikokko, Parvez Rana. Biological Conservation 288 (2023) 110382

Wind power is a rapidly growing source of energy worldwide. It is crucial for climate change mitigation, but it also accelerates the degradation of biodiversity through habitat loss and the displacement of wildlife. To understand the extent of displacement and reasons for observations where no displacement is reported, we conducted a systematic review of birds, bats, and terrestrial mammals. Eighty-four peer-reviewed studies of onshore wind power yielded 160 distinct displacement distances, termed cases.

For birds, bats, and mammals, 63 %, 72 %, and 67 % of cases respectively reported displacement.
Cranes (3/3 cases), owls (2/2), and semi-domestic reindeer (6/6) showed consistent displacement on average up to 5 km.
Gallinaceus birds showed displacement on average up to 5 km, but in 7/18 cases reported to show "no displacement".
Bats were displaced on average up to 1 km in 21/29 cases.
Waterfowl (6/7 cases),
raptors (24/30),
passerines (16/32)
and waders (8/19) were displaced on average up to 500 m.
Observations of no displacement were suggested to result from methodological deficiencies, species-specific characteristics, and habitat conditions favourable for certain species after wind power development.
This review provides information on distance thresholds that can be employed in the design of future wind energy projects. However, most studies assessed the effects of turbine towers of <100 m high, while considerably larger turbines are being built today.

Reference Number 105 : 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 Number 106 : 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.

Reference Number 107 : Observations of wind farm wake recovery at an operating wind farm Raghavendra Krishnamurthy1, Rob K. Newsom1, Colleen M. Kaul1, Stefano Letizia2, Mikhail Pekour1, Nicholas Hamilton2, Duli Chand1, Donna Flynn1, Nicola Bodini2, and Patrick Moriarty. Wind Energ. Sci., 10, 361–380, 2025 https://doi.org/10.5194/wes-10-361-2025 ©Author(s) 2025.

Wind turbine wakes, i.e., velocity deficits due to extraction of the kinetic energy from an operating wind turbine, are observed to extend several kilometers during stable atmospheric conditions both onshore and offshore (Hirth et al., 2012; Banta et al., 2015; Krishnamurthy et al., 2017; Fernando et al., 2019; Ahsbahs et al., 2020; Zhan et al., 2020). Wind farm wakes from a large cluster of wind turbines in mesoscale model simulations, and offshore observations **can reach over 50km downwind** under stable atmospheric conditions (Platis et al., 2018; Lundquist et al., 2019, Schneemann et al., 2020). Large-eddy simulations of large wind farms also show that wind farm wakes can alter the surface momentum and heat fluxes (Calaf et al., 2011). Wind farm wakes are known to impact the local meteorological conditions by, for instance, increasing or decreasing the temperature and enhancing turbulence downwind of a wind farm (Baidya Roy et al., 2004; Smith et al., 2013; Siedersleben et al., 2018; Miller and Keith, 2018, Bodini et al., 2021), although the intensity of the impact depends on atmospheric stability, local atmospheric processes, orientation of the wind farms, downwind distance, and the number and operative regimes of wind turbines.

In operational wind farms, intra-farm wakes can result in significant power losses, and it is important to understand the dissipation of wakes within a wind farm. The effect of a wind turbine is to decrease the mean velocity and increase the turbulent kinetic energy above the rotor layer (the layer from the bottom of the wind turbine blade tip to the top of the blade tip; VerHulst and Meneveau, 2014). The turbulent transport term in a steady-state filtered-energy equation includes the entrainment of the mean momentum due to turbulence and the entrainment of the turbulent kinetic energy due to fluctuating velocities (Allaerts and Meyers, 2017).

Today's wind turbines operate within the lowest 300m of the atmospheric boundary layer (ABL), and in offshore or stable atmospheric conditions the ABL can be lower than 300m (Shaw et al., 2022). Although wind farms operate within 300m above ground level, their impacts can be observed through the entire depth of the boundary layer. Therefore, to accurately assess such impacts, observations of mean and turbulent characteristics of wind and temperature should extend up to the top of the ABL.

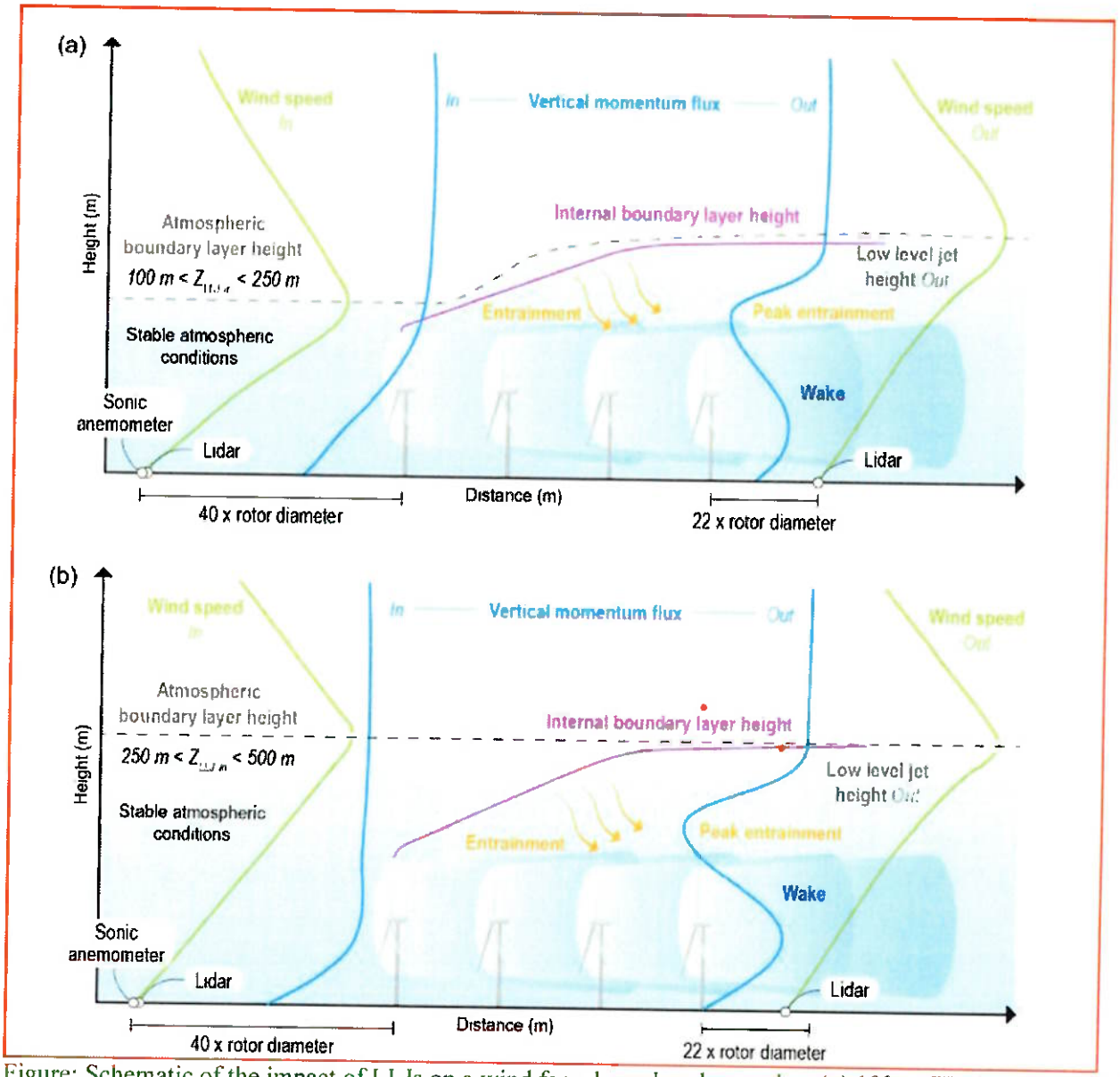


Figure: Schematic of the impact of LLJs on a wind farm boundary layer when (a) 100m<ZLLJ<250m and (b) 250m<ZLLJ<500m.

Note the Wake distance of 22 times rotor diameter which equates to 3.3m for a 150m diameter. Negative wind shear during non-LLJ cases show short wake propagation at 22 Rotor Diameters downwind of a wind turbine.

Reference Number 108 : The effect of varying distances from the wind turbine on meat quality of growing-finishing pigs, Małgorzata Karwowska, Jan Mikołajczak, Zbigniew Józef Dolatowski, Sylwester Borowski. ***Ann. Anim. Sci., Vol. 15, No. 4 (2015) 1043–1054 DOI: 10.1515/aoas-2015-0051***

This study was conducted to assess the effect of rearing pigs at three different distances from a wind turbine (50, 500 and 1000 m) on the physicochemical properties and fatty acid composition of loin and neck muscles. The experiment was carried out on 30 growing-finishing pigs, derived from Polish Landrace × Polish Large White sows mated to a Duroc × Pietrain boar. The results obtained during the noise measurement showed that the highest level of noise in the audible and infrasound range was recorded 50 m from the wind turbine. Rearing pigs in close proximity to the wind turbine (50 m) resulted in decreased muscle pH, total heme pigments and heme iron as well as reduced content of C18:3*n-3* fatty acid in the loin muscle. Loins of pigs reared 50 m from the wind turbine were characterized by

significantly lower iron content (6.7 ppm g–1) compared to the loins of pigs reared 500 and 1000 m from the wind turbine (10.0–10.5 ppm g–1). The concentration of α-linolenic acid (C18:3*n-3*) in loin and neck muscles decreased as the distance from the wind turbine increased. Avoiding noise-induced stress is important not only for maintaining meat quality but also for improving animal welfare.

It should be noted that many applications quote effects from a 2015 paper for Illinois, USA.

Reference Number 109: 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.

Illinois Plant Name	State	Summer Capacity (MW)	Operating Month	Operating Year	Number of Turbines	Size of Turbines (Mw)	Predominant Turbine Manufacturer	Predominant Turbine Model Number	Design Wind Speed (mph)	Wind Quality Class	Turbine Hub Height (Feet)	Turbine Hub Height (metres)
Alta Farms II Wind Project, LLC	IL	200.5	5	2023	100	2	Siemens Gamesa	SG 5.0-145	23.0	2	107.5	32.8
Sapphire Sky Wind Energy LLC	IL	259.8	2	2023	64	4	Vestas	V150-4.2	18.3	2	383.9	117.0
Moraine Sands Wind Power	IL	165.0	12	2023	38	4	Vestas	V150-4.2	16.8	3	394.0	120.1
Shady Oaks Wind 2	IL	108.3	10	2023	22	5	Vestas	V150-4.2	17.5	3	344.5	105.0
Midland Wind	IL	105.5	12	2023	28	4	Vestas	V150-4.2	22.0	1	344.0	104.9
Ford County Wind Farm LLC	IL	121.3	3	2022	43	3	GE	2.82-127	18.1	1	292.0	89.0
Lincoln Land Wind	IL	302.0	11	2021	107	3	GE	2.82-127	17.4	3	374.0	114.0
Bennington Wind	IL	93.0	10	2021	33	3	GE	2.82-127	17.5	2	290.3	88.5
Glacier Sands Wind Power, LLC	IL	185.0	11	2021	43	4	Vestas	V150-4.2	16.8	3	344.0	104.9
Blooming Grove Wind Energy Center	IL	250.0	12	2020	94	3	GE	2.82-127	17.2	2	292.0	89.0
Cardinal Point Wind	IL	150.0	3	2020	60	3	GE	2.82-127	17.0	2	292.0	89.0
Lone Tree Wind, LLC	IL	79.0	12	2020	32	2	GE	2.5-127	17.4	3	292.0	89.0
Whitney Hill Wind Power LLC	IL	65.0	3	2020	24	3	GE	2.82-127	13.0	2	416.0	126.8
Sugar Creek Wind One LLC	IL	202.0	11	2020	114	2	Vestas	V150-4.2	15.6	3	393.7	120.0
Harvest Ridge Wind Farm	IL	202.0	7	2020	48	4	Vestas	V150-4.2	17.0	2	345.0	105.2
Otter Creek Wind Farm LLC	IL	150.0	3	2020	42	4	Vestas	V136-3.45	16.1	3	269.0	82.0
Green River Wind Farm	IL	194.3	11	2019	74	3	Gamesa	G126-2.5	15.7	3	275.6	84.0
Bright Stalk Wind Farm I	IL	205.2	12	2019	57	4	Vestas	V136-3.45	18.2	3	325.0	99.1
Hilltopper Wind Project	IL	185.0	12	2018	74	3	GE	2.5-100	25.0	2	380.0	115.8

Bishop Hill III	IL	119.0	6	2018	53	2	GE	2.3-116	27.0	2	295.3	90.0
Walnut Ridge Wind Farm	IL	212.0	12	2018	106	2	Vestas	V100-2.0	15.7	3	312.0	95.1
Radfords Run Wind Farm	IL	278.0	12	2017	139	2	Vestas	V110-2.0	14.5	4	311.6	95.0
Kelly Creek Wind Project	IL	184.0	12	2016	92	2	Vestas	V100-2.0	19.0	2	262.5	80.0
Pilot Hill Wind Farm	IL	175.0	8	2015	103	2	GE	1.7-100	19.0	3	262.4	80.0
Hoopeston Wind LLC	IL	98.0	3	2015	49	2	Vestas	V100-2.0	17.0	2	311.0	94.8
Minonk Wind Farm	IL	192.3	11	2012	100	2	Gamesa	G90-2.0	18.3	2	328.1	100.0
California Ridge Wind Energy LLC	IL	200.0	12	2012	134	1	GE	1.6-100	18.1	3	328.1	100.0
Bishop Hill Energy LLC	IL	200.0	6	2012	133	2	GE	1.6-97	16.1	2	328.1	100.0
Bishop Hill II Wind Farm	IL	81.0	10	2012	50	2	GE	1.6-100	16.8	3	328.0	100.0
Shady Oaks Wind Farm	IL	109.5	5	2012	71	2	Goldwind	GW 82 1500	17.0	3	328.1	100.0
Heartland Community College	IL	1.7	6	2012	1	2	Vestas	V82-1.65	14.5	3	262.0	79.9
Settlers Trail Wind Farm LLC	IL	150.4	10	2011	94	2	GE	1.6 XLE	16.6	2	262.4	80.0
Pioneer Trail Wind Farm, LLC	IL	150.4	12	2011	94	2	GE	1.6 XLE	17.4	2	262.4	80.0
White Oak Energy LLC	IL	150.0	6	2011	100	2	GE	1.5 XLE	16.8	3	262.5	80.0
Brown County Wind Turbine	IL	1.5	9	2011	1	2	VENSYS	VENSYS77	16.5	2	281.0	85.6
Big Sky Wind LLC	IL	239.4	2	2011	109	2	Vestas	V120-2.0	19.0	2	277.2	84.5
Streator Cayuga Ridge South	IL	300.0	3	2010	150	2	Gamesa	G87-2.0	16.1	3	256.0	78.0
Blackstone Wind Farm II LLC	IL	200.0	8	2010	132	2	GE	1.5 SLE	19.0	2	262.0	79.9
EcoGrove Wind LLC	IL	100.5	7	2009	67	2	Acciona	AW82/1500	16.8	3	262.4	80.0
FPL Energy Illinois Wind LLC Hybrid	IL	217.5	12	2009	145	2	GE	1.5 XLE	17.9	2	262.4	80.0
Blackstone Wind Farm LLC	IL	106.0	10	2009	68	2	GE	1.5 SLE	19.0	2	262.0	79.9
Rail Splitter Wind Farm	IL	100.5	8	2009	67	2	GE	1.5 SLE	19.0	2	262.0	79.9
Grand Ridge Wind Energy Center	IL	51.0	12	2009	34	2	GE	1.5 SLE	17.2	2	263.0	80.2
Grand Ridge Wind Energy Center	IL	49.5	12	2009	33	2	GE	1.5 SLE	17.2	2	263.0	80.2
Grand Ridge Wind Energy Center	IL	10.5	12	2009	7	2	GE	1.5 SLE	17.2	2	263.0	80.2
Geneseo	IL	1.5	9	2009	1	2	VENSYS	VENSYS77	18.0	2	200.0	61.0
Geneseo	IL	1.5	10	2009	1	2	VENSYS	VENSYS77	18.0	2	200.0	61.0

Providence Heights Wind LLC	IL	72.0	8	2008	36	2	Gamesa	G87-2.0	15.7	3	256.0	78.0
Grand Ridge Wind Energy Center	IL	99.0	10	2008	66	2	GE	1.5 SLE	18.3	2	263.0	80.2
Com Adam 1WF-1	IL	2.5	10	2007	1	3	Clipper	Liberty C96	17.0	3	328.0	100.0
Com Adam 1WF-1	IL	2.5	10	2007	1	3	Clipper	Liberty C93	17.0	3	262.4	80.0
GSG LLC	IL	80.0	6	2007	40	2	Gamesa	G87-2.0	19.0	2	256.0	78.0
Camp Grove Wind Farm	IL	150.0	12	2007	100	2	GE	1.5 SLE	15.5	2	262.0	79.9
Agrwind	IL	8.4	7	2007	4	2	Suzlon	S88-2100	15.9	2	262.4	80.0
Old Trail Wind Farm	IL	213.8	12	2007	120	2	Vestas	V82-1.65	19.0	2	262.0	79.9
High Trail Wind Farm LLC	IL	210.9	3	2007	120	2	Vestas	V82-1.65	19.0	2	262.0	79.9
Crescent Ridge	IL	53.0	12	2005	28	2	NEG-Micon	NM82/1650	21.0	2	256.0	78.0
Pike County Wind Power	IL	1.7	5	2005	1	2	Vestas	V82-1.65	13.7	2	235.0	71.6
Mendota Hills, LLC	IL	76.2	11	2003	29	3	Gamesa	G126-2.5	18.0	2	275.0	83.8
				TOTAL no Turbines	3,777							

The **Climate of Illinois** describes the weather conditions, and extremes, noted within the state of Illinois, United States, over time.

Köppen Climate Types of Illinois



Köppen Climate Type

Köppen climate types of Illinois (with counties overlaid), using 1991-2020 climate normals.

Because of its nearly 400-mile (640 km) length and mid-continental location, Illinois has a widely varying climate. Most of Illinois has a humid continental climate (Köppen climate classification *Dfa*) with hot, humid summers and cool to cold winters. However, the southern half of the state, from about Springfield southward, has a humid subtropical climate (Köppen *Cfa*) with winters becoming more moderate as one travels south. Average yearly precipitation for Illinois varies from 48 inches or 1,220 mm at the southern tip to 35 inches or 890 mm in the northern portion of the state. Normal annual snowfall exceeds 38 inches or 0.97 m in Chicago, while the southern portion of the state normally receives less than 14 inches or 0.36 m.[1] The highest temperature recorded in Illinois was 117 °F (47.2 °C), recorded on July 14, 1954, at East St. Louis, while the lowest temperature was −38 °F (−38.9 °C), recorded on January 31, 2019, at Mount Carroll.

Monthly average high and low temperatures in Fahrenheit for various Illinois cities

City	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cairo	41/25	47/29	57/39	69/50	77/58	86/67	90/72	88/69	81/61	71/49	57/39	46/30
Chicago	31/16	35/20	47/29	59/39	70/48	80/58	84/64	82/63	75/54	62/43	48/32	35/21
Edwardsville	36/19	42/24	52/34	64/45	75/55	84/64	85/59	86/66	79/58	68/46	53/35	41/25
Moline	30/12				73/50	83/60	86/64	84/62	76/53	64/42	48/30	34/18
Peoria					73/51	82/60	86/65	84/63	77/54	64/42	49/31	36/20
Rockford					71/48	81/58	84/63	82/61	75/52	62/40	47/30	33/17
Springfield					74/53	83/62	86/66	84/64	78/55	67/44	51/34	38/23

Basically, a tip height of 120m & not comparable to Lemanaghan at 220m & 6Mw, nor is the weather. Using 10-year-old scientific papers for non-comparable windfarm size is not objective.

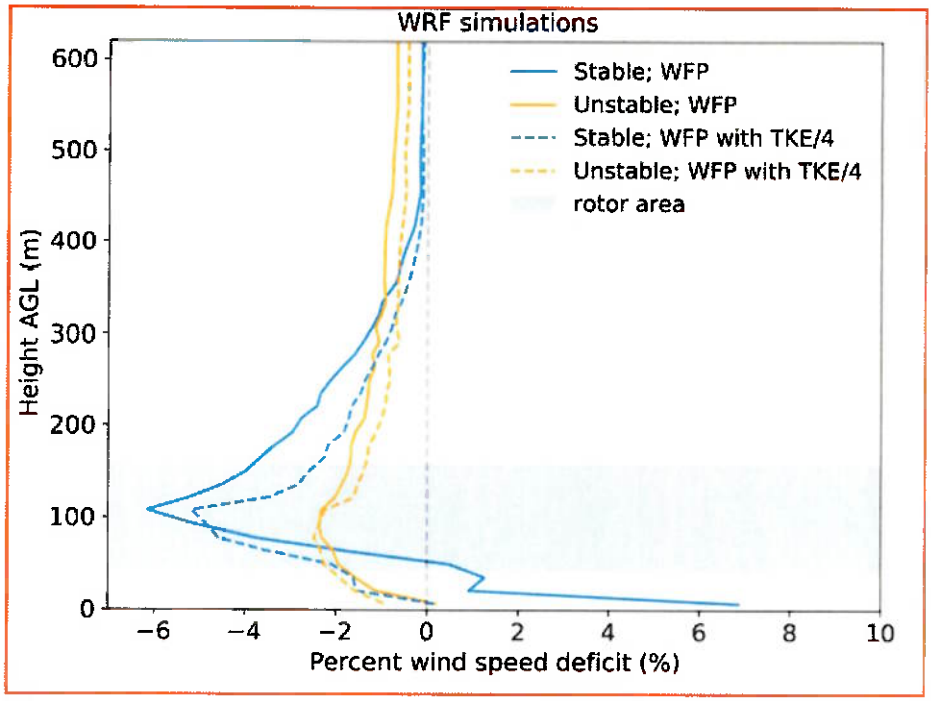
"Most modeling studies indicate that the presence of large groups of wind turbines is expected to have noticeable climatic impacts from local to regional scales, and likely at global scales as well."…. The effect of wind farms on meteorology is essentially an atmospheric boundary layer (ABL) problem. The detailed physical processes of ABL-turbine interactions remain mostly unknown because of the complexity and heterogeneity of turbulence over different regions."

"Turbulence decreases farther downwind from the rotor blades , and a distance of ten rotor diameters downstream is enough for the flow to recover from the turbulence caused by the rotor blades. For example, the 1.5 MW GE wind turbines have a rotor diameter of ~80 m, meaning 10 rotor diameters away would be 800 m."

Reference Number 110 : 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 Number 111 : Local-scale impact of wind energy farms on rare, endemic, and threatened plant species Mihaela Urziceanu, Paulina Anastasiu, Laurentiu Rozylowicz and Tatiana Eugenia Sesan. PeerJ 9:e11390 http://doi.org/10.7717/peerj.11390

Although the number of wind energy farms within protected areas has significantly increased in the past decade, few studies have quantified their impact on protected plant species recovery. Our study suggests that wind energy farms' operation affects the local diversity of protected plant species.

Reference Number 112 : Separating Myth from Fact on Wind Turbine Noise. Prof. Ken Mattsson Separates Myth from Fact on Wind Turbine Noise Av Madeleine Staaf Kura i Vindkraftsupplysningen Publicerat den 11/10/2025 11:31

On October 8, 2025, Professor Ken Mattsson, Professor in Scientific Computing at Uppsala Unniversity (Sweden), delivered a ground-breaking lecture in Copenhagen titled "Separating Myth from Fact on Wind Turbine Noise."

The seminar, organized by *Landsforeningen Naboer til Kæmpevindmoller* took place during Denmark's EU Presidency — in the very centre of Europe's wind industry — and has already been described as a turning point for science, health and public policy.

25 Years of Research Behind SoundSim360

Prof. Mattsson has developed SoundSim360, a scientifically validated model for sound propagation based on more than 25 years of research in mathematics, acoustics and computational simulation.

His results demonstrate that official models such as Nord2000 underestimate real sound levels, particularly in the low-frequency and infrasound range.

"Sound power levels stated by manufacturers are one of the biggest lies — they can vary by more than 20 dB during a single day." — Prof. Ken Mattsson

Wind turbines emit infrasound that can travel at least 10 kilometres from the source and has been shown to affect the human body and brain. Yet, authorities and the industry continue to ignore this, relying on A-weighted dBA scales that cannot describe low-frequency noise.

"The A-weighted scale is misused — it cannot describe infrasound or low-frequency noise accurately."

— Prof. Ken Mattsson

Current models used by agencies in Denmark and Sweden are too simplified, allowing parameters to be adjusted to fit a desired outcome. This leads to distorted environmental assessments and gives a false sense of safety. Atmospheric layering and weather changes can amplify sound dramatically — effects that official methods fail to capture.

Mattsson urged governments and authorities to adopt modern, physics-based models that include pulsation, atmospheric influence and infrasound propagation. According to his analysis, a safe distance from large turbines should be between 5 and 10 kilometres to protect human health.

The second lecture of the day, "Infrasound Affects the Brain," was given by Dr. Håkan Enbom, M.D., Ph.D., ENT-specialist and otoneurologist. Dr. Enbom explained how low-frequency sound influences the brain's balance system and sensory processing, adding critical medical evidence to Mattsson's physical findings.

Strong Political Support in Brussels

On the 25th of September, the European Parliament's Committee on Petitions (PETI) held a historic session in Brussels concerning the petition on wind-turbine noise and human health.

Several major political groups expressed strong cross-party support for regulatory reform, including:

- EPP (European People's Party – Moderates & Christian Democrats)
- S&D (Socialists & Democrats)
- PfE (Patriots for Europe)
- The Greens/EFA (Green Party & European Free Alliance)

Even the Chair of PETI, representing the ECR Group, endorsed the initiative.

The Committee praised the petition's scientific quality and the data presented by independent experts, including Prof. Mattsson and Dr. Enbom.

The European Commission acknowledged that new perspectives are opening within both the Environmental Noise Directive review and the Renewable Energy Directive (RED) — particularly regarding Renewables Acceleration

Areas. The Commission pledged to deliver a written opinion within three months and hinted at a forthcoming revision of the Noise Directive — a unique opportunity to finally bring wind-turbine noise into EU law.

The unanimous support in PETI now paves the way for:

- A PETI fact-finding mission in 2026.
- Possible ENVI Committee action to collect independent data on noise and health impacts.

This is a true breakthrough: for the first time, both the European Parliament and the European Commission recognize the need for clearer rules, scientific accuracy and human-health protection in relation to wind-turbine noise.

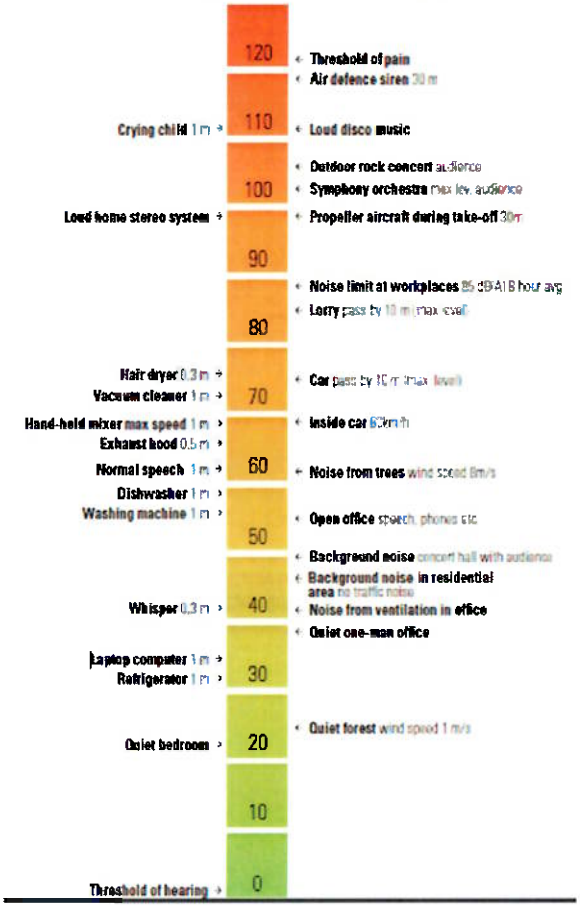
Prof. Ken Mattsson's Copenhagen lecture, combined with the PETI Committee's decision in Brussels, marks a turning point for science, politics and public health in Europe.

After decades of neglect, wind-turbine noise and infrasound are finally on the EU agenda.

This achievement reflects a decade of persistent, evidence-based collaboration — proving that truth and science can still influence policy in the age of the green transition.

Reference number 113 : A laboratory study on the effects of wind turbine noise on sleep: results of the polysomnographic WiTNES study Michael G. Smith, Mikael Ogren, Pontus Thorsson, Laith Hussain-Alkhateeb, Eja Pedersen, Jens Forssen, Julia Ageborg Morsing and Kerstin Persson Waye. *SLEEPJ*, 2020, Vol. 43, No. 9

A greater number of people will likely be exposed to wind turbine noise (WTN) at home. Environmental noise is recognized as a public health concern by the World Health Organization (WHO), which estimates that sleep disturbance constitutes the majority of the disease impacts of environmental noise in Europe, with the annual loss of over 900,000 healthy life years. Adequate sleep is vital for maintaining good health and wellbeing, and chronic short or interrupted sleep duration is associated with an increased risk for obesity, diabetes, hypertension, cardiovascular disease, and all-cause mortality. To protect sleep, the WHO recently recommended nighttime noise limits for road, rail, and air traffic in Europe, but concluded that the quality of evidence of nighttime exposure to WTN was too low to allow a recommendation. Therefore, studies on potential effects of WTN on sleep are needed. Amplitude modulation (AM) is a broadband, rhythmic change in the level of WTN corresponding to the rotational frequency of the turbine blades. AM has been reported as a particularly unpleasant and annoying characteristic of WTN. Local meteorological conditions at the turbine, for instance wind speed gradient across the rotor area, wind shear, and turbulence, affect the acoustical character of the AM. This effect is strongest during the stable atmospheric conditions typical of nighttime, with strong AM "beats" in the 400–2,500 Hz range as a consequence. Furthermore, the stable atmospheric conditions at night are favourable for the propagation of low-frequency noise, such as that emitted by wind turbines, over longer distances than in the daytime. A larger number of dwellings could therefore be exposed to WTN at sound pressure levels relevant for disturbance. Combined with lower nocturnal anthropogenic noise, and lower ambient noise levels due to more stable meteorological conditions, there could be increased audibility of WTN and AM at nearby dwellings during the night.
A series of recent epidemiological studies by Poulsen et al. did not find significant associations between calculated short- or long-term WTN and cardiovascular or metabolic outcomes including stroke and myocardial infarction, antihypertensive medication redemption, or diabetes. The same authors did however find that 5-year average outdoor WTN was associated with increased use of sleep medications among people aged at least 65 years, although there were no significant associations for people aged younger than 65 years or between sleep medication use and indoor average WTN across all age groups. There is some limited evidence from two previous studies that living within 2 km of wind turbines is associated with lower perceived sleep quality, lower health related quality of life, and reduced energy levels, compared to in demographically similar areas.
A single night of WTN exposure shorterm Rapid Eye Movement sleep. No effects of WTN on other measured physiologic outcomes could be detected, including autonomic activation, arousals, awakenings, salivary cortisol, SOL, sleep time, or deep sleep. Despite the low sound pressure level of 32 Db LAEq,indoor,night, the findings show that continuous environmental noise with AM may impact sleep. Self-reported sleep data support these results, with WTN exposure leading to lower sleep quality and restoration in the morning, which was true for populations who both were and were not habitually exposed to WTN.



Reference Number 114 : NOISE ACTION PLAN 2024-2028 – DUBLIN AGGLOMERATION

NOISE POLICY STATEMENT

Dublin City Council, Dún Laoghaire-Rathdown County Council, Fingal County Council, South Dublin County Council, Kildare County Council and Wicklow County Council will adopt a strategic approach to managing environmental noise from road traffic, rail traffic, airports and industrial activity sites, including ports, within its functional area, including the following:

*1. **Prevention** – manage the risk of additional members of the community being exposed to undesirable noise levels where it is likely to have significant adverse impact on health and quality of life.*

*2. **Protection** – protect areas which are desirably quiet, or which offer a sense of tranquillity through a process of identification and validation followed by formal designation of 'Quiet Areas'.*

*3. **Mitigation** – identify and prioritise appropriate mitigation measures to reduce noise levels where they are potentially harmful.*

The Environmental Noise Directive ('END') (2002/49/EC) is a European Union legal instrument vital for protecting public health and the environment by addressing the adverse effects of environmental noise.

The END was transposed into Irish Law by the Environmental Noise Regulations 2006 (S.I. 140/2006) (the 'Regulations'). The Regulations were revised by the European Communities (Environmental Noise) Regulations 2018 (S.I. 549/2018) and amended through the European Communities (Environmental Noise) (Amendment) Regulations 2021 (S.I. 663/2021).

The requirement for SEA for plans and programs is outlined in European Directive 2001/42/EC ('SEA Directive'). In the context of transport sector plans (which could include a Noise Action Plan), this directive is implemented in Irish law through the European Communities (Environmental Assessment of Certain Plans and Programmes) Regulations, 20045 (S. I. 435/2004). This legislation has been amended by the European Communities (Environmental Assessment of Certain Plans and Programmes) (Amendment) Regulations 20116 (S.I. 200/ 2011).

Strategic noise maps should have been prepared in respect of the calendar year 2023 for noise from the following sources:

- ***Road traffic** – all roads and major roads (sections of road with a flow threshold of 3,000,000 vehicle passages per year).*

- ***Industrial activity sites** – Industrial Emission (IE) sites as regulated by the EPA under the IPPC Directive 96/61 EC.*

For the noise action planning process, the Regulations require that;
"Each action plan or revision of an action plan shall address priorities which may be identified on the basis of exceedances of any relevant noise limit value or other relevant criteria established by the Agency [EPA] in accordance with subparagraph (3), and
(ii) shall, in the first instance, address the most important area or areas, as the case may be, established by strategic noise mapping."

Furthermore, the Regulations require each APA to "determine the measures to be included in an action plan." Finally, the action plan must "have as its objective that of also protecting quiet areas in an agglomeration". This Noise Action Plan therefore includes the identification of existing noise emissions, the identification of priority important areas based on an assessment of harmful effects and details of noise management measures for consideration and evaluation at implementation stage. The Noise Action Plan also includes the identification of Candidate Quiet Areas for consideration as Quiet Areas at the implementation stage.

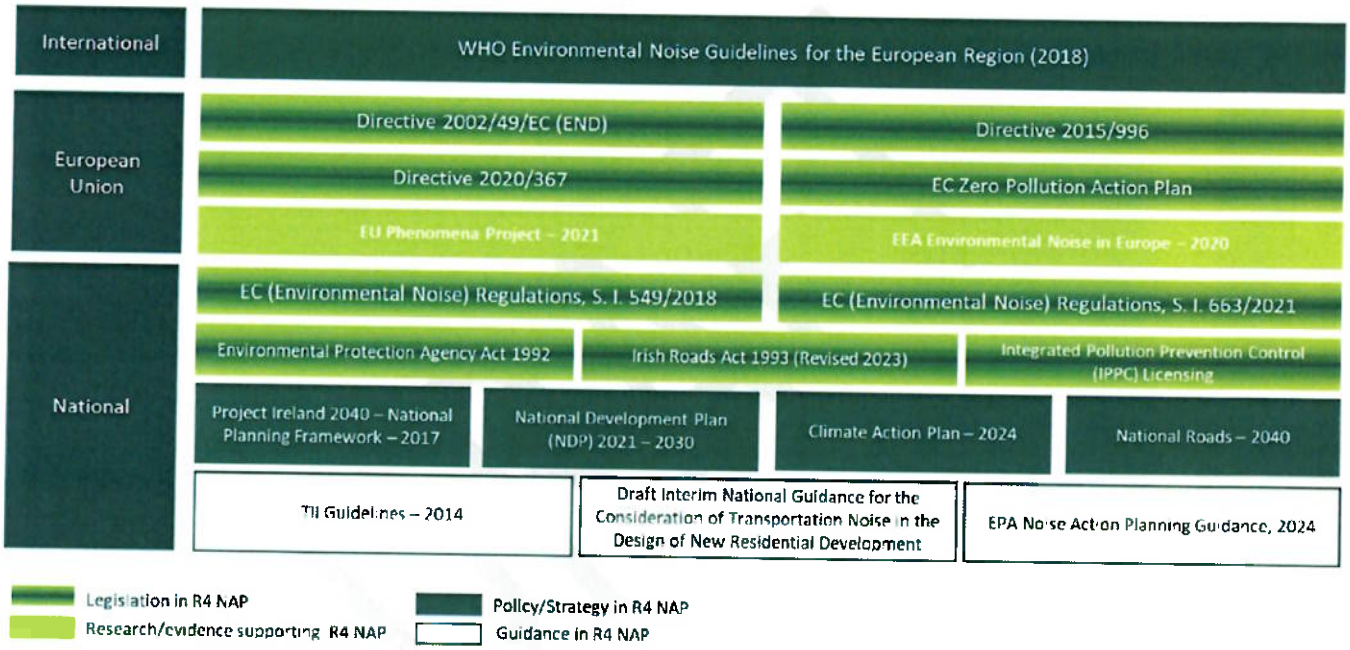
Noise Indicators
The Regulations specify two main noise indicators which much be used in the preparation of the strategic noise maps:
- *Lden – the annual average noise level for the day, evening and night periods and is designed to indicate overall annoyance; and*

- *Lnight – the annual average noise level for the night-time periods, from 23:00 – 07:00 hours and is designed to indicate sleep disturbance.*

Calculations of supplementary noise indicators have also been undertaken, namely the Laeq, 16hr (the annual average noise level for the daytime/evening periods, from 07:00 – 23:00 hours), which has been approved by the EPA as the appropriate noise indicator to inform the identification of Candidate Quiet Areas.

Reference Number 115 : Noise and Effects on Health and Quality of Life : Environmental Noise Guidelines (World Health Organization, WHO), 2018

Figure 2: Existing Noise Management Legislation and Guidance



Noise can have a significant and disruptive effect on everyday life. Since the implementation of the Regulations, there have been extensive studies into the links between environmental noise exposure and health.
The World Health Organization (WHO) in its publication 'Environmental Noise Guidelines for the European Region 2018 and 'Night Noise Guidelines for Europe 2009 has also presented several key health outcomes including: noise annoyance; sleep disturbance; cardiovascular health; mental health, wellbeing, and quality of life; and children's learning.
The Environmental Noise Guidelines for the European Region provides recommendations for protecting human health from exposure to environmental noise originating from various sources including road traffic, railway and aircraft noise.
The recommendations include guideline values using Lden and Lnight metrics in terms of the onset of health effects. However, no single noise metric best correlates with all adverse health outcomes associated with environmental noise effects, and health effects can be correlated with more than one metric. . The noise metrics which are generally considered to best correlate with the different health effects, and are the subject of this Noise Action Plan, are set out in **Table 4**.

Table 4: Noise Metrics and the Associated Health Effects

Noise Metric	Health Effects
L_{den}	Cardiovascular disease, Cognitive impairment, and Annoyance
L_{night}	Sleep disturbance and Wellbeing

Harmful Effects Assessment
The European Communities (Environmental Noise) (Amendment) Regulations 2021 (S.I. 663/2021) sets out the assessment methods for harmful effects, which considers ischaemic heart disease (IHD), high annoyance (HA) and high sleep disturbance (HSD).
Ischaemic heart disease is calculated for road traffic noise only, whereas high annoyance and high sleep disturbance are calculated for road traffic, railway and aircraft noise.
The exposure of harmful effect is assessed independently for each source. Where the same people are simultaneously exposed to different noise sources, the harmful effects may not, in general, be cumulated, however can be compared to identify proportional significance.
The method determines harmful effects on population within an assessment area, rather than an accurate assessment of possible health effects at any specific building or location.

Whilst the Regulations set out the equations to be used for calculating harmful effects, it does not define noise thresholds above which health effects should be calculated for, nor does it stipulate the assessment bands that should be used (0.1 Db, 1 Db or 5 Db), these have been provided by the EPA, and are as follows:

- *The calculations for harmful effects should be undertaken in 1 Db assessment bands.*
- *The assessment of harmful effects should be undertaken above the following thresholds which are in line with WHO Guidelines:*
- ***Road traffic noise:** 53 Db Lden, 45 Db Lnight*

Harmful effects have therefore been calculated from population exposure statistics in 1 Db bands for the noise level thresholds set out above using the calculation methodology set out in the Regulations.

Table 20: BS 8233 Recommended Internal L_{Aeq} Target Levels for Overall Noise in the Design of a Building

Location	$L_{Aeq, 16hr}$ (0700-2300 hrs)*	$L_{Aeq, 8hr}$ (2300-0700 hrs)*
Living Rooms	35 dB	-
Dining Rooms	40 dB	-
Bedrooms	35 dB	30 dB

*see BS 8233:2014 for caveats and notes

The above Noise Standards are in the process of being adopted in the Dublin Authorities & East Leinster. And the applicant for the windfarm indicates far higher threshold values.
The level indicated at 30Db is far lower than the levels indicated in the applicants submission.

Reference Number 116: Influence Of Atmospheric Conditions On Measured Infrasound From Wind Turbines, Sarah D'amico, Timothy Van Renterghem, Dick Botteldooren, *Ghent University, Department Of Information Technology, Waves Research Group, Technologiepark 126, B 9052, Gent, Zwijnaarde, Belgium.* Journal Of Wind Engineering & Industrial Aerodynamics 225 (2022) 105021. Available Online 7 May 2022

Dominant predictors for the infrasound production were mean wind speed, turbulence intensity and turbulent vertical heat flux.

Pressure fluctuations resulting from wind turbines in the infrasonic range lead to both discrete frequencies and broadband components. For modern large horizontal axis wind turbines, the first discrete frequency occurs at the blade passing frequency, typically below 1 Hz. Its harmonics typically predominate in the whole infrasound range. The blade passing frequency (BPF) levels define the acoustic signature of the wind turbine. The broadband component, generally indicated as inflow noise, covers the full infrasound frequency range as well, down to extremely low frequencies, and enters the lower part of the audible frequency range. In this article, the term infrasound is used for frequencies below 20 Hz. The audible frequency range exceeds 20 Hz. The term "low frequency" is used in a more generic way throughout the manuscript, referring to sounds that remain approximately below 100 Hz.

The aerodynamic Interaction between the rotating blades and the tower is the most accredited cause for Blade Passing Frequency levels. For upwind wind turbines, a reduction in the inflow velocity appears in front of the tower since it obstructs the incoming wind flow. This local velocity deficit produces a change in the angle of attack of the passing blade, thus a periodical change in its aerodynamic loading, resulting in a discrete pressure level at the BPF (van den Berg, 2005). Recently, Yauwenas et al. (2017) and Zajamsek et al. (2019) hypothesized that the blade-tower interaction noise could be attributed to the aerodynamic disturbances generated by the blades and impacting on the tower. Through numerical simulations, they could identify the tower as the dominant pressure generation point of BPF noise. Other sources of BPF levels can be identified in the atmospheric turbulences, the cross-winds and the wind shears leading to periodical aerodynamic changes on the rotating blade as well (Goldstein, 2017). Although the latter theory is less cited than blade-tower interaction phenomena, the BPF noise generation mechanism is still not completely clarified.

Wind turbine inflow noise is generated by the interaction between the wind turbine rotating structures and the inflow turbulences present in the atmospheric boundary layer. In particular, large inflow turbulences are the cause of infrasound inflow noise. When eddies much lager that the mean blade chord are convected towards the rotating

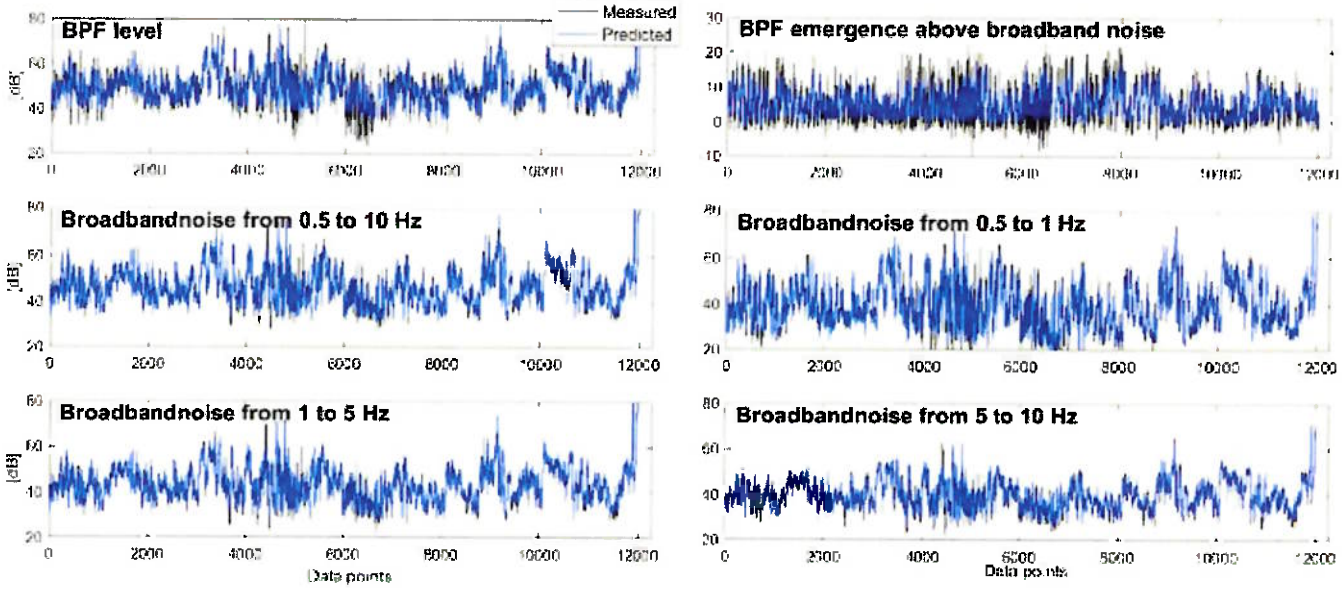
blades, the latter undergo a sudden change in their loading which produces broadband infrasound (Wagner et al., 1996) at a frequency related to the dimension of the turbulent eddy and of the blade chord. For large modern wind turbines, this mechanism affects the lowest part of the infrasound range. For inflow turbulence eddies smaller that the blade chord, the pressure fluctuations are locally generated by the eddies on the surface of the blade (Wagner et al., 1996) and can appear in the remaining part of the infrasound spectra up to the lowest part of the audible frequency range. Wind shear and cross-wind conditions can also provoke a change in the aerodynamic loading of the rotating blades (Zajamsek et al., 2016). In the last decades, research mostly focused on the study of inflow noise through numerical or semi-empirical models. However, such models are restricted to the lower part of the audible frequency range only (Lowson, 1994) (Lee and Chong, 2014) (Klein et al., 2018).

Measuring wind turbine noise emissions in the infrasonic frequency range is not trivial due to its co-occurrence with high levels of wind-induced microphone noise outdoors. Although the BPF levels could in theory be easily distinguishable from the broadband noise, wind-induced microphone noise can completely mask both contributions to the wind turbine infrasound, even at low mean wind speeds (D'Amico et al., 2021).

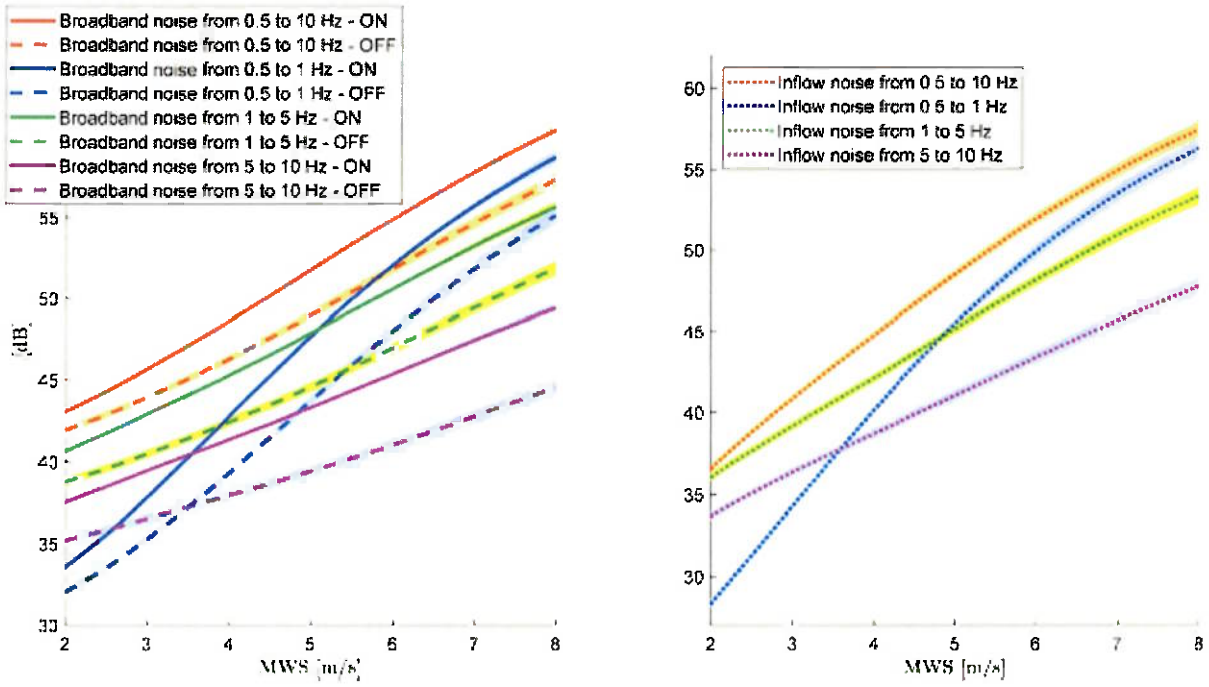
Little work has been published on actually measured wind turbine noise under various weather conditions (Hansen and Hansen, 2020) and studies reporting comprehensive assessment of wind turbine infrasound in different meteorological and wind conditions are even more limited. Zajamsek et al. (2016) related the long-distance propagation of BPF noise at a few dwellings to different atmospheric parameters to investigate the factors that influence their propagation outdoors. That study was able to identify BPF peaks indoors during periods of stable atmospheric conditions. Buck et al. (2016) related measured wind turbine inflow noise to local turbulence determined from the rotor blade vibration, finding a positive correlation at low frequency. Nevertheless, the latter study was limited to the audible frequency range only. No studies were found allowing to predict the generation of infrasound based on (inflow) atmospheric parameters.

The measurement campaign was performed at the Melle Wind Farm on the terrain of Ghent University from August 2019 to December 2019 and from March 2020 to November 2020. Sound pressure levels emissions were measured simultaneously with meteorological data. The wind farm at the measurement location consists of three Enercon E82 turbines of 2.3 MW each, positioned at a distance of approximately 450 m from each other in the NW-SE direction. The three wind turbines are three-bladed and pitch-controlled with hub heights of 108 m and 82 m rotor diameters. The wind turbines reach the rated power at 14 m/s mean wind speed at hub height and have a cut-in wind speed of 2 m/s.

The surrounding environment Is characterized by fully flat agricultural terrain with some sparse buildings located at a distance of 200 m from the microphones and a main motorway at approximately 250 m.



Measured and modelled BPF levels (upper, left), BPF emergence above broadband noise (upper, right), broadband noise from 0.5 to 10 Hz (center, left), broadband noise from 0.5 to 1 Hz (center, right), broadband noise from 1 to 5 Hz (lower, left) and broadband noise from 5 to 10 Hz (lower, right) for each valid data point. Results are expressed in decibel. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)



Predicted broadband noise levels using the ANN for varying the Mean Wind Speed from 2 to 8 m/s. Right: Predicted mean values of the inflow noise levels using the artificial neural network (ANN) and Equation

$$L_{Inflow} = 10\log_{10}\left(10^{\frac{L_{Broad,ON}}{10}} - 10^{\frac{L_{Broad,OFF}}{10}}\right)$$

for Mean Wind Speed from 2 to 8 m/s and positive signal-to-noise ratio. 95% confidence intervals are calculated with the bootstrapping technique assuming no particular data distribution and are presented as shaded areas; averaged values are depicted as full, dashed and dotted lines. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

The vertical turbulent heat flux has a strong Influence on inflow noise especially in the lowest frequency range considered. Positive turbulence heat fluxes lead to an increased amount of inflow noise from the wind turbines, indicating a predominance of turbulence generated noise in the frequency range from 0.5 to 1 Hz.

Reference Number 117 : Draft Wind Energy Guideline. Department of Planning and Environment dpie.nsw.gov.au. Technical Supplement for Noise Assessment November 2023

Decibel (dB)	A measure of sound level. The decibel is a logarithmic way of describing a ratio. The ratio may be power, sound pressure, voltage, intensity or other parameters. In the case of sound pressure, it is equivalent to 10 times the logarithm (to base 10) of the ratio of a given sound pressure squared to a reference sound pressure squared.
Decibel (A-weighted; dB(A))	Unit used to measure 'A-weighted' sound pressure levels. A-weighting is an adjustment made to sound-level measurement to approximate the response of the human ear.
Decibel (C-weighted)	C-weighting is an adjustment made to sound-level measurements that takes account of low-frequency components of noise within the audibility range of humans.

The assessment of noise impacts arising from wind energy development is unique in three key ways.

- *Firstly, wind turbines operate under very different conditions to other industrial noise sources. Wind turbines only function when there is wind, and the noise level from each wind turbine rises as the wind speed increases. The increase in wind speed also results in an equal or greater increase in the background noise level due to*

aerodynamic and foliage noise which can mask turbine noise. The increase in background noise with wind speed is generally site specific and needs to be determined in the assessment process.

- *Secondly, the height of the noise source centre (the machinery inside the enclosure at the top of the tower, called the nacelle) is highly elevated compared to other noise sources such as roads, railways, mines and most industrial facilities. As a result, there is less opportunity to mitigate or shield the propagation of wind turbine noise.*

- *Lastly, activities in rural areas, such as farming and agricultural practices, can generate significant noise resulting from sources including road traffic and farm machinery. Whilst noise from wind turbines is not likely to be dominant, the characteristics of wind turbine noise may be perceived as being different to these existing noise sources.*

Noise limits for residential receivers

The predicted equivalent noise level (LAeq,10 minute)[1], adjusted for tonality and low frequency noise in accordance with these guidelines, should not exceed **35 dB(A)** or the background noise (LA90(10 minute)) by more than 5 dB(A), whichever is the greater, at all relevant receivers for wind speed from cut-in to rated power of the wind turbine generator and each integer wind speed in between.

Note: While the noise criteria is established on the basis of a 24-hour period, noise readings are taken at 10 minute intervals.

Figure 1 shows the average distances at which compliance with different noise standards is expected to occur, using other Australian and International standards as examples.

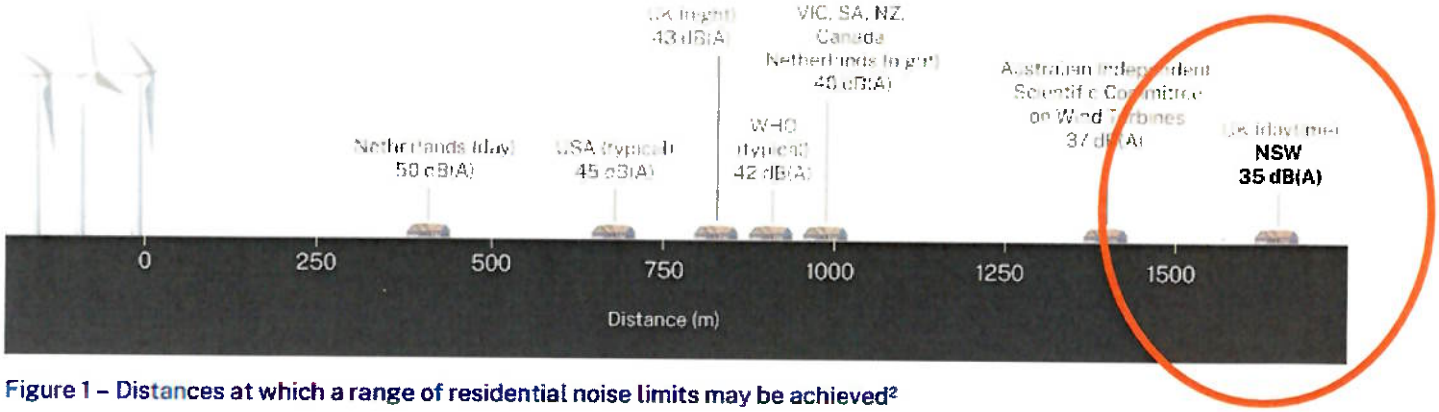


Figure 1 – Distances at which a range of residential noise limits may be achieved[2]

2:- Comparison of inter-jurisdictional wind energy noise criteria is complex. The setback distances are indicative only and do not account for site-specific conditions which may increase or decrease the noise level, such as topography. Modelled using ISO 9613.2 algorithm for three typical 6 MW turbines (with a hub height of 170 m) directly upwind of receivers

Special noise characteristics

While the main noise assessment criteria for wind energy projects is the base noise level, there are alternate special noise characteristics which need to be considered as part of the noise assessment process of any wind energy project.

Tonality

In addition to sound pressure level (measured in decibels, Db), the way sound is perceived is partially determined by its pitch or frequency (measured in Hertz, Hz). Human hearing covers frequencies from 20 Hz to 20,000 Hz and is less sensitive at low and high frequencies. Sounds which have unusually high levels of energy in a relatively narrow band of frequencies may be referred to as being tonal.

Audible tonal sounds from wind turbines are generally related to rotational equipment in the turbine nacelle and can have a specific pitch dependent on the speed of rotation. This can cause the noise to be more noticeable. These tonal characteristics (as defined below) typically do not occur in well designed and well-maintained wind turbines. If present, they are usually caused by a turbine maintenance issue3.

The SA Guideline suggests that the tonality assessment procedure detailed in the International Standard IEC 61400–11 is appropriate for measurement in close proximity to a turbine or that it can be modified for assessing wind farm associated tones at distant receivers. However, the NSW EPA assesses tonality with reference to the ISO 1996.2 standard.

For consistency in NSW, assessment, prediction and compliance of tonality objectives should be undertaken in accordance with ISO 1996.2: 2017 Acoustics — Description, measurement and assessment of environmental noise — Part 2: Determination of sound pressure levels using measured or similar representative data. The survey method described in Annex K (comparison of 1/3rd octave levels) assessed at integer wind speeds provides an acceptable screening test. It defines tonality as when the level of a one-third octave band4 exceeds the level of the adjacent bands on both sides by:

- *5 Db or more if the centre frequency of the band containing the tone is in the range 500 Hz to 10,000 Hz;*
- *8 Db or more if the centre frequency of the band containing the tone is in the range 160 Hz to 400 Hz; and/or*
- *15 Db or more if the centre frequency of the band containing the tone is in the range 25 Hz to 125 Hz.*

If tonality is found to be a repeated characteristic of the wind turbine noise, 5 Db(A) should be added to measured noise levels from the wind energy project. *The tonal characteristic penalty applies only if the tone from the wind turbine is audible at the relevant receiver. Absence of tone in noise emissions measured at an intermediate location is sufficient proof the wind energy project noise is not tonal at a receiver location. The assessment for tonality should only be made for frequencies of concern from 25 Hz to 10,000 Hz and for sound pressure levels above the threshold of hearing (as defined in ISO 389.7:2019 Acoustics – Reference zero for the calibration of audiometric equipment – Part 7: Reference threshold of hearing under free-field and diffuse-field listening conditions).*

Low frequency noise

Low frequency noise is present in all types of environmental noise and is particularly difficult to measure in the presence of wind due to the increased level of background noise. Analysis of wind turbine spectra shows that low frequency noise is typically not a significant feature of modern wind turbine noise when it complies with the A-weighted criteria outlined in Section 3.1.

In the unlikely event that excessive low frequency noise is found to be a repeated characteristic (i.e. noise from the wind project would be repeatedly greater than 60 DbI) of the wind turbine noise, 5 Db(A) should be added to the predicted or measured noise level from the wind energy project.

However, at the discretion of the applicant, a more detailed assessment can be carried out to demonstrate that low frequency noise is not a repeated characteristic. This assessment must be undertaken using Fact Sheet C of the Noise Policy for Industry (NSW EPA, 2017). Minor modifications to this approach are required for wind energy projects. The modified approach is:

- *the assessment must be undertaken for a 24-hour period, rather than the trichotomy of day/evening/night reported in the Noise Policy for Industry.*
- *where any of the one-third octave noise levels in Table C2 (reproduced below) are exceeded by up to and including 5 Db and cannot be mitigated,* ***a 2 Db(A) positive adjustment to measured/predicted A-weighted levels applies.***
- *where any of the one-third octave noise levels in Table C2 (reproduced below) are exceeded by more than 5 Db and cannot be mitigated,* ***a 5-Db(A) positive adjustment to measured/predicted A-weighted levels applies.***

Table C2: One-third octave low frequency noise thresholds

Hz/dB(Z)	One-third octave $L_{Zeq,15minute}$ threshold level												
Frequency (Hz)	10	12.5	16	20	25	31.5	40	50	63	80	100	125	160
dB(Z)	92	89	86	77	69	61	54	50	50	48	48	46	44

Health impacts

In 2018, the World Health Organization (WHO) released their Environmental noise guidelines for the European Region which comprised a suite of recommendations including "reducing noise levels produced by wind turbines below 45 Db Lden, as wind turbine noise above this level is associated with adverse health effects." The WHO recommended level of Lden 45 Db(A) is a minimum of 3.5 Db higher than the base NSW criterion and would typically be expected to equate to a level measured in NSW of around Leq 42 – 50 Db(A).

The NSW Government's position on potential health impacts of wind energy projects continues to be informed by the scientific findings of the NHMRC and the advice of NSW Health. The National Wind Farm Commissioner and the Independent Scientific Committee on Wind Turbines was established by the federal government in 2015 to provide advice on the potential impacts of wind turbine sound on health and the environment.

This work resulted in several publications including Wind turbine sound limits: Current status and recommendations based on mitigating noise annoyance (2018). ***THIS CONCLUDES THAT A LEVEL OF LA90,10 MIN (EQUAL TO 37 DB), IS AN APPROXIMATE MAXIMUM LEVEL OF NOISE TO WHICH RESIDENTS SHOULD BE EXPOSED. These measurements are averaged over 10 minute periods & exclude the higher noise emissions.***

The criteria adopted in this guideline is significantly lower than the WHO recommended level and slightly below the levels recommended by the Independent Scientific Committee on Wind Turbines.

The NSW Government will continue to monitor contemporary scientific research outcomes to ensure its position reflects robust evidence on any health effects.

Reference number 118 : 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.

Reference Number 119 : Wind turbine blade damage detection based on acoustic signals Chenchen Yang, Shaohu Ding & Guangsheng Zhou www.nature.com/scientificreports. (2025) 15:3930 | https://doi.org/10.1038/s41598-025-88276-x

When the wind turbine blade rotates, it radiates sound which mainly includes aerodynamic sound and mechanical sound to the surrounding environment. Aerodynamic sound is produced by the interaction between the blade and the wind blowing in the face. Mechanical sound mainly originates from the noise generated by the work of gearboxes, transmission bearings and other parts. In addition, defective blades produce abnormal sounds that mix with the sound radiated into the environment to form
complex wind turbine sounds containing damage signals. For example, in a study by Traylor et al. wind turbine blades with and without cracking defects were experimentally analysed. It was observed that for the blades with cracks on the trailing edge, the noise from the wind turbine unit was accompanied by a distinctive acoustically sharp whistling sound. Another study by Chen et al. proposed that the detection of defects in the drainage holes of the wind turbine blades is associated with a unique event of whistle sound. Thus, a specific defect generates a corresponding sound event.

Reference Number 120 : Impact of a two-dimensional steep hill on wind turbine noise propagation Jules Colas1, Ariane Emmanuelli1, Didier Dragna, Philippe Blanc-Benon, Benjamin Cotté, and Richard J. A. M. Stevens. Wind Energ. Sci., 9, 1869–1884, 2024 https://doi.org/10.5194/wes-9-1869-2024. Published: 7 October 2024.

This study demonstrates that terrain topography can significantly affect wind turbine sound propagation. In the case of a wind turbine on a hilltop, both the sound levels and the AM are greatly enhanced downwind compared to the flat case. This could result
in increased annoyance and is mainly an effect of mean flow field modification. In all cases, the far-field AM downwind is created by the wind turbine's wake. When the turbine is placed in front of the hill, we observed that, despite a strong shielding effect from the terrain, SPL just after the hill is comparable to that of the flat case. This is due to focusing induced by the hill's wake, which also increases AM at this location.
For a turbine on a hilltop, the sound emitted is higher than in the flat case due to increasing wind speed. For a turbine upstream of a hill, the sound emitted is slightly lower due to the decrease in wind speed before the hill. Finally, we find that the sound-focusing effect becomes more pronounced and closer to the turbine with increasing wind speed and that most of the propagation effects are directly behind the wind turbine (close to $t = 0$). However, this might be because our study used an N x2D approach, which does not consider the full 3D sound propagation through the wake. Also, turbulence in the atmosphere can scatter the sound and reduce the focusing effect we observed, but further research is needed to determine to what extent this happens.

Reference Number 121 : PSYCHOACOUSTIC EVALUATION OF MODELLED WIND TURBINE NOISE Josephine Siebert Pockele and Roberto Merino-Martinez . 30th International Congress on Sound and Vibration.

Current validation of wind turbine noise models primarily focuses on sound levels averaged over time, typically expressed in metrics such as the equivalent A-weighted sound pressure level (LA,eq). Whereas valid for regulatory purposes, these methods are not sufficient for psychoacoustic research, as time-averaged levels alone do not fully explain the measured noise annoyance. Therefore, this research aims to establish whether psychoacoustic sound quality metrics (SQMs) provide additional value when analysing wind turbine noise models. This work employs the Horizontal Axis Wind turbine simulation Code 2 (HAWC2) to generate noise source spectrograms, which are propagated through the atmosphere with a Gaussian beam-tracing approach. The final sound signals are retrieved through an inverse Short-Time Fourier Transform (Istft). This methodology is applied to a case study featuring a stall-controlled, horizontal-axis, Nordtank NTK 500/41 wind turbine. The results are evaluated against measurements by considering LA,eq, SQMs, and a comparative listening experiment. The LA,eq metric shows a consistent underprediction of the simulations with respect to measurements, which is partly explained by a ground reflection modelling error. In the high-frequency range, stall noise is known to be significantly underpredicted by the aero-acoustic simulation model. This usually translates in increasing discrepancies between measurements and models as the wind speed increases. The comparative listening experiment confirms that participants experience the simulations and the measurements as significantly different. The difference ratings show a good agreement with the differences in the psychoacoustic annoyance and loudness metrics. It is more difficult to relate the results from the listening experiment to LA,eq. These findings confirm that an evaluation with psychoacoustic metrics next to conventional methods provides additional value in validating wind turbine noise models for human perception research.

Reference Number 122 : The multiple understandings of wind turbine noise: Reviewing scientific attempts at handling uncertainty. 2024. Julia K. Kirkegaard, Tom H. Cronin, Sophie Nyborg, Daniel N. Franzten. DTU Wind and Energy Systems, Technical University of Denmark, Roskilde, 4000. Denmark https://doi.org/10.5194/wes-2024-34

Sound and noise are measured in the same acoustic unit, that is, the decibel (or Db), that was originally coined for audio levels in telephone cables back in the early 1900s (Garret 2020, p. 466 on the Bell Labs). As the human ear is not equally sensitive to all frequencies (first measured by Fletcher and Munson, 1933), then a method of averaging (or weighting scale) has been developed and is now governed by the international standard ISO 226 (International Standardization Organization). While the so-called A weighting (Db(A)) inevitably masks the individual frequencies of the original sound, it is by far the most commonly used metric.

When propagating and traveling to our ears, sound vibrations cause the vibration of the 160 human ear drum, which in turn are translated into impulses that the brain perceives as sound (Gunther, 2012, p. 306). Pure sound (e.g. a musical note where air particles vibrate in a neat/regular and predictable, and thus calculable, fashion) is hereby a very tangible and physical phenomenon. The vibrations are always depicted graphically by waves, much the same as electricity, and something that can relatively easily be shown to "obey" the natural laws of wave physics such as superposition (Gunther, 2012, p. 205).
It is when sound vibrations become uncontrollable and unpredictable, that sound is referred to not as musical but as noise in the technical epistemic community: "Although noises are sometimes not entirely unmusical, and notes are usually not quite free from noise, there is no difficulty in recognising which of the two is the simpler phenomenon. There is a certain smoothness and continuity about the musical note" (Rayleigh, 1945, p. 4). In contrast to pure sound, noise is more difficult to simulate/calculate: while noise still obeying the laws of physics, it is difficult to demonstrate through equations/calculations that it does so, as it "does not so easily yield to conventional mathematical analysis" (Garret, 2020, p. 26). In general, noise is thus considered a sound that is unwanted, not useful or indicating that something is wrong, and the physics of air particles reflects this (Lee and White, 1998).

The noise emanating from a turbine Is mostly aerodynamic noise, that Is, air flowing over the blades resulting in turbulence and rapid vibration of air particles (Wagner, 1996). The design of a wind turbine blade has historically concentrated on optimising power production and is key to this epistemic community, but these blade design considerations are entangled with questions around noise. The principal fundamentals of air flowing over the blades of a wind turbine go back to the 1920s with research in the aviation industry because of the similar requirements of an aircraft wing needing the force of lift to keep the aircraft flying up in the air, and the need for the force of torque to turn the rotor of a wind turbine. So, when wind turbine blade design development started in the 1970s, the research topic of aerofoil design was already established (Bak, 2021). Particularly important reference work was carried out by NASA in the 1950s who produced a catalogue of aerofoil designs, each tested in their wind tunnel (Abbott and von Doenhoff, 1959). The reason for the aircraft designers and wind turbine designers being interested in aerofoil design are similar: efficiency of the air flowing over the aerofoil. The more efficient an aircraft wing is, the more lift force is generated to keep it in the air, and the more efficient a wind turbine blade
is, the more torque Is generated t" tur' the rotor, the more energy can be extracted from the kinetic energy of the wind and converted into electrical energy. This is the energy that is then sold to produce revenue for the wind turbine owner.

However, whilst noise from aircraft is mostly from the engines, noise from wind turbines is an important constraint in wind turbine blade design. Much of the engineering driver for working on wind turbine noise and its reduction is the belief that the public's perspective on sound is 'annoying noise' (Deshmukh et al., 2018). Work by Pedersen and Waye (2004) is often quoted relating perception and annoyance due to wind turbine noise (see Health section) and that a reduction of the noise level (the dose) at the human ear is a desirable goal as "noise is one of the major hindrances in the development of wind power industry" (Dai et al., 2015) as people "experience annoyance" when they live in the vicinity of wind turbines. Indeed, research by acousticians using listening tests and "idealised wind turbine sounds" (von Hünerbein, 2010) have tried to
establish "audibility thresholds and equal annoyance contours" in order to quantify an impact. However, a reduction in noise generation often comes at a price: a reduction in power produced (Wagner, 1996, p. 164).

The aerodynamics of the blades has been a consistent object of research for noise generation research. When the airflow passes over the wind turbine blade "at the trailing edge", it becomes turbulent (unruly), producing a scattering mechanism which makes up the main part of aerofoil noise (Wagner, 1996, p. 67). In terms of the shape of the aerofoil, various "fixes" or adaptations have been applied, such as trailing edge serrations (or "dinotails") in order to reduce the noise from the back edge of turbine blades (Fuglsang and Oerlemans, 2012). With these devices, typically, noise reductions of about 2-3 decibel (Db) in overall A-weighted sound levels have been achieved, even if the exact mechanism is not yet understood and is still today the subject of wind tunnel testing (e.g. Ryi et al., 2014).

The study of the relationship between Infrastructure developments and health can be traced back to around the beginning of the 20th century where noise figured as one amongst many environmental hazards or risks. In a study

from 1910, the impacts of noise on the work efficiency of industrial workers were observed for the first time (Wynne, 1930). Since the 1960s, 'risk' studies (Kasperson et al., 1988), constituting noise in the environment as a health concern (and risk), has become established as a field in itself (foreword, ICBEN, 1973). Importantly, health is defined not just as a matter of absence of disease, but a matter of complete physical, mental, and social well-being (WHO, 1946). Therefore, the World Health Organisation (WHO) considers (noise) annoyance as a health issue resulting from noise exposure, along with e.g. sleep disturbance, mental health, diabetes and heart disease (WHO, 2018). Annoyance is one of the most prevalent health effects of noise (Guski et al., 2017) but is moreover hypothesised to mediate a range of other 'physical' health effects (e.g. stress, anxiety, sleep disturbance, metabolic and cardiovascular disease) (WHO, 2018; Van Kamp and Van den Berg, 2018, 2021, Michaud, 2016, Taylor and Klenk, 2018). While traffic, industry and 'neighbourhood noise', for instance, have been investigated since at least the 1950s (Stevens et al., 1955), the health impact of wind turbine noise has only been an issue in the last decades (WHO, 2018, Pedersen and Waye, 2004). Annoyance, though, continuously comes forward as the most important health consequence of wind turbine sound (Van Kamp and Van den Berg, 2021).
Low frequency and infra sound from wind turbines is also a topic of public and political concern, with concerns that these lower, inaudible sound frequencies may lead to other health effects than audible sounds, such as the "Wind Turbine Syndrome" caused by Vibroacoustic disease (VAD) (vibration of the body, nausea or dizziness). However, there is no evidence that these lower frequencies have any health effects, nor that they lead to extra annoyance (Van Kamp and Van den Berg, 2021).

This epistemic community focuses on self-reported health effects (e.g. annoyance, stress or sleep disruption) in survey studies as well as in laboratory experiments (e.g. Müller et al., 2023; Hübner et al., 2019; Boorsma and Schepers, 2017), which also include objective measurement of bodily reactions, for instance polysomnography to detect sleep disturbance.
Epidemiological studies on the population include self-reported health effects in surveys, but a couple of studies also use more objective data. The Canadian Community Noise and Health Study by Michaud et al. (e.g. 2016), for instance, used hair cortisol concentrations to complement self-reported data. The Danish Health Study on the health-impacts of wind turbine noise (Poulsen et al., 2019) used wind turbine location data and modelled noise levels together with medical register data in order to study the relationship between wind turbine noise and a range of medical conditions on the population.

A formative study in the 1950's by Stevens et al. (1955, p. 64) developed the "Composite Noise Rating" approach whereby people's reaction to noise could be predicted, so that a "realistic criterion" or limit for neighbourhood noise. This was based on the recognition that levels, or doses, of noise – measured in decibels (Db(A)) – could elicit a certain human response way below that which can damage hearing, namely influencing the wellbeing and health of the general public. However, annoyance studies today build on a seminal paper on noise annoyance published in 1978 by Theodor Schultz (Schultz, 1978). He developed a model which rested on the conviction that both the noise dose and the response can be standardised and quantified and plotted in a graph that shows visually the particular relation between sound dose and response ("% highly annoyed") for different noise sources.
The dose-response model emerged from a need to be useful for planning, regulation and policy, the raison d'être for the health-based epistemic community: In 1978, the hitherto limited agency of science to produce 'facts' for policy and planning was problematized by Professor Paul Borsky (Columbia University). In a paper presented at an environmental noise conference, Borsky argued that the "lack of agreement on standardized units of measurement and comparable methods for obtaining and analysing objective data" in the scientific community was one of the main reasons "why community noise abatement has made such slow progress" (Borsky, 1978, p. 453).

To overcome this seeming lack of influence on policy, Schultz's overarching aim with his dose-response paradigm, which was supported in part by the U.S. Department of Housing and Urban Development (Schultz, 1978, p. 403), was to find a stable model that could better inform policymaking on land use and planning and offer "guidance for regulatory decisions about noise" (1978, p. 403; also see Fidell, 2003; Miedema and Vos, 1998, p. 3434). To do so, Schultz changed the main metric from median response (resembling an "average response" of a community) which was the common approach at the time, to "percent highly annoyed" plotted against noise exposure. The argument was that this approach would provide a more stable (universal) model, since "the median response is much more difficult to translate from one annoyance scale to another, in everyday terms that are understood by politicians and policy makers" (Schultz, 1978, p. 379). Moreover, if the person was highly annoyed, he hypothesized the response would be strongly correlated to the sound itself, providing a more "useful indication of acceptable community noise exposure" (Schultz, 1978, p. 379). Further, without providing further evidence, Schultz (1978, p. 389) commented that restricting the percentage of the 310 population being 'highly annoyed' to 10% would be a "desirable condition". Noise limits should in other words meet that target. Pedersen and Waye (2004) conducted the first – and now seminal – annoyance

dose-response study for wind energy in 2004 to explore "acceptable exposure levels". "There is clearly a need for field studies to investigate the impact of wind turbines on people living in their vicinity And to further explore the presence of disturbances. In particular, Dose–response relationships should be investigated to achieve a more precise knowledge of acceptable exposure levels" (Pedersen and Waye, 2004, p. 3461).

They concluded that wind turbine noise is a particularly annoying noise source as, despite lower doses, it produced higher annoyance rates than other noise sources at the same dose level. (See Figure). The idea that different types of noise sources (aircraft, road traffic, train, etc.) would result in varying degrees of annoyance at similar noise levels was already put forward by Miedema and Vos (1998). **Such comparative studies on different noise sources have helped to demonstrate that wind turbine noise may have particularly annoying characteristics (e.g. the "swishing" or "thumping" sound character, technically referred to as amplitude modulation) that can be perceived at "low dose levels", but which are not often captured by the measuring methodology in regulation (Janssen et al. 2011, Haggett, 2012).**

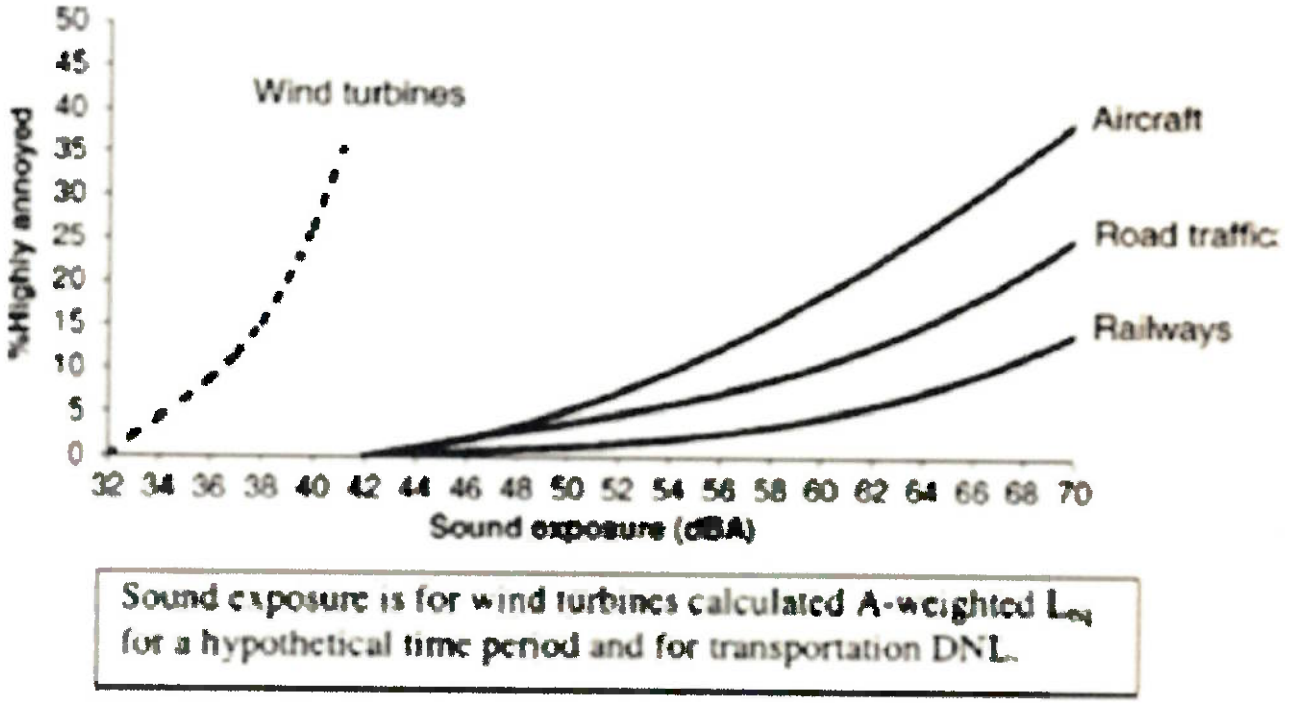


Figure 2: Pedersen and Waye's dose-response model (2004, p. 3468)

Another key example of inconclusive attempts at taming the unruly nature of the epistemic object of wind turbine noise are the publications that came out of the Danish health study on wind turbine noise (e.g. Poulsen et al., 2018). Funded by the Danish government with high hopes that the study could provide "objective proof" on (the lack of) health impacts (cardiovascular disease and other diseases related to stress and sleep deprivation), the study was in the end unable to establish with certainty either that there were or there were not health effects from wind turbine noise, and the researchers behind the study recommended further research (Danish Agency of Public Health (Sundhedsstyrelsen), 2019; Poulsen et al., 2019). Thus, in a sense, the cancer study has produced evidence, or, rather "arguments" both for proponents of and opponents to wind power, sparking even more controversy.

It Is therefore worth summarising the communities' understandings here, to crystallise their differences: For the technical community, noise is something that can be measured and modelled, with the expectation that its impact on people can be reduced to a quantifiable estimate of Db(A). Hereby, there is the assumption that by quantifying and reducing the noise level, the risk of opposition to wind energy as well as revenue loss, is reduced.
For the health community, a statistical approach translates the noise Db(A) level into the risk of a certain percentage of highly annoyed people, enabling the setting of a limit that can be relied upon for informing policy and regulation, providing a quantifiable threshold below which the risk of adverse health effects is reduced to an acceptable level.
Comment: This level of uncertainty invokes the Precautionary Principle & refusal of development.

Reference Number 123 : Environmental noise in Europe — 2020 No 22/2019 EEA Report

Long-term exposure to environmental noise is estimated to cause 12 000 premature deaths and contribute to 48 000 new cases of ischaemic heart disease per year in the European territory. It is estimated that 22 million people suffer chronic high annoyance and 6.5 million people suffer chronic high sleep disturbance.

As a result of aircraft noise, 12 500 schoolchildren are estimated to suffer learning impairment in school.

These significant health impacts are most likely to be underestimated, with new WHO evidence demonstrating effects at levels below the obligatory END reporting thresholds. In addition, the END does not comprehensively cover all urban areas, roads, railways and airports across Europe.

Exposure to environmental noise does not affect everyone equally. Socially deprived groups, as well as groups with increased susceptibility to noise, may suffer more pronounced health-related impacts of noise.

Description of the main non-auditory adverse health effects of noise

Annoyance	*It is one of the most prevalent responses to noise, and it is described as a stress reaction that encompasses a wide range of negative feelings, including disturbance, dissatisfaction, distress, displeasure, irritation and nuisance. The individual response to noise depends not only on exposure levels but also on contextual, situational and personal factors. It can initiate physiological stress reactions that, if long-term, could trigger the development of cardiovascular disease.*
Sleep disturbance	*Sleep serves to facilitate vital functions in our body. Noise fragments sleep, reduces sleep continuity and reduces the total amount of sleep time, which can have impacts on alertness, performance at work and quality of life. Sleep restriction causes, among other things, changes in glucose metabolism and appetite regulation, impaired memory consolidation and a dysfunction in blood vessels. Long-term sleep disturbance can also lead to cardiovascular health issues.*
Cardiovascular and metabolic effects	*Noise is an important risk factor for chronic diseases. Noise exposure activates stress reactions in the body, leading to increases in blood pressure, a changing heart rate and a release of stress hormones. In addition, the cardiovascular and metabolic effects related to noise exposure may also be a consequence of a reduction in sleep quality, caused by noise exposure during the night, among other additional or interrelated mechanisms. These chronic effects can lead to premature mortality.*
Cognitive development in children	*Noise in classrooms affects children in many ways, including lowering their motivation, reducing speech intelligibility, listening comprehension and concentration, producing annoyance and disturbance, and increasing restlessness. As a result, children exposed to noise at school may experience poorer reading ability, memory and performance. Cognitive impairment could also be linked to noise exposure at home during night-time hours, which can cause low mood, fatigue and impaired task performance the next day. Noise at home may also be linked to hyperactivity and inattention problems, which can cause lower academic performance.*

Noise annoyance, sleep disturbance and their relation to health and well-being

Although noise annoyance and sleep disturbance may be short lived in some situations, in this report and according to the World Health Organization (WHO) environmental noise guidelines (WHO, 2018), noise annoyance and sleep disturbance refer to those affecting people long-term/chronically. In terms of severity, WHO (2018) based its results on the percentage of the population giving the highest ratings for long-term, self-reported noise annoyance and sleep disturbance, namely the 'percentage of the population highly annoyed' and the 'percentage of the population highly sleep disturbed'. Therefore, throughout this assessment, we refer to 'high annoyance' and 'high sleep disturbance' to describe the long-term impacts of noise on annoyance and sleep disturbance.

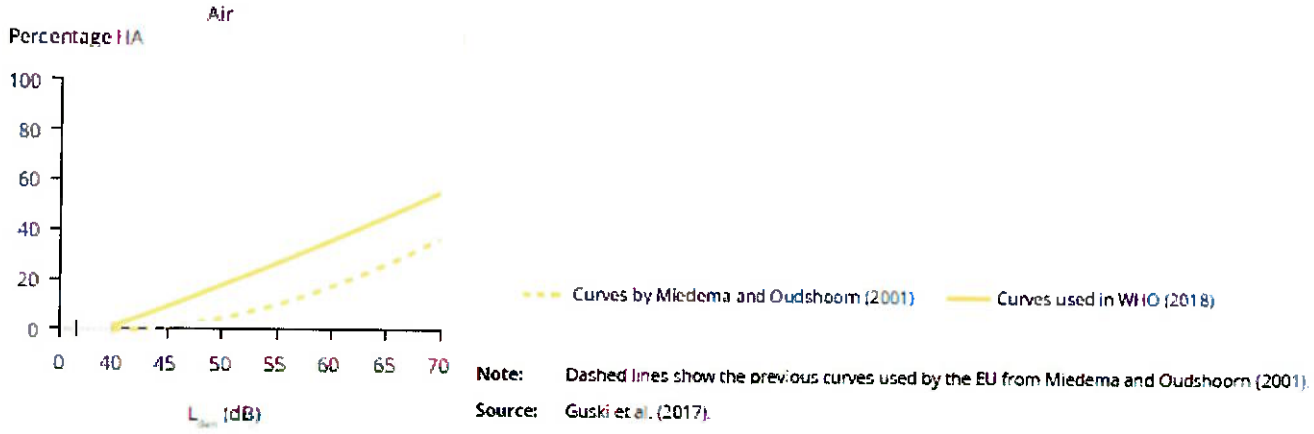
The WHO environmental noise guidelines (WHO, 2018) consider long-term annoyance and sleep disturbance due to noise to be important health outcomes. According to the WHO definition of health, which is 'a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity (International Health Conference, 2002)', documenting only physical health does not present a complete picture of general health.

Therefore, being undisturbed by noise in all activities, including sleep, constitutes an asset worthy of protection (WHO, 2018). The importance of considering both annoyance and self-reported sleep disturbance as health outcomes is further supported by evidence indicating that they may play a part in the causal pathway of noise-induced cardiovascular and metabolic diseases (Eriksson and Pershagen, 2018; WHO, 2018).

Recommendations from the WHO environmental noise guidelines

Reducing noise below these levels is strongly recommended			
Noise indicator	*Road*	*Rail*	*Air*
Lden	*53 Db*	*54 Db*	*45 Db*
Lnight	*45 Db*	*44 Db*	*40 Db*

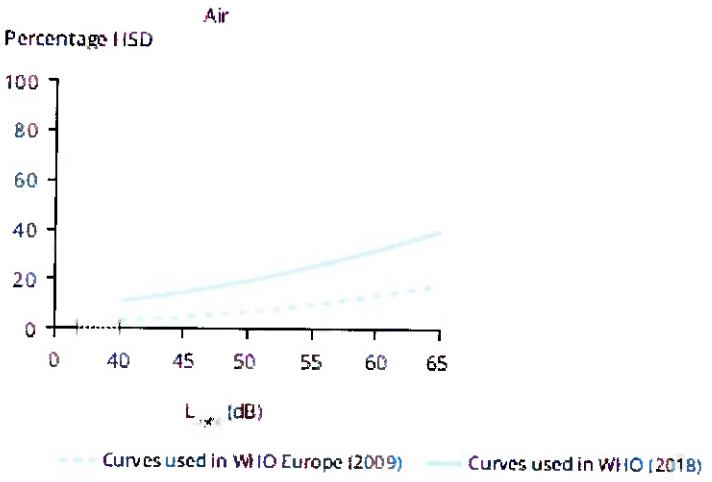
Estimated percentage of people in the category 'Highly Annoyed (HA) by noise for air, road and rail traffic' according to the WHO environmental noise guidelines



Note: Dashed lines show the previous curves used by the EU from Miedema and Oudshoorn (2001).

Source: Guski et al. (2017).

Estimated percentage of people in the category 'Highly Sleep Disturbed (HSD) by noise for air, road and rail traffic' from the WHO environmental noise guidelines



Note: Dashed lines show previous curves from *Night-Noise Guidelines for Europe* (WHO Europe, 2009).

Source: Basner and McGuire (2018).

Other health effects of noise

Although current guidance from the WHO mainly focuses on direct links between noise levels and priority health effects such as annoyance, sleep disturbance, cognition impairment, cardiovascular outcomes and hearing impairment, given the disease-inducing mechanisms of noise, i.e. stress and the disturbance of night-time sleep, noise may have wider impacts on people's health and well-being.

For example, it has recently been suggested that exposure to transport noise may be involved in the development of some types of breast cancer (Sorensen et al., 2014; Hegewald et al., 2017; Andersen et al., 2018). It is also hypothesised that psychological stress caused by noise may exacerbate respiratory disease (Recio et al., 2016). Noise causes stress and annoyance and has also been linked to serious mental health problems such as depression and anxiety (Beutel et al., 2016; Orban, et al., 2016).

Other studies have shown the indirect impacts of living in noisy areas. For instance, transport noise may, through sleep disturbance, lead to physical inactivity (Foraster et al., 2016; Roswall et al., 2017). Other associations between traffic noise and lifestyle factors such as smoking, alcohol consumption or medication intake have also been reported (Bocquier et al., 2014; Roswall et al., 2018).

Environmental noise impacts on vulnerable groups

Group	Vulnerability	Adapted from
Children	Exposure to aircraft noise in schools affects children's cognition. Compared with adults, children are in an important learning and developmental phase and may therefore be disproportionately affected by noise. Children also may lack coping strategies and have less control over environmental noise than adults. As children also spend more time in bed, they may be exposed more to night noise levels.	WHO Europe, 2009; Clark and Paunovic, 2018a
Elderly	Since sleep structure becomes more fragmented with age; elderly people are more vulnerable to sleep disturbance. Elderly people may also be more prone to suffering cardiovascular effects due to noise than younger adults. The risk of suffering health conditions related to the heart and circulatory system increases with age. In addition, the elderly typically spend more time at home or have lived in a property exposed to noise for many years.	WHO Europe, 2009; Tobias et al., 2014; Halonen et al., 2015
Shift workers	Shift workers may be at an increased risk of experiencing negative impacts from exposure to environmental noise, because their sleep structure is under stress. Shift workers may also need to sleep during the day, when environmental noise levels are higher.	WHO Europe, 2009
Pre-existing health conditions	People suffering from chronic diseases may have a higher cardiovascular risk due to noise than those without such pre-existing conditions.	Babisch, 2006
Noise sensitive	People considered to be noise sensitive (e.g. people who pay more attention to noises, discriminate more between noises, find noises more threatening and out of their control, and react to and adapt to noises slowly) are generally more susceptible to sleep disturbance as well as psychological effects due to noise.	Stansfeld, 1992; Marks and Griefahn, 2007
Pregnant women	The sleep structure of pregnant women becomes more fragmented. Environmental noise may also increase the risk for pre-term birth and low birth weight.	WHO Europe, 2009; Nieuwenhuijsen et al., 2017
Socio-economically disadvantaged	Lower socio-economic groups may be exposed to higher levels of noise. Those living in more deprived locations have less access to quiet areas. Deprived populations may experience the worst effects of noise pollution as a result of poorer housing, pre-existing health conditions or fewer opportunities for coping with noise.	EEA, 2018c; Dreger et al., 2019; WHO, 2019

Effects of noise on biodiversity

- *Anthropogenic noise not only affects species sensitive to noise, but has impacts on a wide range of terrestrial and aquatic species that inhabit very different ecosystems.*

- *Anthropogenic noise causes a range of physiological and behavioural responses in terrestrial and marine wildlife, which can lead to reduced reproductive success, increased mortality risk and emigration, resulting in decreased population densities.*

- *Although the responses to noise are very much species dependent, effects can start to appear at levels as low as 40 Db(A) for terrestrial animals. In addition to levels of noise, impacts may also depend on noise frequency and type.*

- *At least 19 % of nature protection areas covered by Natura 2000 are located in areas where noise levels are above the Environmental Noise Directive reporting thresholds because of roads, railways and aircraft.*

Effects on terrestrial wildlife due to general background, transport and industrial noise

Terrestrial	Birds		Changes in singing and communication behaviour
			Changes in spatial distributions and movements
			Reduced breeding
			Effects on physiological development
			Increased stress levels
			Reduced reproductive success
			Decline in species diversity
			Changes in distribution and abundance.
			Changes in community species
	Mammals		Changes in vocal and communication behaviour
			Reduced foraging
			Increased stress levels
			Reduced reproductive success
	Reptiles and amphibians		Changes in vocal and communication behaviour
			Difficulties in locating mates
	Invertebrates		Changes in mate attraction behaviour

	Physiological response
	Behavioural response
	Impact on fitness
	Consequences for population and communities

Sources: Adapted from Francis and Barber (2013) and Shannon et al. (2016).

Reference Number 124 : Recent Advances in Wind Turbine Noise Research Colin Hansen 1, and Kristy Hansen. Acoustics 2020, 2, 171–206; doi:10.3390/acoustics2010013 www.mdpi.com/journal/acoustics

Special Characteristics of Wind Farm Noise

Some special characteristics of wind farm noise can be accounted for by adding a penalty in Dba to the measured A-weighted sound pressure level before comparing the measured A-weighted level to the allowed level. Other characteristics may be accounted for by specifying an allowable limit for a particular measurement that quantifies that particular characteristic. However, research is still needed to determine how regulations can best address all characteristics of wind farm noise at the typical range of distances between the nearest turbine in a wind farm and potentially affected residences. Characteristics of wind farm noise that are potentially annoying to residents are listed and explained below.

Amplitude modulation (AM) *which is the periodic variation in wind farm noise level. Allowed levels should be expressed in terms of a single parameter that is proportional to the annoyance and magnitude of the modulation. A suitable modulation metric as well as its suitable value are both subjects of current research. The single parameter could then be used as a basis for an AM penalty (decrease in allowed A-weighted sound pressure level as a function of*

a suitable modulation metric). It may also be necessary for the magnitude of the AM penalty to be a function of the A-weighted noise level.

Low-frequency noise (LFN). *This is currently addressed in some regulations that do consider it, in a number of ways by specifying one or more of the following:*

- *(i) an allowed maximum C-weighted noise level ;*
- *(ii) an allowed maximum decibel difference between the C-weighted level and the A-weighted level*
- *(iii) allowed overall maximum indoor noise levels in a specified frequency range (see, for example, which specifies, in Danish regulations, an allowed 20 Dba in the range 10–160 Hz for wind speeds at hub height between 6 and 8 m/s); and*
- *(iv) allowed maximum indoor noise levels for each 1/3-octave band in the frequency range 20–200 Hz (Swedish and Finnish regulations according to Sorensen and Kishore and DEFRA criteria according to Moorhouse et al. or 5–80 Hz*

A limitation of the methods presented above is their use in isolation. For instance, considering the overall C-weighted level or Dbc minus Dba exclusively will result in false positives in the results. On the other hand, comprehensive spectral analysis can be complex for compliance assessment purposes.
After reviewing the approaches to LFN assessment and regulation used in various international jurisdictions, Downey and Parnell proposed a new approach that uses a three-stage assessment of LFN:
(i)simple initial screening so that assessment proceeds only if the C-weighted level minus the A-weighted level (Dbc-Dba) exceeds 15 Db;
(ii) comparison of 1/3-octave band levels between 10 and 160 Hz with allowed 1/3-octave band levels; and
(iii) assignment of a penalty to the measured A-weighted level, depending on the extent by which the measured 1/3-octave band levels exceed the allowed levels.
As wind turbines become larger, the likelihood of annoyance from excessive infrasound and LFN becomes greater, due to the shift to lower frequencies of the wind turbine noise spectrum. On the other hand, some would argue that, if turbines become sufficiently high, the noise reaching dwellings would be reduced, but this remains very speculative. Research is needed to determine whether or not existing regulations are applicable to turbines larger than those existing in wind farms at the time that the regulations were drafted, and whether satisfaction of the various different requirements in different regulations adequately protects residents from LFN annoyance.

Tones. *It is well known that tones add to the annoyance of wind farm noise. The international standard, IEC61400 describes how to determine tonal prominence for noise measured close to a wind turbine. As discussed, the procedure is not appropriate for determining the extent of tonality at a dwelling located some distance from the nearest turbine in a wind farm. In addition, results of round robin tests in various laboratories show inconsistencies in identification of the same tone, probably due to inconsistencies in interpretation of the standard by different research groups. These inconsistencies in interpretation of IEC61400, probably as a result of the high complexity of IEC61400, will need further research to resolve. It is important that any new standard for wind farm noise specifies appropriate frequency-dependent and sound pressure level-dependent tonal penalties that can be used in regulations.*

Infrasound. *A single number rating for the level of infrasound is currently the G-weighted level (Dbg). The G-weighting network has a maximum response at 20 Hz that rolls off in a similar way to the response of the ear as the frequency is decreased to 2 Hz. Above 20 Hz, the weighting is not zero but rolls off at a rate such that the weighting at 2 Hz is similar to that at 63 Hz. It needs to be established whether this is a suitable descriptor to be used in regulations for wind farm noise and, if so, what would be an appropriate allowed Dbg level. The appropriate level would have to be based on the outcomes of further research on the effects of infrasound on annoyance and sleep disruption.*

Ground Vibration

It is generally accepted that seismic vibration generated by wind turbines is sufficiently small that it cannot be detected by residents living more than 2 km from the nearest turbine in a wind farm. In fact, it is highly unlikely that vibrations would be detectable by residents living even closer than this. However, vibration levels generated by wind farms are sufficiently high that they can interfere with stations set up to monitor atomic bomb testing, earthquakes and volcanoes. For this reason, wind farms are generally excluded within 30–50 km of military establishments or seismic monitoring stations.
Recently, questions have arisen concerning the ability of seismic waves generated by wind farms to generate significant levels of acoustic infrasound, but work by Nguyen et al. would suggest that this is unlikely to be the case. Although they found that vibration levels on the floor in dwellings were unlikely to be due to infrasound, they did find

that vibration levels on the window were well correlated with the wind farm acoustic signature (not the ground vibration). However, more extensive studies of wind farm vibration levels in dwellings closer than 1 km to the nearest turbine in a wind farm are warranted.
Although it is generally accepted that ground vibrations due to turbines do not have a detectable effect on humans, more research effort is needed to quantify the effect of wind farms on ground vibration and the distance they should be from sensitive seismic measurement stations used for detection of volcanoes, earthquakes and atomic testing.

Local Native Wildlife and Agriculture
Quite a few studies have been undertaken to evaluate whether or not wind farms cause wildlife to leave their vicinity (see for example. In cases where this is true, it is difficult to determine whether the reason was turbine noise, construction activity, or the visual presence of a huge tower with rotating blades.
Studies have also been undertaken on the effect of wind turbines on livestock (see, for example, and on wildlife (see, for example. These studies have shown that wind turbine noise may affect communication between animals, which may affect breeding, and/or contribute to increased cortisol, indicating a stress response that could make the animals more susceptible to infection and disease.
Although it is relatively easy to show that wildlife tend to leave wind farm areas, it is not clear whether this is due to the noise emission or other effects such as the turbine presence or shadow flicker.

Reference Number: 125 : Long-term wind turbine noise exposure and the risk of incident atrial fibrillation in the Danish Nurse cohort. Elvira V. Brauner, Jeanette T. Jorgensen, Anne Katrine Duun-Henriksen, Claus Backalarz, Jens E. Laursen, Torben H. Pedersen, Mette K. Simonsen, Zorana J. Andersen. Environment International 130 (2019) 104915
The results from this first nationwide, prospective cohort study of Danish female nurses assessing the relationship between WTN exposure and AF offer suggestive evidence of an association. We used a large nationwide prospective cohort with a representative distribution of present and historical addresses around entire Denmark and benefited from objective assessment of AF incidence based on high quality Danish registries with near 100% coverage (Helweg-Larsen, 2011; Lynge et al., 2011; Schmidt et al., 2015),
as well as detailed information on AF risk factors. This assessment implies minimal possibility of recall and information bias and no selection bias. We furthermore benefited from the state-of-the-art high resolution validated exposure models for WT and road traffic noise (Backalarz et al., 2016; Kragh et al., 2001; Sondergaard et al., 2009) as
well as air pollution (Kakosimos et al., 2010; Ketzel et al., 2011), which were based on geocodes and also accounted for all address changes, meteorological conditions as well as the size and the type of WTs.
We found a significant effect of exposure to WTN above 20 Db compared to<20 Db at night. We acknowledge that noise levels below 20 Db and probably not able to cause sleep disturbance, but if real this implies that night exposure to WTN is important in the causal pathway. This is plausible as the second mechanism involved in the effects of noise exposure relate to indirect noise-induced sleep disturbances, which are proposed pathways implicated in the development of metabolic changes (Munzel et al., 2017a, 2017b, 2017c).
Sleep has a regulatory influence on the immune system (Ali and Orr, 2014; Gomez-Gonzalez et al., 2012) and disturbed sleep has been associated with systemic impairment of the immune system. Sleep disturbances are similarly associated with impairment of the immune system, including changes in circulating white blood cells and increases in pro-inflammatory molecules (Aho et al., 2013; Irwin et al., 2016) that are on the causal pathway to AF. Notably, our results suggesting a strong association between nighttime WTN and AF, are supported by a recent study of noise annoyance and AF, where the authors report that annoyance due to noise at night was most strongly associated with AF prevalence (Hahad et al., 2018).
We found suggestive evidence of an association between long-term exposure to WTN and AF amongst in women above age 44. This should be interpreted with caution as levels of WTN exposure were low and direct auditory effects leading to AF are not expected.

Reference Number: 126 : PHYSICAL AND PERCEPTUAL PREDICTION OF WIND TURBINE NOISE. Andrea P. C. Bresciani 2023. ISBN: 978-90-365-5954-6.**DOI:** 10.3990/1.9789036559546
The increasing demand for renewable energy has led to a surge in wind turbine installations. However, the noise emitted by wind turbines is hampering their deployment close to inhabited places because of the annoyance caused to the residents. Despite lower sound levels than other common sources, wind turbine noise ranks as the most annoying sound source compared to wind, road, and rail noises.
Wind turbines emit mechanical and aerodynamic noise. Sources of mechanical noise are the drivetrain and the gearbox. Aerodynamic noise is caused by the interaction of the moving wind turbine blades and the air. The dominant noise sources in the audible frequency range (20 Hz to 20 kHz) are aerodynamic, mainly trailing- and leading-edge

noise. Trailing-edge noise is caused by the interaction of the turbulent boundary layer on the blade with the trailing edge of the blade itself, while leading-edge noise is generated by the interaction of the turbulence in the inflow with the leading edge of the blade. This research focuses on developing a wind turbine noise model, accounting for trailing- and leading-edge noise sources, atmospheric propagation, and creating audible sound files (auralization) from a numerical workflow. Furthermore, the impact of terrain and atmospheric conditions on noise emission, propagation, and perception is investigated. Using analytical and empirical methods, the study prioritizes fast computational turnaround methods that can be used in a real environment and practical applications. The methods should be robust, delivering accurate results for various conditions and turbine geometries.
The acoustic emissions from a wind turbine can be categorized Into two primary sources: mechanical and aerodynamic noise. The mechanical noise is usually tonal and associated with the vibrations of the gearbox that are transmitted to the nacelle and tower. The aerodynamic noise is generated by the blades passing through the air. Horizontal-axis turbines rotate at a relatively low speed and, hence, tonal peaks caused by the blade loading will appear in the infrasound region (frequencies lower than 20 Hz). In the audible frequency region (frequencies between 20 Hz and 20 kHz), the airfoil noise is considered the dominant noise source.
Several noise mechanisms could contribute to the total airfoil noise, including trailing-edge noise, leading-edge noise, tip-vortex noise, blunt trailing-edge noise, and separation-stall noise. However, for wind turbines, the trailing-edge noise caused by the turbulent boundary layer and the leading-edge noise caused by the turbulent inflow are believed to be the main noise sources in design operating conditions.
Besides the characteristics of acoustic emissions, the atmosphere and the ground strongly influence the noise perceived by the listener. The levels at the listener position can be increased or reduced with respect to free-field propagation depending on the frequency range, ground type, and atmospheric conditions. The most important physical phenomena are ground reflection, atmospheric absorption, and refraction.
The sound propagating in a turbulent atmosphere fluctuates in amplitude and phase. This phenomenon, known as acoustic scintillation, is caused by random fluctuations in the acoustic refractive index of the air induced by atmospheric turbulence. Auralization techniques should consider this phenomenon to increase the realism of the synthetic sound.
A sound wave propagating in a turbulent medium encounters variations in the acoustic refractive index caused by random fluctuations in temperature and velocity. As a result, the wave is randomly distorted, causing changes in its amplitude and phase. For example, for a pure tone emitted by a static source, a listener sufficiently far will perceive a fluctuation (around the nominal, undisturbed values) in amplitude and frequency.

The cumulative Noise impact from Wake effects, plus friction effects/noise from insect detritus on the wind blades on residences from the South-West/West prevailing winds & shear winds are not provided. The N/S axis of the turbines indicate increased noise at the north-eastern boundary adjoining the existing houses.

Reference Number 127 : Balz Anor -v- An Bord Pleanala Supreme Court judgement [2016] [IESC 124]

While the 2019 guidelines remain in draft form, Note the Balz Anor -v- An Bord Pleanala Supreme Court judgement [2016] [IESC 124] which states that the Board, in deliberating on an application, should have some regard to the guidance set out therein. The preferred approach as set out in the Section 5.7.4 of the 2019 draft guidelines is for noise limit restriction limits consistent with World Health Organisation guidelines of 5 Db(A) above existing background noise within a range of 35 to 43 Db(A) with 43 Db(A) being the maximum noise limit permitted day or night. This criteria is below that permitted under the 2006 guidelines. As noted the predicted noise levels do not comply with same.

Reference Number 128 : 2024 TNEI Wind Farm Judicial Review Case Overview – Wind Turbine Noise
As we approach May, we highlight an interesting Judicial Review case that TNEI was involved with last year in the Republic of Ireland. The case related to a consented wind farm whose approval was challenged by a local objector group (the Applicants). A number of challenges were presented, including the suggestion that the decision to consent the wind farm by An Bord Pleanála (the Board) had not properly considered all of the information presented to them i.e. the information that had been previously submitted by the Applicants and other objectors; the argument that the current Wind Energy Development Guidelines are out of date; and, the argument that there was a lack of consideration and assessment of Amplitude Modulation (AM).

To summarise a long case, the Applicant argued that the Decision made by the Board:

- Lacked relevant consideration of other material relating to wind turbine noise, other than the currently adopted Wind Energy Development Guidelines (WEDG) 2006;

- Failed to consider submissions arguing the WEDG 2006 were / are out of date and no longer represent best scientific knowledge as regards wind turbine noise; and
- Failed to consider / assess amplitude modulation (AM), and therefore erred in law.

The Judge ultimately decided that the Board did consider submissions made by the Applicant and other material outside that of the WEDG2006, including the more recent draft WEDG2019 (which are currently being revised), consideration of several other guidance documents (including British Standard 4142, and WHO guidelines).
The Judge also decided that AM was sufficiently considered, following contributions by TNEI's Jim Singleton (originally the Applicant contended that a planning condition to control AM should be imposed, but Jim noted that imposing an AM planning condition is at odds with the advice stated in the Institute of Acoustics (IOA) 'A Good Practice Guide to the Application of ETSU R 97 for the Assessment and Rating of Wind Turbine Noise'). It was noted that, currently, whilst there is a method to measure and quantify AM, further work is required to develop a robust mechanism for controlling AM that could be incorporated into a planning condition.
The Applicant submitted Information "elati"g to a huge range of issues and objections over the course of a 700+ page submission, each of which demanded certiorari (grounds to quash a decision). It was noted that the objections lacked detail and were perhaps more *quantity than quality*, and in the end the Judge ordered the proceedings to be dismissed.
The need to thoroughly consider potential impacts associated with wind turbine noise remains an essential part of the wind farm design and consenting process. Whilst an update to the WEDG is expected this year it is essential that noise continues to be properly considered in the meantime to protect wind farm neighbours, to help inform decision makers and to provide certainty to wind farm developers.

Reference Number 129 : A planning condition for wind turbines. ***Andy McKenzie, Matthew Cand, Dick Bowdler, Mark Jiggins, Gavin Irvine, Michael Reid, Richard Perkins, Michael Lotinga, Malcolm Hayes and Andrew Bullmore,*** **Acoustics Bulletin November/December 2017, Vol 42 No 6.**

Introduction
This article sets out a proposed wording for a planning condition on noise for wind farms or individual wind turbines. Whilst local authorities and developers have waited for a planning condition that could be applied to newly consented wind farms, or to those already consented but with a suspensive condition, the report Wind Turbine AM Review (WTAMR) by WSP/Parsons Brinckerhoff for DECC arguably did not provide that. In addition there have been a number of comments on WTAMR that we consider should be addressed. The introductory sections and the conditions text represent the broad consensus view of those whose names appear below, following a period of discussion, compromise and agreement. This approach is proposed based on the current state of understanding but may be subject to modification in light of new research and further robust information.
Copies of the condition only in Word format are available from the following websites:
www.hayesmckenzie.co.uk/uploads/A_Planning_Condition_for_Wind_Turbines_Sept_2017.docx
www.dickbowdler.co.uk/content/publications/

Proposed wording condition: The annex contains the condition wording which takes fairly typical wording for a planning condition on wind farm noise, including adjustments for tonal penalties if relevant, and adds a mechanism for adding a penalty for AM. Consistent with the recommendations of the WTAMR, the AM penalty is applied in addition to the tonality penalty. But how to calculate an AM penalty in practice is not clear from the WTAMR report.
WSP researchers in their subsequent *Acoustic Bulletin* article have discussed this aspect further: the penalty "should be applied to each individual 10-minute period assessed, and the rated levels separated into wind speed integer 'bins' for the purposes of comparison with the condition limits". They explain that to "aggregate the AM penalty" values would give an equivalent result to adding the penalty to each 10-minute period and then averaging the resulting "rated" levels, which is our experience in practice. In contrast, as they note, averaging the AM ratings and deriving an AM penalty on that basis would in many cases lead to different results.
The proposed condition has therefore been drafted on the basis of aggregating the AM penalties obtained, and applying this to the overall noise levels. This is considered to be a pragmatic way to represent the frequency/intensity of AM typically observed in relevant weather conditions. The condition explains that this averaging should only be done in relevant subsets of conditions which are determined in each case based on the observed complaints (if relevant), data analysis results or practitioner judgment. Analysis in wind direction bins or plotting the amplitude modulation as a polar plot may be important in determining the appropriate subset. An example is shown in Fig 1 which is a polar plot of AM values as a function of wind direction and speed.

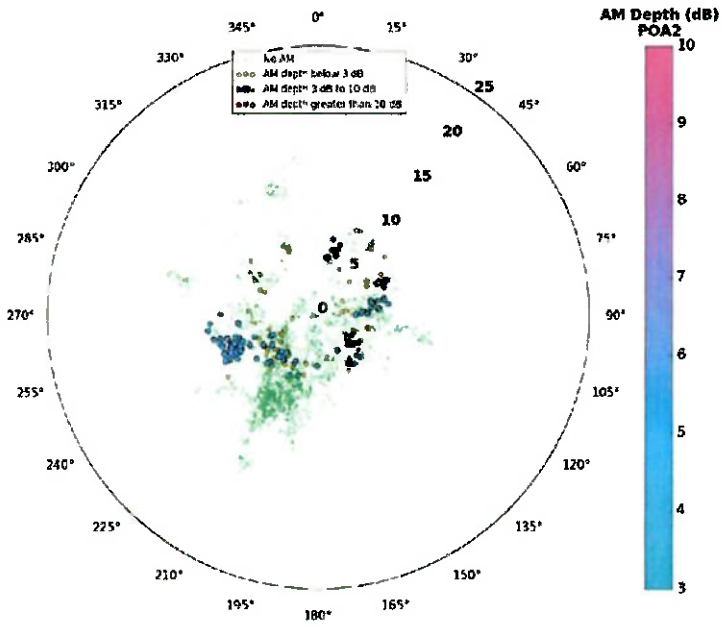


Fig 1 – plot of calculated AM ratings (dots) as a function of wind direction (circular direction) and wind speed (radial direction).

M penalty – general aspects.

As various people before us have discovered, the derivation of a penalty is not easy. There is not sufficient reliable research to be confident that a penalty system would always provide a fair indication of the impact of AM. However, to do nothing would be unfair on those wind farm neighbours adversely affected by AM and, in any case, there seems to be general agreement amongst many stakeholders on all sides of the debate that a robust condition including AM is required.

There are a significant number of people who have reservations about the penalty scheme proposed in the WTAMR report and this has been discussed in some detail by interested parties. The conclusion is that the penalty graph needs further research to establish whether it should be amended to take account of rotational speed and the difference between Leq and L90 (which increases as AM increases) and that this should be progressed as soon as possible. Meanwhile we have included the WTAMR graph in this condition. It is intended for medium to large scale turbines with a rotational speed up to 32 rpm.

A note on the night time limit

There has been criticism from some quarters of the method the WTAMR report proposed for an additional penalty to be applied at night to take account of the difference between the night-time and day-time limits; specifically, where the night-time limits are higher. With a few exceptions (where suspensive conditions for AM have been applied, typically as a scheme to be agreed) the condition we are discussing here applies only to new consents. That means that, in the majority of cases, it will be applied as part of a complete set of noise limits. In such cases, the night-time and day-time limits can be set appropriately in accordance with the circumstances of the case. It should be noted that, if the nighttime limit is higher than the day time limit this could mean that an AM penalty would take the wind farm over the limit during the day but not at night. Where a suspensive condition for AM has been applied, the AM penalty would have to be tailored to the individual case unless an application were made to amend the conditions as a whole.

Annex

Proposed planning conditions on noise for **** Wind Farm: The rating level of noise emissions from the combined effects of the wind turbines hereby permitted (including the application of any tonal penalty and amplitude modulation (AM) penalty), when determined in accordance with the attached guidance notes, shall not exceed the values for the relevant integer wind speed set out in or derived from Table 1 attached to these conditions and:

A) Within 21 days from receipt of a written request of the planning authority, following a complaint to it alleging noise disturbance at a dwelling, the wind farm operator shall, at its expense, employ an independent consultant and provide a written protocol to be approved by the planning authority. The protocol shall describe the procedure to assess the level and character of noise emissions from the wind farm at the complainant's property in accordance with the procedures described in the attached guidance notes. The written request from the planning authority shall set out as far as possible the time or meteorological conditions to which the complaint relates and time or conditions relating to tonal noise or AM if applicable. Measurements to assess

compliance with the noise limits shall be undertaken in accordance with the assessment protocol which shall be approved in writing by the planning authority.

B) The wind farm operator shall provide to the planning authority the independent consultant's assessment of the rating level of noise emissions undertaken in accordance with the protocol within two months of the date of the approval of the protocol by the local authority unless otherwise agreed by the planning authority. The assessment shall include all data collected for the purposes of undertaking the compliance measurements and analysis, such data to be provided in a format to be agreed with the planning authority. Certificates of calibration of the equipment shall be submitted to the planning authority with the report.

C) Where a further assessment of the rating level of noise emissions from the wind farm is required pursuant to Guidance Note 5 of the attached Guidance Notes, the wind farm operator shall submit a copy of the further assessment within 21 days of submission of the independent consultant's initial assessment unless otherwise agreed by the Planning Authority.

[It is acknowledged that there may be other parts of the current IOAGPG conditions which require inclusion here, such as the clause discussing limits which apply at non named locations etc. The text included above aims to show how rating of AM scheme fits within the normal WF compliance approach.]
(Insert here the table or tables relevant to the specific planning condition)

Guidance notes for noise condition
These notes are to be read with and form part of the planning condition on noise. The measured data is to be split into bins as described below. The rating level in each bin is the arithmetic sum of the wind farm noise level, any tonal penalty applied in accordance with Note 3 and any AM penalty applied in accordance with Note 4. Reference to ETSU-R-97 refers to the publication entitled "The Assessment and Rating of Noise from Wind Farms" (1997) published by the Energy Technology Support unit (ETSU) for the Department of Trade and Industry (DTI). IOAGPG is "A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise" or any update of that report current at the time of measurement. The IOA Metric is "A Method for Rating Amplitude Modulation in Wind Turbine Noise" dated 9th August 2016 or any update of that current at the time of measurement.

Note 1 – Data collection

A) Values of the LA90,10-minute noise index should be measured in accordance with the IOAGPG. Measurements shall be undertaken in such a manner to enable a tonal penalty to be calculated and to allow an AM penalty to be calculated for selected periods where a tonal or AM assessment is required.

B) To enable compliance with the conditions to be evaluated, the wind farm operator shall continuously log arithmetic mean wind speed in metres per second (m/s) and arithmetic mean wind direction in degrees from north in each successive 10-minutes period in a manner to be agreed in writing with the planning authority. The wind speed at turbine hub height shall be "standardised" to a reference height of 10 metres as described in ETSU-R-97 at page 120 using a reference roughness length of 0.05 metres. It is this standardised 10 metre height wind speed data which are correlated with the noise measurements determined as valid. The wind farm operator shall continuously log arithmetic mean nacelle anemometer wind speed, arithmetic mean nacelle orientation, arithmetic mean wind direction as measured at the nacelle, arithmetic mean rotor RPM and whether each wind turbine is running normally during each successive 10-minutes period for each wind turbine on the wind farm. All 10-minute periods shall commence on the hour and in 10-minute increments thereafter synchronised with Universal Time (UT).

Note 2 – Data analysis

4. The independent consultant shall identify a subset of data having had regard to:-

- the conditions (including time of day and corresponding wind directions and speeds) at times in which complaints were recorded.
- the nature/description recorded in the complaints if available.
- information contained in the written request from the local planning authority.
- likely propagation effects (downwind conditions or otherwise);
- the results of the tonality/AM analysis where relevant.

In cases where it is possible to identify patterns of clearly different conditions in which complaints have arisen additional subsets may be considered provided this does not introduce unreasonable complexity in the analysis and can be justified by the independent consultant.

5. Within each of the subset(s) of data identified, data shall be placed into separate 1 m/s wide wind speed bins.

Note 3 – Tonal penalty

A) Where, in accordance with the protocol, the noise contains or is likely to contain a tonal component, a tonal audibility shall be calculated for each ten-minute period using the following procedure.

B) For each 10-minute period for which a tonal assessment is required this shall be performed on noise emissions during two minutes of each 10-minute period. The two-minute periods should be spaced at10-minute intervals provided that uninterrupted uncorrupted data are available ("the standard procedure").

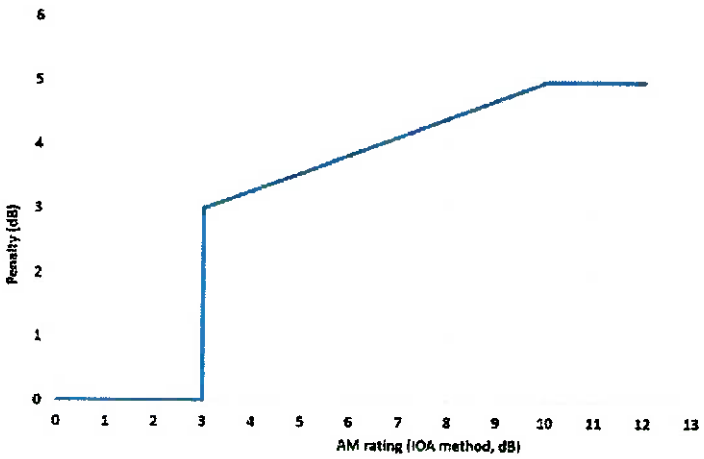
C) For each of the two-minute samples the tone level above audibility shall be calculated by comparison with the audibility criterion given in Section 2.1 on pages 104 -109 of ETSU-R-97. Samples for which the tones were below the audibility criterion or no tone was identified, a value of zero audibility shall be substituted. Where data for a ten-minute period are corrupted, that period shall be removed from the tonal analysis.

D) The tone level above audibility for each 10-minute period shall be placed in the appropriate data subset and wind speed bin.

Note 4 – AM penalty

A) Where, in accordance with the protocol, the noise contains or is likely to contain AM, an AM penalty shall be calculated for each ten-minute period using the following procedure.

B) For each 10-minute interval for which an AM assessment is required this shall be performed in accordance with the IOA Metric. The value of AM for each ten-minute period shall be converted to a penalty in decibels in accordance with the graph below and the penalty shall be placed in the appropriate data subset and wind speed bin. Where a penalty is zero it should be placed in the bin in the same way.



Technical Penalty graph

Note 5 – Calculation of rating level

A) The LA90 sound pressure level for each data subset and wind speed bin is the arithmetic mean of all the 10-minute sound pressure levels within that data subset and wind speed bin except where data has been excluded for reasons which should be clearly identified by the independent consultant. The tonal penalty for each bin is the arithmetic mean of the separate 10-minute tonal audibility levels in the bin converted to a penalty in accordance with Fig 17 on page 104of ETSU-R-97. The AM penalty for each bin is the arithmetic mean of the AM penalties in the bin. The assessment level in each bin is normally the arithmetic sum of the bin LA90, the bin tonal penalty and the bin AM penalty except where the AM penalty and the tonal penalty relate to the

same characteristic (e.g. amplitude modulated tones) when the sum of both penalties may overly penalise the characteristics of the noise. Such cases should be identified and only the larger of the AM or tonal penalty should be applied.

B) If the assessment level in every bin lies at or below the values set out in the table(s) attached to the conditions. then no further action is necessary. In the event that the assessment level is above the limit(s)set out in the tables attached to the noise conditions in any bin, the independent consultant shall undertake a further assessment of the rating level to correct for background noise so that the rating level relates to wind turbine noise emission only. Correction for background noise need only be undertaken for those wind speed bins where the assessment level is above the limit.

C) The wind farm operator shall ensure that all the wind turbines in the development are turned off for such periods as the independent consultant requires to undertake the further assessment. The further assessment shall be undertaken in accordance with the following steps:-

i. Repeating the steps in Note 1, with the wind farm switched off, and determining the background noise (L3) in each bin as required in the protocol. At the discretion of the consultant and provided there is no reason to believe background noise would vary with wind direction, background noise in bins where there is insufficient data can be assumed to be the same as that in other bins at the same wind speed.

ii. The wind farm noise (L1) in each bin shall then be calculated as follows where L2 is the measured level with turbines running butwithout the addition of any tonal nor AM penalty:

$$L_1 = 10\log\left[10^{L_2/10} - 10^{L_3/10}\right]$$

iii. The rating level shall be calculated by adding the tonal and AM penalties to the derived wind farm noise L1 in that bin.

iv. If the rating level after adjustment for background noise contribution and adjustment for tonal and AM penalties in every bin lies at or below the values set out in the Tables attached to the condition at all wind speeds then no further action is necessary. If the rating level at any integer wind speed exceeds the values set out in the Table(s) attached to the condition then the development fails to comply with the planning condition in the circumstances represented by that bin.

Reference Number: 130 : Institute of Acoustics Statement in Respect of Wind Farm Noise Assessment. December 2024

The Institute of Acoustics (IOA) is the UK's professional body for those working in acoustics, noise and vibration. It engages widely with other professional bodies in related fields, and members are active in UK, European and International Standards development. Members also work in many sectors including consultancy, research and development, local and central UK Government, as well as for developers of, and objectors to, wind turbines, where they get involved with wind farm noise assessments.

ETSU-R-97

Published in 1996, ETSU-R-97 'The Assessment and Rating of Noise from Wind Farms' contains a methodology for generating noise limits for a wind turbine, and wind farms, and is currently referenced by the UK Government as a guidance document. The UK Government has endorsed ETSUR- 97 in various policy documents / statements since its publication, and it is the UK Government (that is responsible for planning policy) who decide the noise limits in ETSU-R-97. IOA Good Practice Guide

At the invitation of the Department for Energy and Climate Change (DECC), the IOA agreed to produce a Good Practice Guide (GPG) to the application of ETSU-R-97, considering the technical elements only. The GPG was published in 2013, with additional supplementary guidance notes published in 2014. This remains current guidance endorsed for use until such time as an updated version is published.

Response: The Irish High Court decision supercedes this document.

Amplitude Modulation

'Amplitude Modulation' (AM) is a feature of the character of wind farm noise caused by the cyclical nature of the blades. An understanding of the causal mechanisms has been gained in recent years, along with control methods to help assist with sites where AM can lead to complaints. An IOA endorsed metric was published in 2016 and can be found at: [http://ioa.org.uk/publications/windturbine- noise]. A sample planning condition was proposed by IOA members which was published in the IOA bulletin (November-December 2017 issue).

Infrasound
The IOA is aware that there is some information presented at planning inquiries suggesting the potential for physiological health effects from infrasound from wind turbines. **It is current advice to members that there is no need to assess infrasound as part of the noise impact assessment process**, as the absolute levels are well below those reported to trigger physiological health effects based on peer reviewed research to date.
Low Frequency Noise
The IOA is aware that there is some information presented at planning inquiries suggesting the potential for physiological health effects from low frequency noise from wind turbines. **It is current advice to members that there is no need to assess low frequency noise as part of the noise impact assessment process**, as the absolute levels, whilst potentially audible at typical receptor distances, are well below those reported to trigger physiological health effects based on peer reviewed research to date.

Vibration
Vibration from operational wind turbines has been measured by extremely sensitive measurement equipment such as seismic arrays. But in terms of human perception, measured vibration levels are well below perception thresholds even on the actual wind turbine sites. **There is, therefore, no need to assess vibration affecting people for operational wind turbine developments.**

Summary
The IOA has a responsibility to provide guidance on technical matters within its sphere of activity. The GPG and the IOA metric are endorsed by IOA Council to give advice to members on how to apply ETSUR- 97. It will continue to advance the understanding of AM through its renewable energy advisory group and update its advice when new evidence emerges.

The article includes the comment **"to do nothing would be unfair on those wind farm neighbours adversely affected by AM and, in any case, there seems to be general agreement amongst many stakeholders on all sides of the debate that a robust condition including AM is required."**

I thought it interesting because the blog was quoting the IOA's Good Practice Guide is dated May 2013 !!

https://www.tneigroup.com/news_event/2024-tnei-wind-farm-judicial-review-case-overview-wind-turbine-noise/

"The Judge also decided that AM was sufficiently considered, following contributions by TNEI's Jim Singleton (originally the Applicant contended that a planning condition to control AM should be imposed, but Jim noted that imposing an AM planning condition is at odds with the advice stated in the Institute of Acoustics (IOA) 'A Good Practice Guide to the Application of ETSU R 97 for the Assessment and Rating of Wind Turbine Noise'). It was noted that, currently, whilst there is a method to measure and quantify AM, further work is required to develop a robust mechanism for controlling AM that could be incorporated into a planning condition."

Below is evidence from an environmental health officer in Scotland which mentions the IOAs planning condition. I believe Dick Bowdler's testimony said that particular condition doesn't work very well. If he did, he'd be right, I've been told it's very clear to see the flaws in the code.

But the point is... the IOA working group said... it would be unfair not to impose a planning condition.

To be honest, I've spent my time looking at noise predictions etc I don't know enough about planning conditions but if I was looking for best practice, New South Wales guidance is the first place I'd look. And New Zealand, they looked at ETSU R 97, way back when and decided not to use it.

Reference Number 131 : ENVIRO ACOUSTIC RESEARCH *ENIA – Koup 1 Wind Energy Facility*

Effect of Wind

Wind alters sound propagation by the mechanism of refraction, that is, wind bends sound waves. Wind nearer to the ground moves more slowly than wind at higher altitudes, due to surface characteristics such as hills, trees, and man-made structures that interfere with the wind. This wind gradient, with faster wind at higher elevation and slower wind at lower elevation, causes sound waves to bend downward when they are traveling to a location downwind of the source and to bend upward when traveling toward a location upwind of the source. Waves bending downward means that a listener standing downwind of the source will hear louder noise levels than the listener standing upwind of the source. This phenomenon can significantly impact sound propagation over long distances and when wind speeds are high. Over short distances wind direction has a small impact on sound propagation as long as wind velocities are reasonably slow, i.e., less than 5 m/s.

Wind speed frequently plays a role in increasing sound levels in natural locations. With no wind, there is little vegetation movement that could generate noises and faunal noises (normally birds and insects) dominate, however, as wind speeds increase, the rustling of leaves increases which subsequently can increase sound levels. This directly depends on the type of vegetation in a certain area. The impact of increased wind speed on sound levels depends on the vegetation type (deciduous versus conifers), the density of vegetation in an area, seasonal changes (in winter deciduous trees are bare) as well as the height of this vegetation. This excludes unanticipated consequences, as suitable vegetation may create suitable habitats and food sources attracting birds and insects (and the subsequent increase in faunal communication).
Generally, noises from wind turbines:

- could be significant within 500 m, with receptors3 staying within 500 m from operational WTG subject to noises at a potentially sufficient level to be considered disturbing.

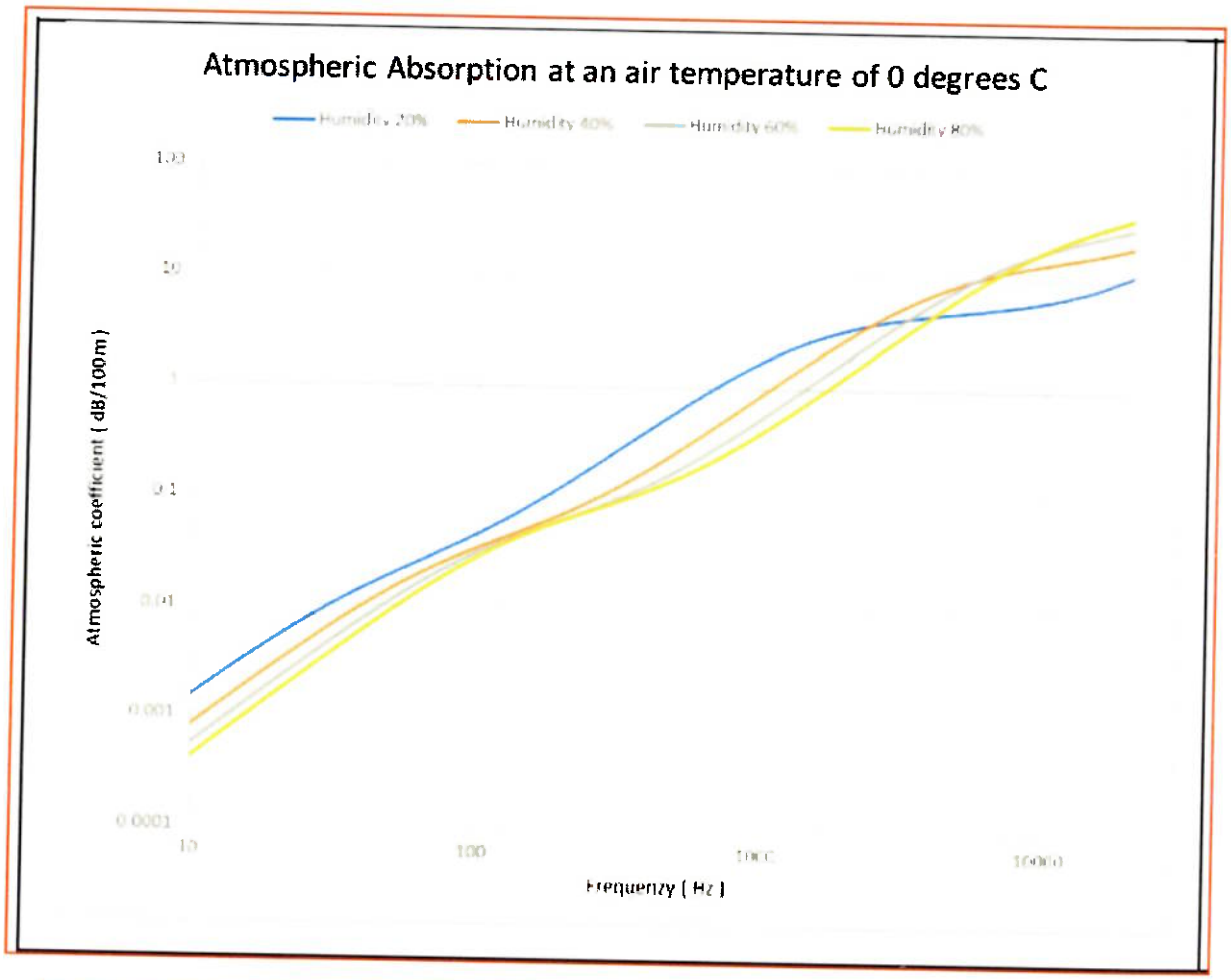
- **are normally limited to a distance of approximately 1,000m from operational wind turbines** (subject to WTG layout, as the WTG cumulatively contribute to noise levels with 2,000m from WTG). Night-time ambient sound levels could be elevated and the potential noise impact measurable; and

- likely to be audible up to a distance of 2,000m at night. Noises from the WTG are of a low concern at distances greater than 2,000m, although the sound of the WTGs may be audible at greater distances during certain metrological phenomena (sound levels are generally very low at distances greater than 2,000m).

- **Effect of Humidity and Temperature**

- Generally, sound propagate better at lower temperatures (down to 10^0 C), and with everything being equal, a decrease in temperature from 32^0 C to 10^0 C could increase the sound level at a listener 600 m away by **±2.5 Db** (at 1,000 Hz).

- The effect of humidity on sound propagation is quite complex, but effectively relates to how increased humidity changes the density of air. Lower density translates into faster sound wave travel, so sound waves travel faster at high humidity. With everything being equal, an increase in humidity from 20% to 80% would increase the sound level at a listener 600 m away by **±4 Db** (at 1,000 Hz at 20^0 C).
- Together, the impact of temperature and humidity (together with air pressure – to a minor extent) are complex and highly dependent on the frequency composition of the noise.


Atmospheric Absorption at an air temperature of 0 degrees C
Humidity 20%
Humidity 40%
Humidity 60%
Humidity 80%
Atmospheric coefficient (dB/100m)
Frequenzy (Hz)

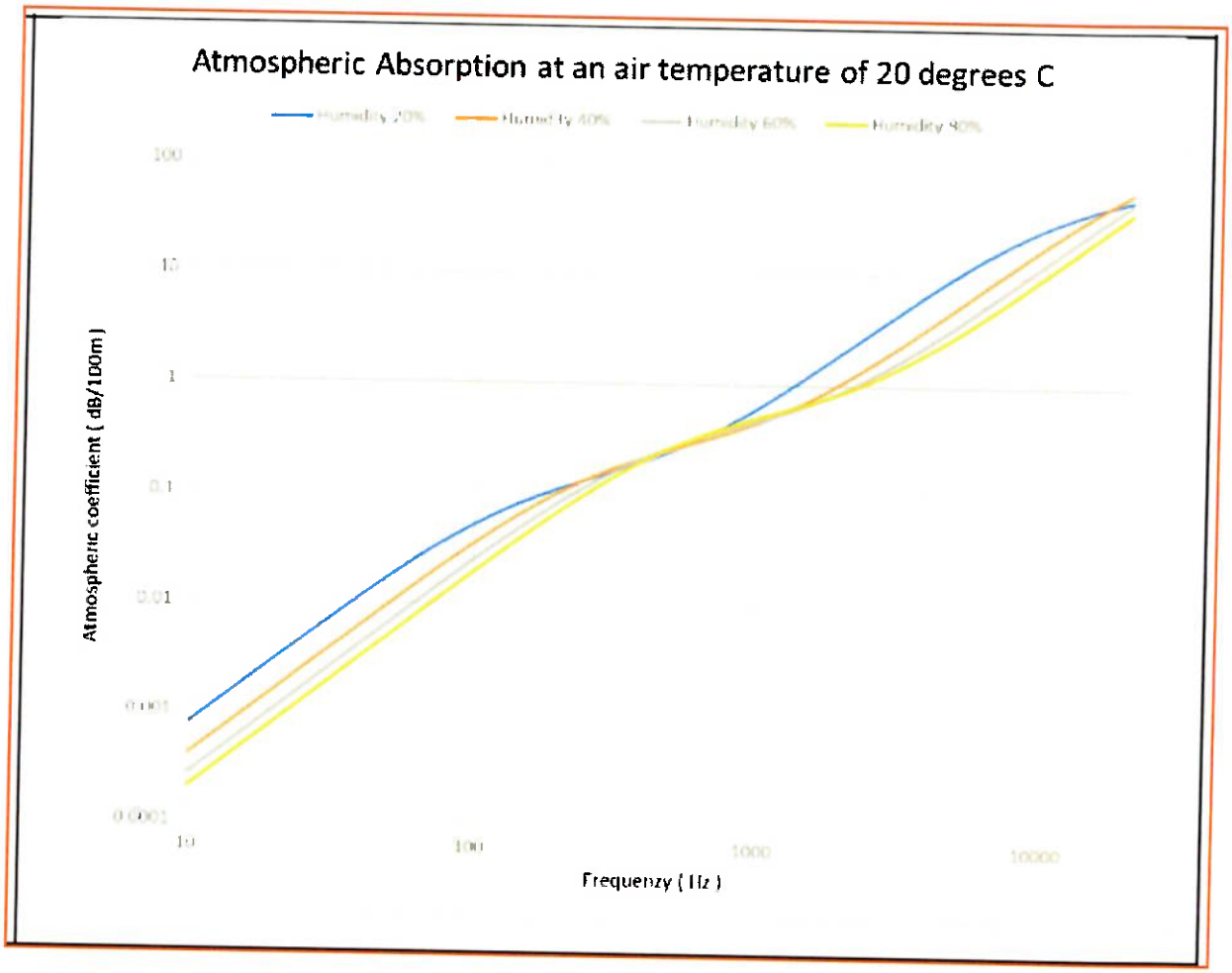

Atmospheric Absorption at an air temperature of 20 degrees C
Humidity 20%
Humidity 40%
Humidity 60%
Humidity 80%
Atmospheric coefficient (dB/100m)
Frequenzy (Hz)

Figure: Effect of Temperature and Humidity on propagation of Sound

Equipment Description[21]	Impact Device?	Maximum Sound Power Levels (dBA)	Operational Noise Level at given distance considering potential maximum noise levels (Cumulative as well as the mitigatory effect of potential barriers or other mitigation not included – simple noise propagation modeling only considering distance) (dBA)											
			5 m	10 m	20 m	50 m	100 m	150 m	200 m	300 m	500 m	750 m	1000 m	2000 m
Backhoe	No	114.7	89.7	83.7	77.6	69.7	63.7	60.1	57.6	54.1	49.7	46.2	43.7	37.6
Compactor (ground)	No	114.7	89.7	83.7	77.6	69.7	63.7	60.1	57.6	54.1	49.7	46.2	43.7	37.6
Compressor (air)	No	114.7	89.7	83.7	77.6	69.7	63.7	60.1	57.6	54.1	49.7	46.2	43.7	37.6
Concrete Batch Plant	No	117.7	92.7	86.7	80.6	72.7	66.7	63.1	60.6	57.1	52.7	49.2	46.7	40.6
Concrete Mixer Truck	No	119.7	94.7	88.7	82.6	74.7	68.7	65.1	62.6	59.1	54.7	51.2	48.7	42.6
Concrete Pump Truck	No	116.7	91.7	85.7	79.6	71.7	65.7	62.1	59.6	56.1	51.7	48.2	45.7	39.6
Crane	No	119.7	94.7	88.7	82.6	74.7	68.7	65.1	62.6	59.1	54.7	51.2	48.7	42.6
Drill Rig Truck	No	118.7	93.7	87.7	81.6	73.7	67.7	64.1	61.6	58.1	53.7	50.2	47.7	41.6
Drum Mixer	No	114.7	89.7	83.7	77.6	69.7	63.7	60.1	57.6	54.1	49.7	46.2	43.7	37.6
Dump Truck	No	118.7	93.7	87.7	81.6	73.7	67.7	64.1	61.6	58.1	53.7	50.2	47.7	41.6
Excavator	No	119.7	94.7	88.7	82.6	74.7	68.7	65.1	62.6	59.1	54.7	51.2	48.7	42.6
Flat Bed Truck	No	118.7	93.7	87.7	81.6	73.7	67.7	64.1	61.6	58.1	53.7	50.2	47.7	41.6
Front End Loader	No	114.7	89.7	83.7	77.6	69.7	63.7	60.1	57.6	54.1	49.7	46.2	43.7	37.6
Generator	No	116.7	91.7	85.7	79.6	71.7	65.7	62.1	59.6	56.1	51.7	48.2	45.7	39.6
Generator (<25KVA)	No	104.7	79.7	73.7	67.6	59.7	53.7	50.1	47.6	44.1	39.7	36.2	33.7	27.6
Grader	No	119.7	94.7	88.7	82.6	74.7	68.7	65.1	62.6	59.1	54.7	51.2	48.7	42.6
Impact Pile Driver	Yes	129.7	104.7	98.7	92.6	84.7	78.7	75.1	72.6	69.1	64.7	61.2	58.7	52.6
Jackhammer	Yes	119.7	94.7	88.7	82.6	74.7	68.7	65.1	62.6	59.1	54.7	51.2	48.7	42.6
Man Lift	No	119.7	94.7	88.7	82.6	74.7	68.7	65.1	62.6	59.1	54.7	51.2	48.7	42.6
Mounted Impact Hammer	Yes	124.7	99.7	93.7	87.6	79.7	73.7	70.1	67.6	64.1	59.7	56.2	53.7	47.6
Pickup Truck	No	89.7	64.7	58.7	52.6	44.7	38.7	35.1	32.6	29.1	24.7	21.2	18.7	12.6
Pumps	No	111.7	86.7	80.7	74.6	66.7	60.7	57.1	54.6	51.1	46.7	43.2	40.7	34.6
Vibratory Concrete Mixer	No	114.7	89.7	83.7	77.6	69.7	63.7	60.1	57.6	54.1	49.7	46.2	43.7	37.6
Vibratory Pile Driver	No	129.7	104.7	98.7	92.6	84.7	78.7	75.1	72.6	69.1	64.7	61.2	58.7	52.6

Equipment Description	Equivalent (average) Sound Levels (dBA)	Operational Noise Level at given distance considering equivalent (average) sound power emission levels (Cumulative as well as the mitigatory effect of potential barriers or other mitigation not included – simple noise propagation modelling only considering distance) (dBA)											
		5 m	10 m	20 m	50 m	100 m	150 m	200 m	300 m	500 m	750 m	1000 m	2000 m
Air compressor	92.6	67.6	61.6	55.6	47.6	41.5	38.0	35.4	31.9	27.3	25.6	20.9	14.2
Bulldozer CAT D10	111.9	86.9	80.9	74.9	66.9	60.8	57.3	54.7	51.2	46.6	42.9	40.2	33.5
Cement truck (with cement)	111.7	86.7	80.7	74.7	66.7	60.6	57.1	54.5	51.0	46.4	42.7	40.0	33.3
Crane	107.5	82.5	76.5	70.5	62.5	56.4	52.9	50.3	46.8	42.2	38.5	35.8	29.1
Diesel Generator (Large - mobile)	106.1	81.1	75.1	69.1	61.1	55.0	51.5	48.9	45.4	40.8	37.1	34.4	27.7
Dumper/Haul truck - Terex 30 ton	112.2	87.2	81.2	75.2	67.2	61.1	57.6	55.0	51.5	46.9	43.2	40.5	33.8
Excavator - Hitachi EX1200	113.1	88.1	82.1	76.1	68.1	62.0	58.5	55.9	52.4	47.8	44.1	41.4	34.7
FEL (988) (FM)	115.6	90.6	84.6	78.6	70.6	64.5	61.0	58.4	54.9	50.3	46.6	43.9	37.2
General noise	108.8	83.8	77.8	71.8	63.8	57.7	54.2	51.6	48.1	43.5	39.8	37.1	30.4
Grader - Operational Hitachi	108.9	83.9	77.9	71.9	63.9	57.8	54.3	51.7	48.2	43.6	39.9	37.2	30.5
Road Truck average	109.6	84.6	78.6	72.6	64.6	58.5	55.0	52.4	48.9	44.3	40.6	37.9	31.2
Rock Breaker, CAT	120.7	95.7	89.7	83.7	75.7	69.6	66.1	63.5	60.0	55.4	51.7	49.0	42.3
Vibrating roller	106.3	81.3	75.3	69.3	61.3	55.2	51.7	49.1	45.6	41.0	37.3	34.6	27.9
Substation (one transformer)	85.2	60.2	54.2	48.2	40.2	34.1	30.6	28.0	24.5	19.9	16.2	13.5	6.8
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Wind Turbine: Acciona AW125/3000	108.5	83.5	77.5	71.5	63.5	57.4	53.9	51.3	47.8	43.2	39.5	36.8	30.1
Wind Turbine: Goldwind GW165 6.0	112.6	87.6	81.6	75.6	67.6	61.5	58.0	55.4	51.9	47.3	43.6	40.9	34.2
Wind Turbine: Goldwind GW182 7.2	112.2	87.2	81.2	75.2	67.2	61.1	57.6	55.0	51.5	46.9	43.2	40.5	33.8
Wind Turbine: Nordex N163 / 5.X	109.2	84.2	78.2	72.2	64.2	58.1	54.6	52.0	48.5	43.9	40.2	37.5	30.8
Wind Turbine: Vesta V66, ave	110.4	85.4	79.4	73.4	65.4	59.3	55.8	53.2	49.7	45.1	41.4	38.7	32.0
Wind Turbine: Vestas V162-7.2MW	107.1	82.1	76.1	70.1	62.1	56.0	52.5	49.9	46.4	41.8	38.1	35.4	28.7

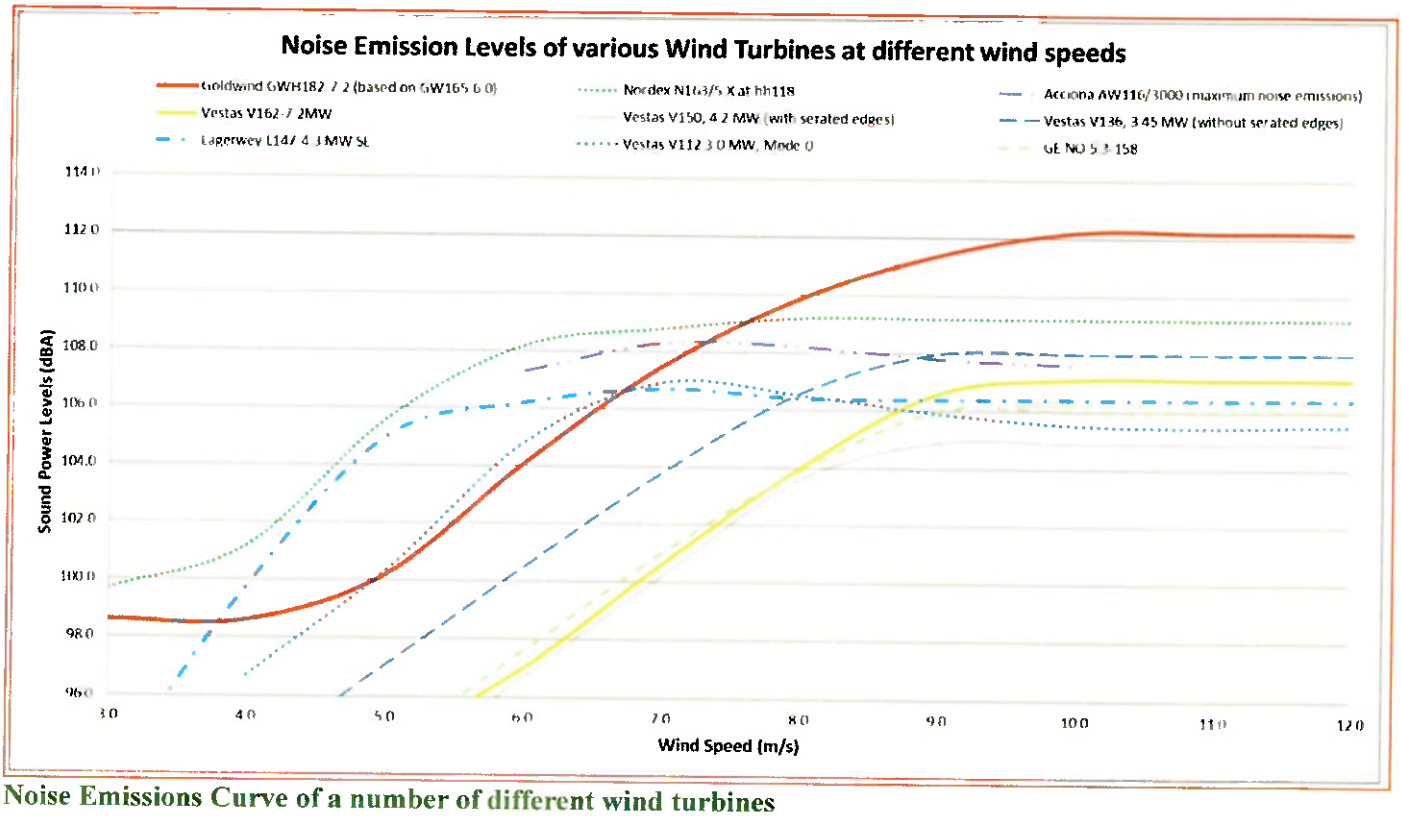
Potential equivalent noise levels generated by various equipment. Without proof from the Noise Model, it is assumed that a radius of 750m & 40.2dBa was used for various maps. These numbers are wind tunnel calculations for singular wind turbines & do not reflect the cumulative noise at a windfarm for turbulence from wake effects.

Wind Turbine Noise: Aerodynamic sources

Aerodynamic noise is emitted by a wind turbine blade through a number of sources such as:
1. Self-noise due to the interaction of the turbulent boundary layer with the blade trailing edge.
2. Noise due to inflow turbulence (turbulence in the wind interacting with the blades).
3. Discrete frequency noise due to trailing edge thickness.

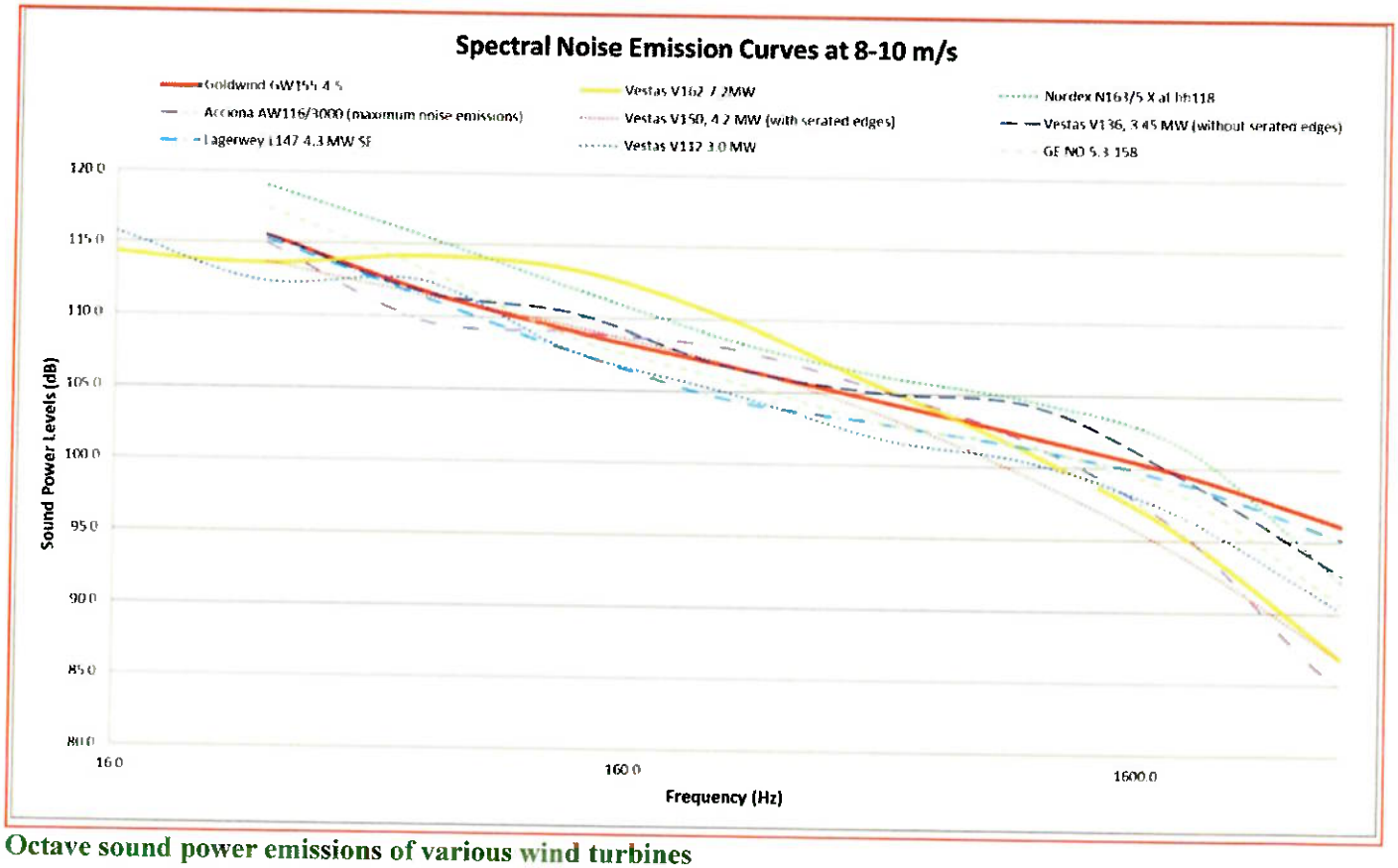
4. Discrete frequency noise due to laminar boundary layer instabilities (unstable flow close to the surface of the blade).
5. Noise generated by the rotor tips.

Therefore, as the wind speed increases, noises created by the wind turbine also increase. At a low wind speed the noise created by the wind turbine is generally (relatively) low except at start up, and increases to a maximum at a certain wind speed when it either remains constant, increase very slightly or even drops.



Noise Emissions Curve of a number of different wind turbines

The propagation model also makes use of various frequencies, because these frequencies are affected in different ways as it propagates through air, over barriers and over different ground conditions providing a higher accuracy than models that only use the total sound power level.



Octave sound power emissions of various wind turbines

Noise from Mechanical sources

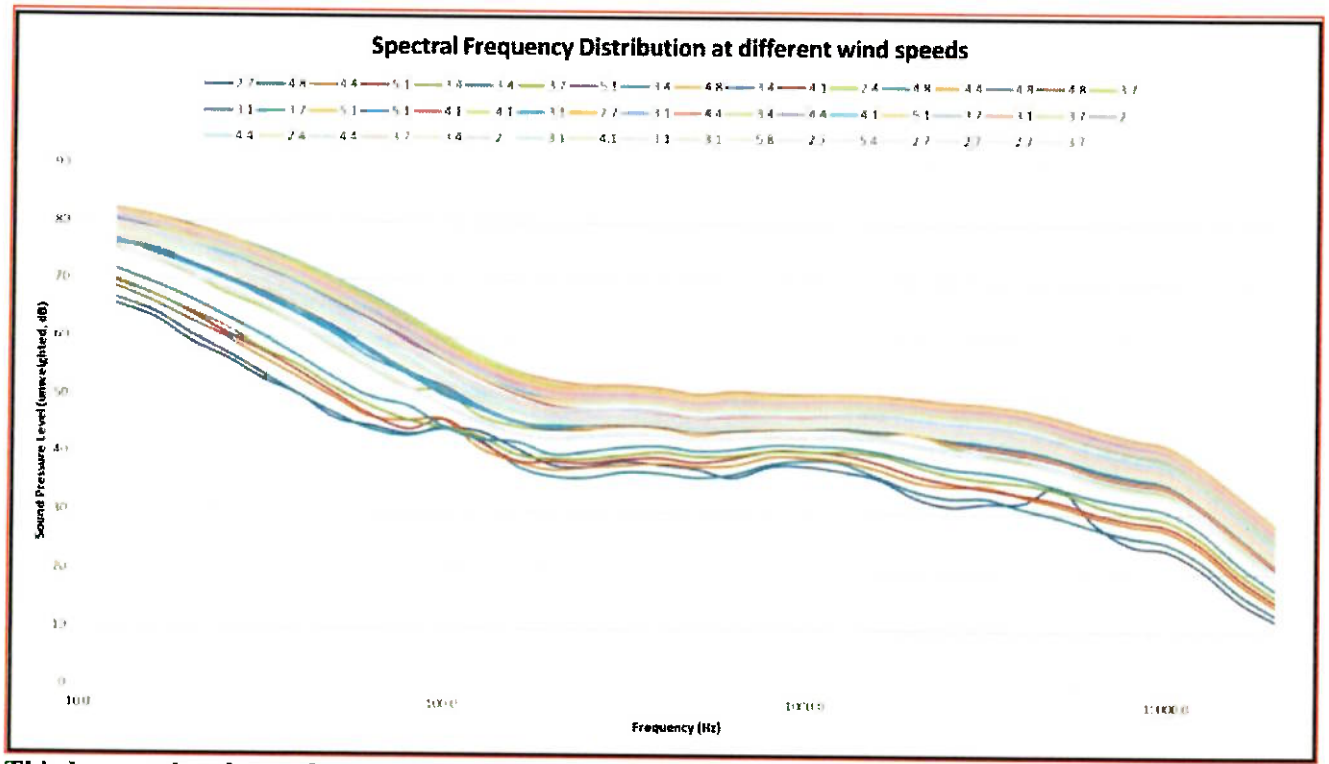
Mechanical noise is normally perceived within the emitted noise from wind turbines as an audible tone(s) which is subjectively more intrusive than a broad band noise of the same sound pressure level. Sources for this noise are normally associated with:

- the gearbox and the tooth mesh frequencies of the step-up stages;
- generator noise caused by coil flexure of the generator windings which is associated with power regulation and control;
- generator noise caused by cooling fans; and
- control equipment noise caused by hydraulic compressors for pitch regulation and yaw control.

Tones are noises with a narrow sound frequency composition (e.g., the whine of an electrical motor). Annoying tones can be created in numerous ways: machinery with rotating parts such as motors, gearboxes, fans and pumps often create tones. An imbalance or repeated impacts may cause vibration that, when transmitted through surfaces into the air, can be heard as tones. Pulsating flows of liquids or gases can also create tones, which may be caused by combustion processes or flow restrictions. The best and most well-known example of a tonal noise is the buzz created by a flying mosquito.

Noise from Low Frequency Noise

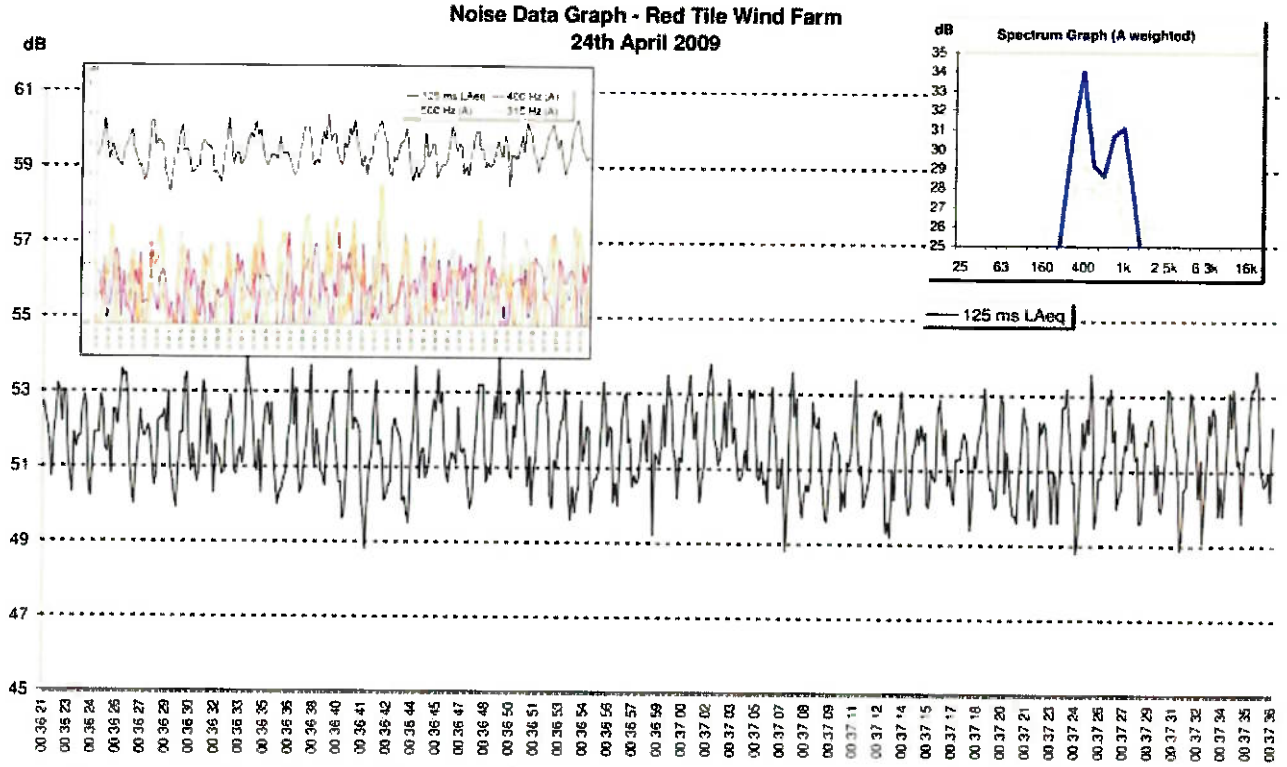
Low frequency sound is the term used to describe sound energy in the region below ~200 Hz. The rumble of thunder and the throb of a diesel engine are both examples of sounds with most of their energy in this low frequency range. Infrasound is often used to describe sound energy in the region below 20 Hz.



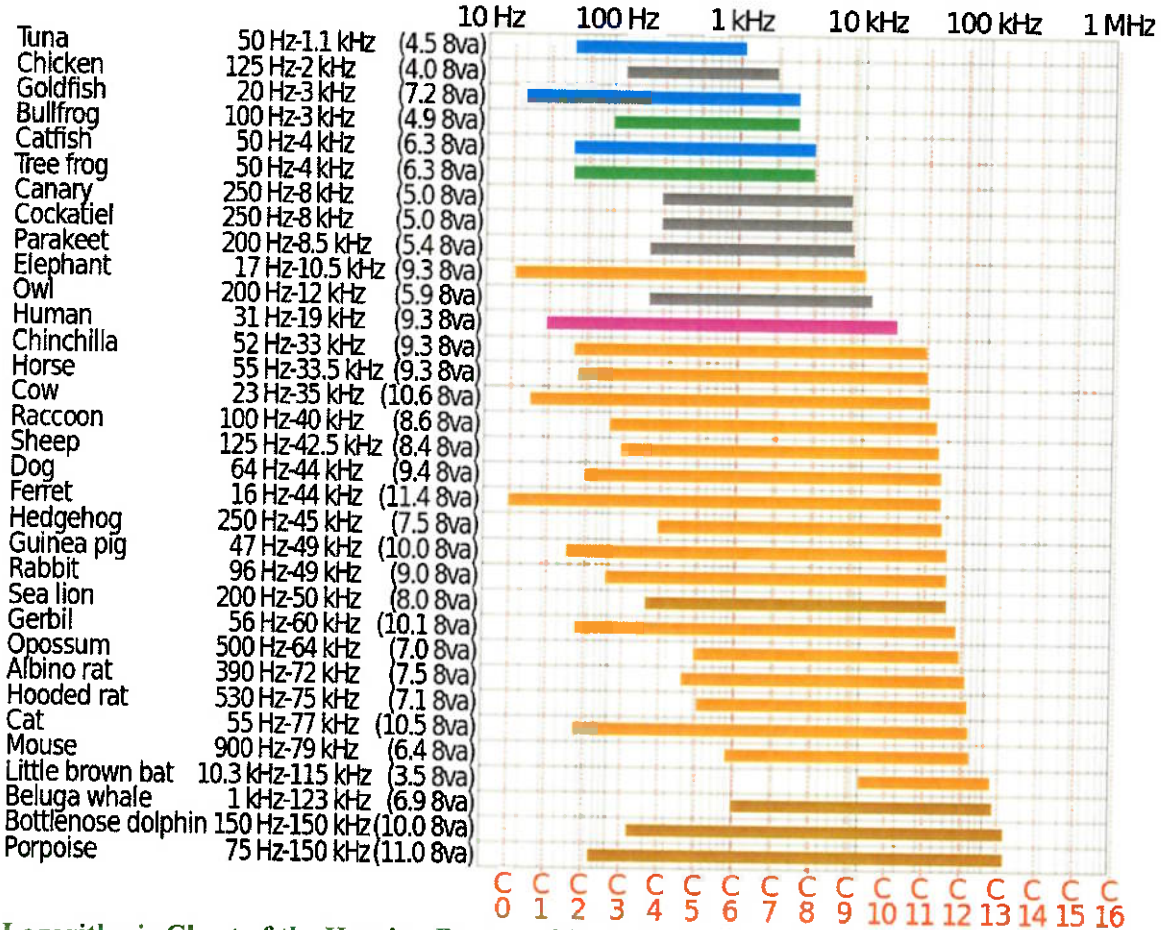
Third octave band sound power levels at various wind speeds at a location where wind induced noises dominate

Noise from Amplitude modulation

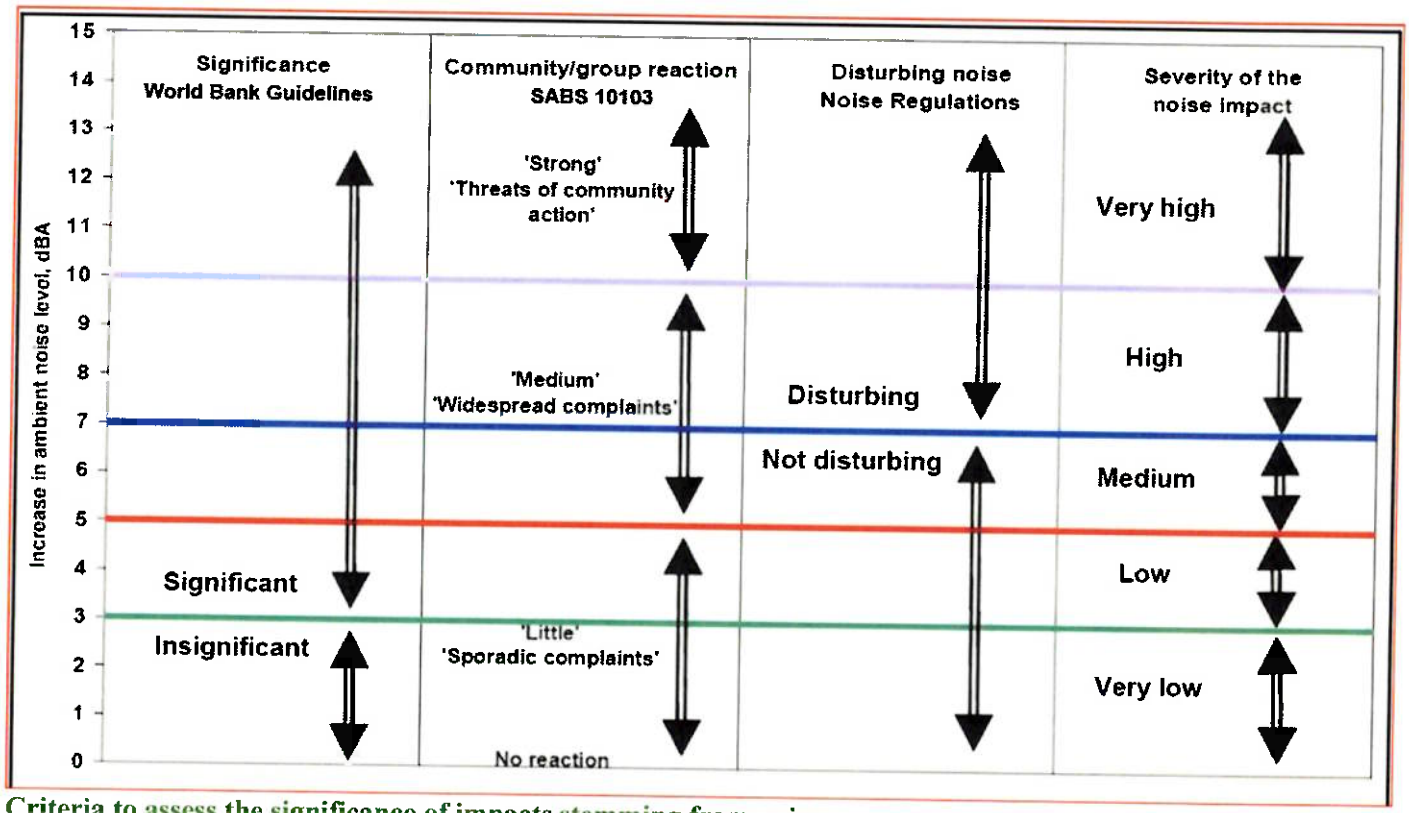
The amplitude modulation (AM) of the sound emissions from the wind turbines creates a repetitive rise and fall in sound levels synchronized to the blade rotational speed, sometimes referred to as a "swish" or "thump".



Example time-sound series graph illustrating AM as measured by Stigwood (2013)



Logarithmic Chart of the Hearing Ranges of Some Animals



Criteria to assess the significance of impacts stemming from noise

1	2	3	4	5	6	7
Type of district	Equivalent continuous rating level ($L_{Req,T}$) for noise dBA					
	Outdoors			Indoors, with open windows		
	Day/night $L_{R,dn}$ [a]	Daytime $L_{Req,d}$ [b]	Night-time $L_{Req,n}$ [b]	Day/night $L_{R,dn}$ [a]	Daytime $L_{Req,d}$ [b]	Night-time $L_{Req,n}$ [b]
a) Rural districts	45	45	35	35	35	25
b) Suburban districts with little road traffic	50	50	40	40	40	30
c) Urban districts	55	55	45	45	45	35
d) Urban districts with one or more of the following: workshops; business premises; and main roads	60	60	50	50	50	40
e) Central business districts	65	65	55	55	55	45
f) Industrial districts	70	70	60	60	60	50

Acceptable Zone Sound Levels for noise in districts (SANS 10103:2008)

Reference Number 132 : Laboratory Validation of 3D Model and Investigating Its Application to Wind Turbine Noise Propagation over Rough Ground James Naylor and Qin Qin. Wind 2024, 4, 363–375. https://doi.org/10.3390/wind4040018 https://www.mdpi.com/journal/wind

In an investigation into how wind turbine noise interacts with the surrounding terrain, its propagation over rough ground is simulated using a parabolic equation code using a modified effective impedance model, which characterizes the effects of a three-dimensional, rigid roughness within a relatively long wavelength limit ($ka \leq 1$). The model is validated by comparison to experiments conducted within an anechoic chamber wherein different source–receiver geometries are considered. The relative sound pressure level spectra from the parabolic equation code using the modified effective impedance model highlight a sensitivity to the roughness parameters. At a low frequency and far distance, the relative sound pressure level decreased as the roughness coverage increased. A difference of 4.9 Db has been reported. The simulations highlight how the roughness shifts the ground effect dips, resulting in the sound level at the distance of 2 km being altered. However, only the monochromatic wave has been discussed. Further work on broadband noise is desirable. Furthermore, due to the long wavelength limit, only a portion of audible wind turbine noise can be investigated.

Large wind turbines are quite serious sources of noise, making the acoustic impact one of the major hindrances to the public's acceptance of the technology. Conclusions from a government-commissioned analysis of the current guidance for wind turbine noise control in the UK indicate that the current framework is outdated in light of the large volume of new research and technologies spanning decades after the initial publishing of the document.

Reviews on the effects of wind turbine noise indicate that, at a minimum, wind turbine noise is a cause for annoyance, and despite the levels being modest compared to other sources like traffic noise, the wind turbine noise seems more annoying.

This paper focuses on the reflections and scattering of the noise from the rough terrain that often surrounds wind turbines. It is well understood that roughness can have a significant effect on the propagation of sound, such that considering its effect in the context of wind turbine noise is worthwhile. It is valuable to understand how this noise propagates through the environment toward the homes of those living near wind turbines.

Reference Number 133 : Characterization of wind turbine noise using psychoacoustical indicators Manish Manohare, Eoin King, Eugene MC Keown. Proceedings of INTER-NOISE 2024

Wind energy is widely recognized as a promising source of renewable energy. However, the noise generated by wind turbines poses a significant concern for residents living in close proximity to these installations. The rotor blades of wind turbines emit noise levels ranging from 98 to 104 Db(A) at an average wind speed of 8m/s, translating to 33-40 Db(A) at a distance of 500 meters from dwellings. While these noise levels might not be considered problematic in comparison to road traffic or industrial noise, the distinctive swishing sound produced by wind turbines can be perceived as highly annoying by nearby residents due to its rhythmic modulation, primarily driven by the rotor blades.

Extensive research has been conducted on the perception of wind turbine noise (WTN), with a focus on assessing the levels of annoyance and associated stress. Studies indicate that exposure to WTN levels exceeding 35 Db(A) can lead to increased annoyance and disturbances in sleep patterns. Consequently, regulations and standards have been established to guide acceptable levels of WTN, with parameters such as LA90 and Laeq (equivalent continuous noise level) being a primary consideration. These standards typically account for factors such as wind speed, noise-sensitive areas, and background noise levels. For example, in Denmark, maximum allowable WTN levels range from 42-44 Db in general and 37-39 Db in noise sensitive areas with an average wind speed of 8 m/s].

SEISMIC ISSUES & VIBRATION

Reference number 134 : SEISMIC ANALYSIS OF WIND TURBINE WITH SOIL STRUCTURE INTERACTION: CRITICAL REVIEW. Saher El-Khoriby, Marwan Shahen, Tamer M. El Koran3, Faten El-Fekky., *International Conference on Advances in Structural and Geotechnical Engineering* ICASGE'21 15-18 March 2021, Hurghada, Egypt

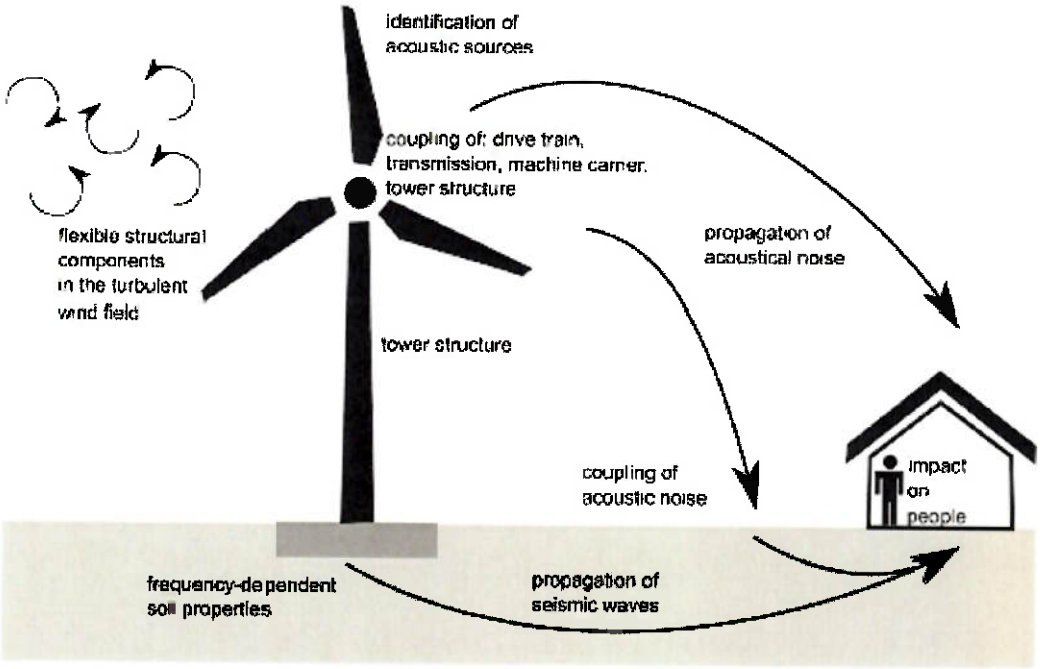
Long-term versus short-term conditions (onshore wind turbines case)

An important aspect of the FE model was the modelling of groundwater and drainage conditions of the soil. In this regard, it must be acknowledged that because one of the mechanisms for cyclic degradation is the accumulation of excess pore water pressure with increasing number of loading cycles, it is primarily associated with fully saturated soil conditions. It must further be recognized that in terms of soil behaviour, cyclic loading can be categorized into short-term or long-term loading.

Long-term conditions	***short-term conditions***
During long-term cyclic loading, the pore pressure generated by cyclic loading dissipates and drained soil behaviour may be assumed.	*short-term cyclic loading leads to undissipated pore pressures which result in:* *decrease the effective stresses in the soil* *stiffness degradation*

Reference number 135 : Ground motions induced by wind turbines Sven Nagel, Toni Zieger, Birger Luhmann, Peter Knödel, Joachim Ritter, Thomas Ummenhofer. Civil Engineering Design. 2021;3:73–86. wileyonlinelibrary.com/journal/cend

Wind flow transfers forces to the wind turbine's rotor blades. These then set the rotor in motion. The hub and the gearbox, where present, transfer this rotational energy to the generator for conversion into electrical power. All the rotating components have significant mass and are located at the head of a slender, elastic load-bearing tower in which they induce dynamic effects. The resulting vibrations, generated at the upper end of the tower, are modified by the dynamic properties of the tower structure and pass through the foundations into the ground. Broadband seismometers record these ground vibrations not only directly adjacent to the wind turbine but also at greater distances of (up to) several kilometres from the turbine. We are aware that local residents and opponents of wind power consider that these vibration phenomena bear potential negative health effects. In the context of this paper, seismic vibrations were measured at the foundation of a 2 MW reference turbine. These seismic signals were compared to numerical simulations. Based on this, we explain the physical background. In the past, any ground vibrations measured have usually been attributed exclusively to the excitation frequencies from the rotor. However, the investigations presented here show that the structural properties of the tower structure significantly influence the type and intensity of the vibrations induced in the ground and dominate the ground motion amplitudes.



The issue of seismic vibration is not addressed in the application. During the last Ice Age, about 10,000 years ago, Ireland was covered by a 1km deep ice glacier. As this glacier melted, it left eskers & drumlins. The South Gort karstic flooding in 2009 resulted in the bringing to the surface of vast amounts of sand from buried conduits. A similar situation with deposited mud & sand exists for this site application in its present karstic underlying strata. These materials could be moved by vibration to block existing conduits serving groundwater drinking schemes. It could also be flushed out into Lough Corrib & create damage to existing Salmon & Trout. Additionally, the effect of the seismic vibration on fish species is unknown.

Reference Number 136 : Assessment of Brazilian onshore wind turbines foundations Andrei Nardellia , Marcos Massao Futaib , IBRACON Estrut. Mater., vol. 15, no. 5, e15508, 2022

Onshore wind turbine foundations are subjected to large overturning moments. The wind action imposes cyclic and dynamic loading conditions which occur in extreme and service scenarios. Deep foundations, when used, transfer this large overturning moment through a pile group which combines the axial and lateral resistance of all piles. The paper explored the key aspects of onshore wind turbine foundations in Brazil. The main reason to explore this subject is that several authors consider onshore wind turbine foundations a well-understood topic; however, limited data from actual situations have been published, especially in developing countries where wind energy projects have only recently started. Thus, a survey of Brazilian energy companies and foundation designers was conducted, and the first Brazilian database of wind turbine foundations was created. This database contains data from more than three thousand Brazilian wind turbine foundations. The key aspects, types and dimensions of these foundations were summarized. Worldwide, concrete gravity foundations are the most used foundation type for onshore wind turbines. In Brazil, 43.3% of wind turbines have shallow foundations, essentially concrete gravity, and 56.7% have deep foundations, mostly continuous flight auger piles. This first stage of the research identified that Brazilian wind turbine foundations are significantly different from the ones of other countries. Approximately 70% of Brazilian wind turbine deep foundations used continuous concrete flight auger piles, most of them embedded in sandy soils. Concrete and steel are the main materials used in wind turbine structures.

Wind farms consist of an ensemble of wind turbines. The main components of these wind turbines are the foundation, grid connection cables, tower, nacelle, generator, and rotor blades. Foundation is a crucial component which transfers permanent and variable loads from the structure to the ground throughout wind turbine's lifespan. As a result of structure height and slenderness, wind turbine foundations are subjected to large overturning moments due to the presence of considerable horizontal loads, primarily caused by wind . The wind imposes a cyclic and dynamic loading condition which occurs in extreme and service scenarios. The progressive increase in the turbine size, tower height, and rotor diameter, implied in significant increase in the overturning moment at the foundation, which can raise the tower and foundation costs . Although the foundations are a key component of a wind turbine, wind farm locations are mostly based on energy assessments and, as a result, it is common that the construction sites are geotechnical unfavourable . Horgan identified five influential foundation design variables, which include surface roughness, soil

type, construction materials, generating capacity and tower height. According to Hassanzadeh, the type and the size of a wind turbine foundation are chosen according to the geotechnical conditions of the site, rated power of the wind turbine, and the type of the tower.

Reference Number 137 : The impact of seismic noise produced by wind turbines on seismic borehole measurements Fabian Limberger, Georg Rümpker, Michael Lindenfeld, and Hagen Deckert. Solid Earth, 14, 859–869, 2023 https://doi.org/10.5194/se-14-859-2023

Seismic signals produced by wind turbines can have an adverse effect on seismological measurements up to distances of several kilometres.
Seismic signals of WTs are characterised by frequencies between 1 and 10 Hz and have been described in detail in a number of studies (e.g. Saccorotti et al., 2011; Stammler and Ceranna, 2016; Zieger and Ritter, 2018). The systematic decays of the corresponding signal amplitudes with distance from the WT or wind farms (WFs) have been analysed at various WFs (Neuffer and Kremers, 2017; Limberger et al., 2021; Gaßner and Ritter, 2023). Analytical and numerical approaches to modelling the amplitudes have been developed in terms of considering single WTs (Gortsas et al., 2017; Lerbs et al., 2020; Abreu et al., 2022) and complete WFs (Limberger et al., 2021, 2022), including wave field interferences from multiple WTs. On this basis, methods for predicting and reducing seismic noise from WTs or other noise sources are developed taking into account, for example, meta-materials (Colombi et al., 2016; Abreu et al., 2022), interferences and topographic effects (Limberger et al., 2021, 2022), and denoising methods (e.g. Heuel and Friederich, 2022). However, effective and robust solutions to compensate the seismic noise without losing the quality of the natural seismological signals are missing.

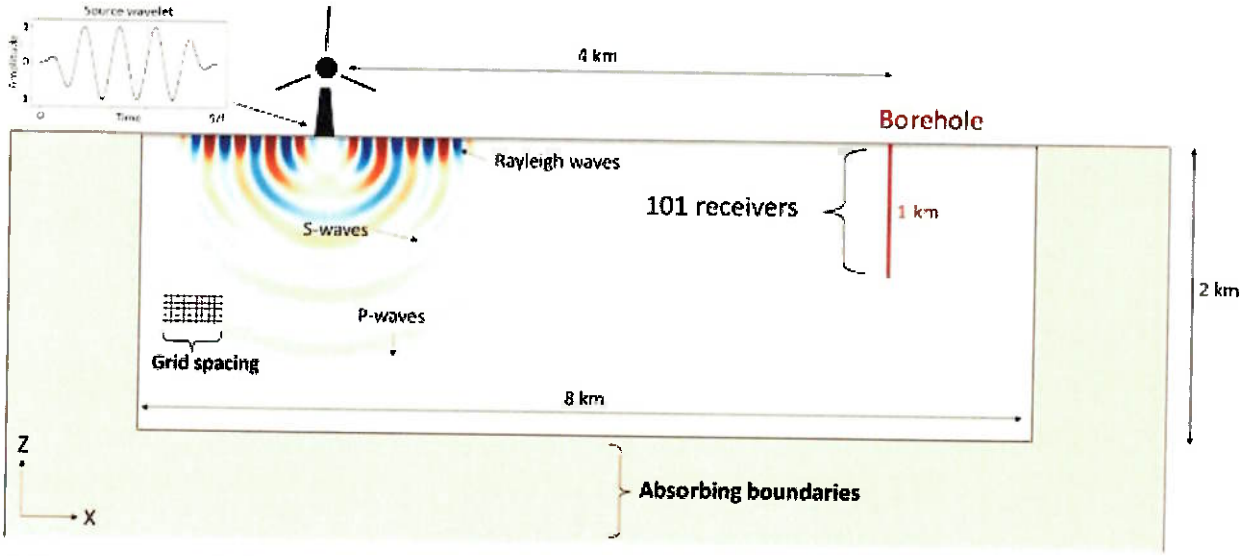


Figure 1. The numerical model includes a sinusoidal source wavelet, receivers located along a line from the surface to a depth of 1 km and a sufficient grid spacing (three elements per minimum wavelength of the simulation) as well as absorbing boundaries (2 times the maximum wavelength of the simulation). P waves, S waves and surface waves are simulated during the forward modelling. Synthetic seismograms are extracted at positions indicated by the red line (borehole).

Reference Number 138 : Structural vibration considerations for the design of onshore piled wind turbine foundations, N.R Featherston *,Mott Macdonald Limited 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 early wind towers were

only approximately 20 meters tall, which limited their power generation capabilities to approximately 75 kW and were constructed with a simple lattice-type or tubular steel design.
The next generation of wind farms will require turbines with 250m high towers and generation capacity exceeding 20MW. The global projected rate of increase in demand is 1.2 GWH to 2 GWH per year (Sassi, 2106). Figure 2 gives an indication of the expected growth capacity of wind turbine development with the diameter of the blades being indicated. 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.

There are several loads and unbalanced forces acting on the wind turbine tower which are ultimately transferred to the foundation and can be classified into two types: static (or dead load) due to the self-weight of the components and the dynamic loads (which in some instances can be cyclic).
These include the dead loads of the nacelle, the rotor's self-weight and tower's self-weight. Gravity forces on the blades generally cause sinusoidal loading due to their rotation. This kind of load is important for fatigue analysis since wind turbines are designed to produce electricity for a minimum of 20 years. Thus, a turbine with blades rotating at an average of 11.2 rpm will be subjected to 1.1773×10^8 stress cycles over its lifetime (Sassi, 2016). In the average life of a wind turbine tower it is therefore subjected to an order of magnitude higher number of loads than a bridge receiving daily traffic would.

Any machinery with a rotating component causes forces on its foundation. The amplitude of the centrifugal force F depends on the rotating mass m, the mass unbalance e and the angular frequency ω as follows:
$F = me\omega 2$
Foundations carrying machinery on soil with or without foundation piles can be analyzed as one or two mass-spring systems (van Koten, 2012). The harmonic loading by rotating machines can be accurately determined. Concise formulas are available for the stiffness, equivalent mass and damping calculations. The natural system frequencies and displacement amplitudes can be obtained by hand calculations, without the use of complex software. The amplitude can then be evaluated as acceptable or not.
Soil at the sides of foundations has been found to considerably increase the damping and strongly reduce the displacement amplitudes (van Koten, 2012). The vertical vibrations are well damped by the soil, but the horizontal vibrations can be disturbing even at a large distance from the foundation. The challenging part of the analysis is therefore the understanding of the dynamic loads acting on the wind turbine which are discussed below (Bhattacharya, 2014):

(a) The lateral load acting at the level of the hub (top of the tower) from the rotating blades produced by the turbulence in the wind. The magnitude of this dynamic component will depend on the turbulent wind speed.

(b) The load caused by the vibration at the hub level due to the mass and aerodynamic imbalances of the rotor. This load has a frequency equal to the rotational frequency of the rotor (referred to as 1P loading in the literature). This is the known as the Primary system excitation frequency. Since most industrial wind turbines are variable speed drive machines, 1P is therefore not a single frequency but rather a frequency band between the frequencies associated with the lowest and the highest rpm.

(c) Loads in the tower due to vibrations caused by blade shadowing effects (this is referred to as 2P/3P in the literature). The blades of the wind turbine passing in front of the tower itself cause a 'shadowing effect' and consequently inflict a loss of wind load on the tower. This is also a dynamic load having frequency equal to three times the rotational frequency of the turbine (3P) for three bladed wind turbines, and two times (2P) the turbine rotational frequency for a two bladed turbine. The 2P/3P loading is also a frequency band such as 1P and is simply obtained by multiplying the limits of the 1P band by the number of the turbine blades.

Due to their slender nature, it is no surprise that wind-turbines are dynamically sensitive at low frequencies, the first modal frequency of the system (often less than 1Hz) being very close to the excitation frequencies imposed by environmental and mechanical loads. As an example, the predominant frequencies of wind are about 0.1 Hz whilst the rotor frequencies are in the range from 0.15 – 0.5 Hz. Figure 6 shows the main frequencies for a three-bladed standard wind turbine. It is clear from the frequency content of the applied loads that the designer of the turbine and foundation

has to select a system frequency (the global frequency of the overall wind turbine foundation system) which lies outside the range of environmental frequencies in order to avoid system resonance.
From the point of view of the first natural frequency (fo) of the structure, three types of designs are possible (Bhattacharya, 2014):

(1) Soft-Soft design where fo is placed below the 1P frequency range which is a very flexible structure and almost impossible to design for a grounded system.

(2) Soft-Stiff design where fo is between 1P and 3P frequency ranges. This is generally the most commonly used design in the industry.

(3) Stiff-Stiff designs where fo has a higher natural frequency than the upper limit of the 3P band which would therefore require a very stiff support structure.

The usual choice for fixed wind turbines would lie in the interval between turbine and blade passing frequencies (referred to as a 'soft-stiff' structure). Other definitions of "soft-soft" and "stiff-stiff" can be found n Bhattacharya (2014).

Small scale 1-g tests reported by Bhattacharya et al (2011) and Cox et al (2011) showed that the natural frequency of a wind turbine system changes with its cycles of loading. The main reason for this change is due to the alteration of the foundation stiffness from strain-hardening or strain-softening behaviour of the soil supporting the foundation due to the loading cycles.
The main conclusions drawn from this study can be summarized as follows:

a) For strain-hardening sites (typically - loose to medium dense sand) where the stiffness of the soil increases with cycles of loading, the natural frequency of the overall system will increase.
b) For strain-softening sites (clay sites) where the stiffness of the soil may decrease with cycles of loading, the natural frequency of the overall system will also decrease correspondingly. This depends on the strain level in the soil next to the pile and the number of cycles.

It has been shown that a certain amount of change in natural frequency is acceptable without seriously compromising the performance of a wind turbine. In this respect there are three challenges to the designer:

(a) The foundation stiffness needs to be estimated very accurately from the available soil data for estimation of natural frequency of the system.

(b) The potential for change in foundation stiffness with time (as a consequence of cyclic loading) must be understood so that the risk of the system frequency coinciding with a loading frequency can be minimized.

(c) While a given change in natural frequency may be acceptable over the life time of the structure, it is necessary to understand if that change is gradual or sudden.

This will have a large influence in accurately estimating the corresponding response amplitudes and the structure's subsequent life expectancy.

Many pile types are designed with a reliance on skin friction effects, however piles that are subjected to vibrations can potentially lose their frictional bond with the surrounding soil (particularly with coarse grained materials).
Furthermore, the presence of lateral loads to the pile shaft can also often cause compaction of the soil which also results in further diminishment of the pile frictional resistance. The recommendation therefore is that an unrestrained shaft be assumed and that the frictional resistance along the shaft should be ignored in piles that are subjected to vibrations (Tomlinson, 1987).
Under dynamic conditions, the influence of the surrounding soil medium is greatest at the beginning stages of vibration loading, but this tends to reduce with time as the soil becomes more compacted, potentially creating a gap around the shaft. Gohnert et al, (2008) considered a simplified approach using a lumped parameter model with stiffness
equations (piles as springs) that are adapted from CP 2012 (subsequently withdrawn in 2015) – the design code was for many years adopted worldwide for the design of foundations with machine vibrations. The simplified model required effective length and boundary conditions to be calculated or assumed and this relied on the calculation of four

coefficients representing the pile group stiffness – the coefficient of uniform compression (cu), the coefficient of non-uniform compression (cO), the coefficient of uniform shear (cr) and the coefficient of non-uniform shear (cs). These coefficients were expressed in the same form as coefficients of subgrade reaction.
In general, piles that are used in foundations with vibrations should be of the end-bearing type. To achieve minimal settlement of the toe of the pile, the pile should preferably be founded on rock, or be sufficiently far into dense/stiff stratum so that an effective length for the pile may be estimated. Shear and moment fixities for the pile toe are achieved with sufficient embedment of the toe into a sufficiently stiff stratum (1.5 diameters into the rock stratum).

Reference Number 139 : Increasing the Efficiency of Wind Turbines. Jamaladdin Nuraddin Aslanov, Kamran C. Cafarov. September 2025. Tribology in Industry 47(3):475-483. DOI: 10.24874/ti.1949.05.25.08
The research work is devoted to the improvement of wind turbines. **Wind turbines do not work when the minimum wind speed is 5 m/s. However, they ensure their operability when the wind speed exceeds 6 m/s.** The creation of shock-resistant wind turbines that can operate in low wind conditions and are easy to install is currently relevant. The article presents improved wind turbines that can operate at low wind speeds by increasing the friction force acting on the turbine blades based on the Bernoulli principle. The study proposes an optimal patented wind turbine that works by increasing the wind speed due to the friction force acting on the turbine blades and has the ability to be conveniently installed in residential buildings. Also, a power analysis of the turbine was carried out based on Bernoulli's law and the pressure resistance of the turbine was checked using modern programs.

Reference Number 140 : **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	Important health outcome
Cardiovascular disease	Adverse birth outcomes
Annoyance	Quality of life, well-being and mental health
Effects on sleep	Metabolic outcomes
Cognitive impairment	
Hearing impairment and tinnitus	

Reference Number 141 : Computational Modelling of the Effects of Rain on Wind Turbine Performance. Aishwerya Gahlot, Lakshmi Sankar Auraluck Pichitkul Suranaree. Proceedings of ASME Turbo Expo 2022 Turbomachinery Technical Conference and Exposition GT2022 June 13-17, 2022, Rotterdam, The Netherlands GT2022-82500

Wind turbines often operate under misty or rainy conditions. There is a considerable body of experimental evidence on the adverse effects of rain on wind turbine power production. Physical understanding of these effects, guided by quantitative modelled, is necessary to fully understand the effects of rain power production.

2-D viscous flow simulations are presented for a representative wind turbine airfoil for several angles of attack under wet and dry conditions. Regression fits of these drag polars have been used in a combined blade element- momentum

analysis for the NREL Phase VI rotor. The calculations indicate a loss of 30% to 40% in power production, attributable to rain, over a range of wind speeds

Moisture and rain cause two noticeable effects on wind turbine performance – surface erosion, and deterioration of aerodynamic performance caused by the formation of a water layer over the rotor surface.

There are several hypotheses that may be proposed for the loss of airfoil performance while operating in rain, as measured by the lift-to-drag ratio:

1. As stated earlier, erosion of the blade surface may trip the boundary layer and cause the blade section drag to dramatically increase, even though the blades were designed using laminar flow airfoils. This effect is modelled by some researchers by tripping the boundary layer at user-specified locations in the vicinity of the blade leading edge, within a Reynolds Averaged Navier-Stokes analysis or an interactive boundary layer analysis. In the present study, the flow is assumed to be fully turbulent.

2. Secondly, the wavy surface of the thin water film over the airfoil may trigger the transition in a manner similar to surface roughness. This would require a more sophisticated analysis that accurately resolves the interaction between the water layer and the external airflow. Verification of this hypothesis has not been attempted in the present study.

3. Thirdly, the extra displacement thickness of the water layer over and above the aerodynamic boundary layer, and the loss of airflow momentum caused by the Stokes reaction forces exerted by water droplets on the airflow, would substantially alter the pressure field over the airfoil. An interactional aerodynamics numerical simulations liking the water droplet transport to the aerodynamic flow would allow this hypothesis to be tested. This is the approach used in this study.

As stated earlier, exposure to rain over a period of time would cause erosion of the blade surface causing the **flow to be turbulent** even under dry conditions.

As expected, there is some deterioration in power production when the airfoil is assumed to be rough, caused by the increase in sectional drag in a fully turbulent flow. It is also seen that the power production for the wet rotor is well below the values for the dry rotor. At 9 m/s, the highest speed modelled using the Blade Element Momentum (BEM) analysis, the baseline rotor with laminar flow airfoil data generates 9.1 KW of power, while the wet rotor generates only 6.6 KW of power, a 25% loss in power.

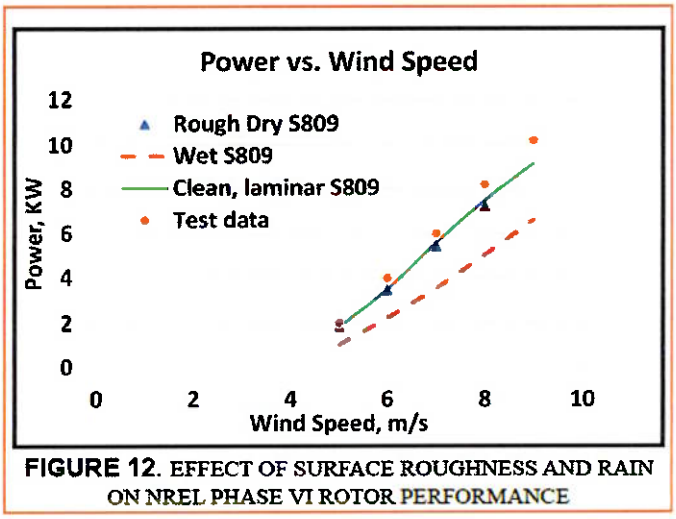


FIGURE 12. EFFECT OF SURFACE ROUGHNESS AND RAIN ON NREL PHASE VI ROTOR PERFORMANCE

Reference number 142 : Mapping of Meteorological Observations over the Island of Ireland to Enhance the Understanding and Prediction of Rain Erosion in Wind Turbine Blades JamesW. K. Nash, Iasonas Zekos and Margaret M. Stack

One of the most prevalent factors is the presence of rain and the subsequent rain erosion of the leading edge of wind turbine blades. Damage caused by impacts from other projectiles, including hail, sand insects and birds, also contributes to the degradation. However, they are less understood and particularly site specific, with early research on hail erosion displaying little erosion damage, insects preferring warm humid air for flight, sand being mainly present

in dry, arid areas or certain coastal sites and turbine siting and development aiming to minimise bat or bird strikes. Extreme weather and rainfall have increased over recent years in northern latitudes. With the increasing size of turbines and therefore tip speed, one can assume that rain erosion is set to become a dominating issue for the sector, highlighting the need to find a solution. In some cases, severe erosion can occur in as little as 2 years.

Typically, the leading edge of a wind turbine blade is protected using some form of polymeric coating or tape, referred to as a leading-edge protection system (LEP). LEPs are susceptible to environmental conditions during erosion. Temperature sensitivities are particularly common in polyurethane (PU) coatings, with their low glass transition temperatures. In recent solid particle erosion tests, PU coatings have exhibited varying erosion behaviours at a range of temperatures (30–100 _C). This performance is largely dependent on coating composition and, although some of the temperatures used were outside of typical operational values during rain events, these results exemplify their temperature sensitivities. Thermal cycling and ageing can also affect mechanical properties, further highlighting the need to understand the impact conditions.

During rain events, the relative humidity is often high. This atmospheric moisture can interact with polymers to a varying degree. Degradation from humidity fluctuations through water ingress and hydrolysis can temporarily or permanently change mechanical properties. Hydrothermal ageing is well documented too within pure composites. However, to the authors acknowledge, there have been no investigating the influence of humidity or hydrothermal ageing. Furthermore, as wind turbine blade surfaces contain two or more different polymers (at least one LEP layer and the composite), even if the top layer is not affected by humidity, another LEP layer or the composite beneath may potentially absorb water, leading to swelling, which could delaminate or fatigue the interface between layers.

Impurities in rain can also lead to chemical reactions and, with the prevalence of acid rain in northern Europe and sea salt aerosols in coastal and offshore sites, this contribution to the erosion process requires further investigation. In northern Europe, sulphuric and nitric acids are the most common, typically from burning fossil fuels or agricultural sources, respectively. Sea salt aerosols are predominantly composed of chloride (Cl^-), sodium (Na^+), sulphate ($SO2^{4-}$), magnesium ($Mg2^+$), calcium ($Ca2^+$), and potassium (K^+). Salt concentrations are typically much higher than acidic pollutants and are of interest in situations where materials (including polymers) are prone to corrosion. Recent evidence suggests enhanced degradation due to the presence of sea salt, acidity or at sites in close proximity to quarries. The influence of salt will be more pronounced at sites near the coast or offshore. Exposure to other pollutant concentrations, such as particulate matter and air pollution, is irregular, site specific and changes over time in relation to the pollution from factories, vehicles and other sources. Without the appropriate data, addressing these other pollutant influences becomes difficult.

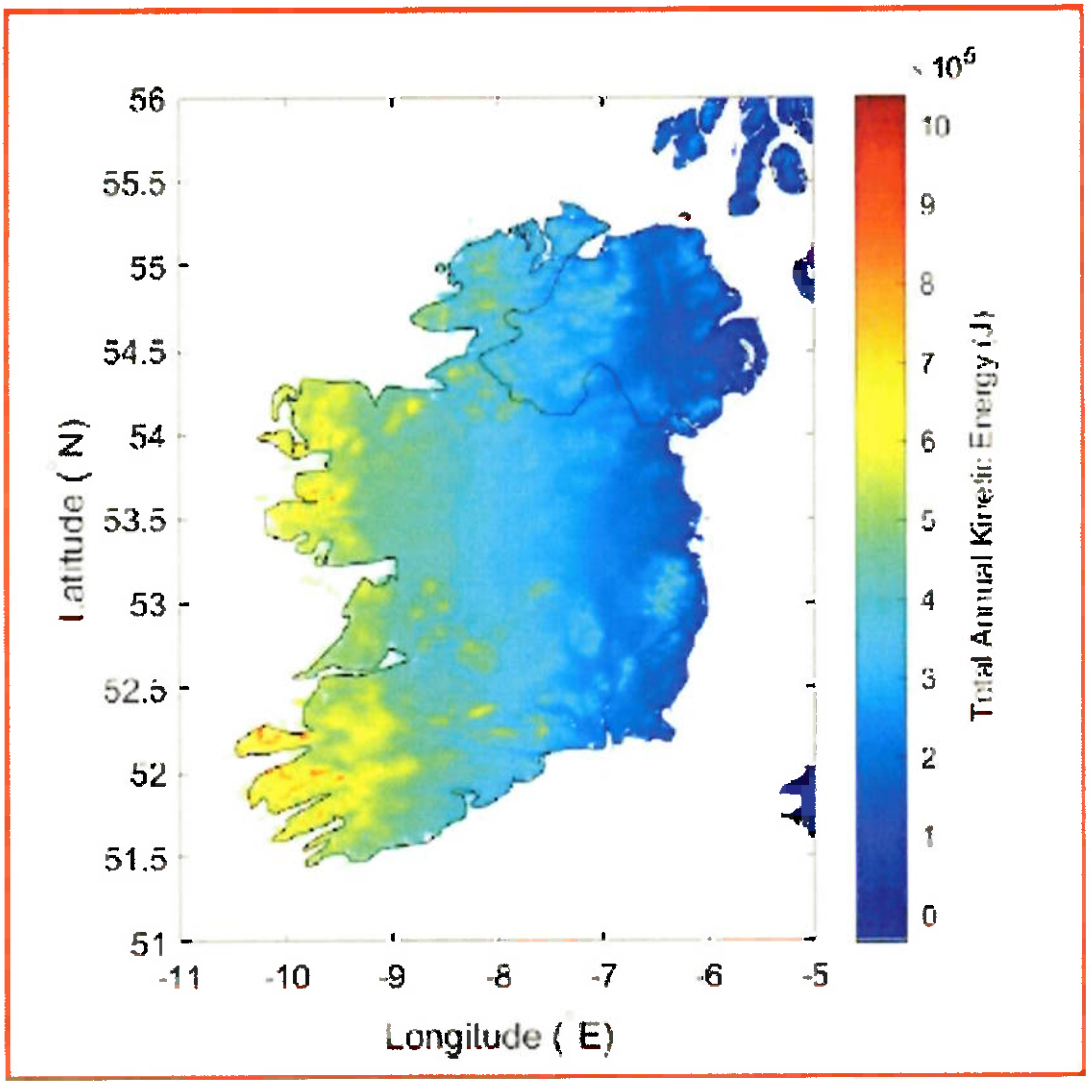


Figure. A total annual kinetic energy map of the island of Ireland.

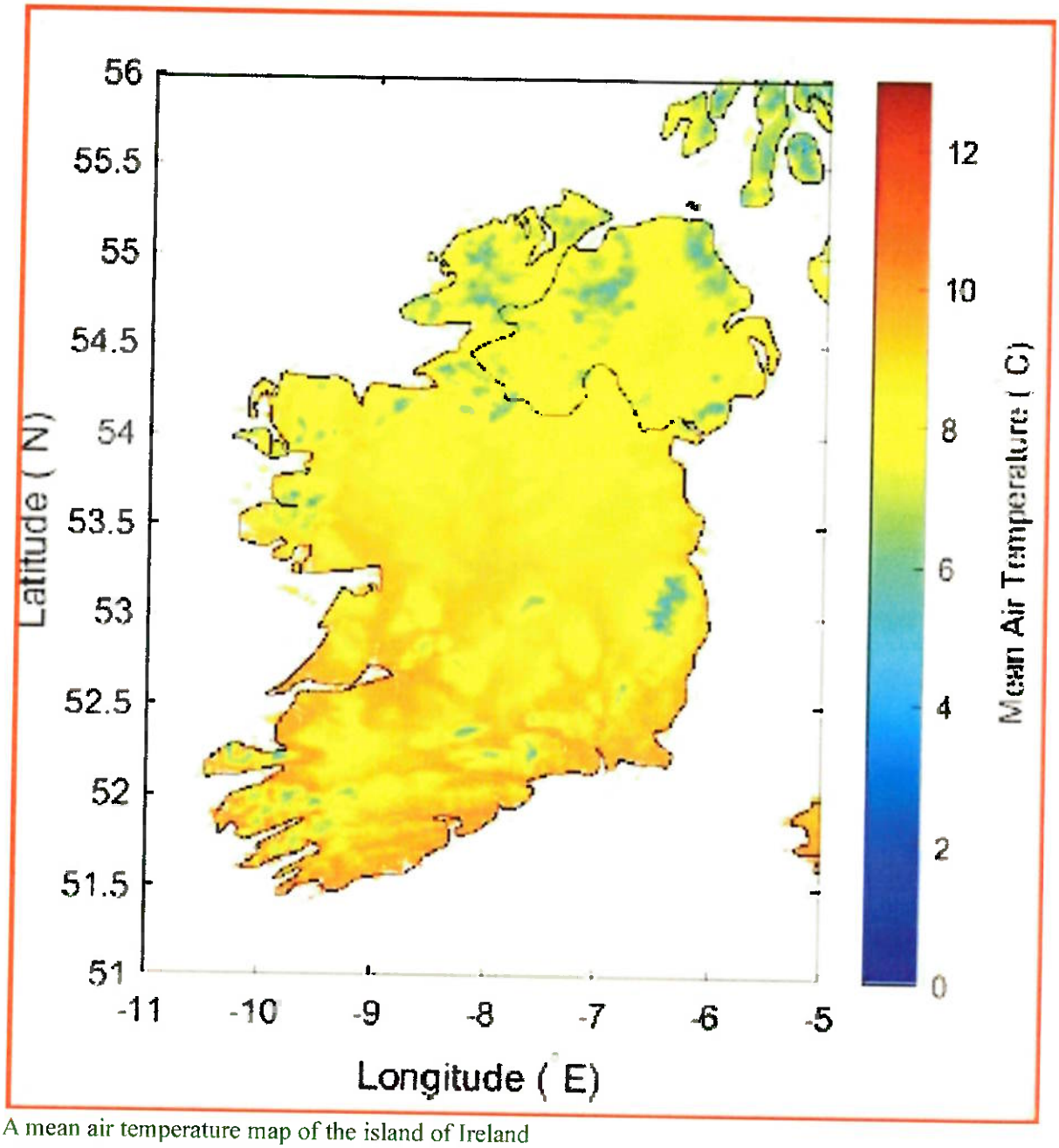


Figure. A mean air temperature map of the island of Ireland

Temperature strongly influences the mechanical properties of temperature sensitive polymers. Impacts generating localized heating and fluctuations in air temperature during rainfall may well lead to accelerating the aging process. As discussed by Pugh et al., Polymeric materials typically used as coatings may have glass transition temperatures in the range of 0–30 _C. In practice, this means the behaviour of coatings will change over the operational range of a wind turbine.

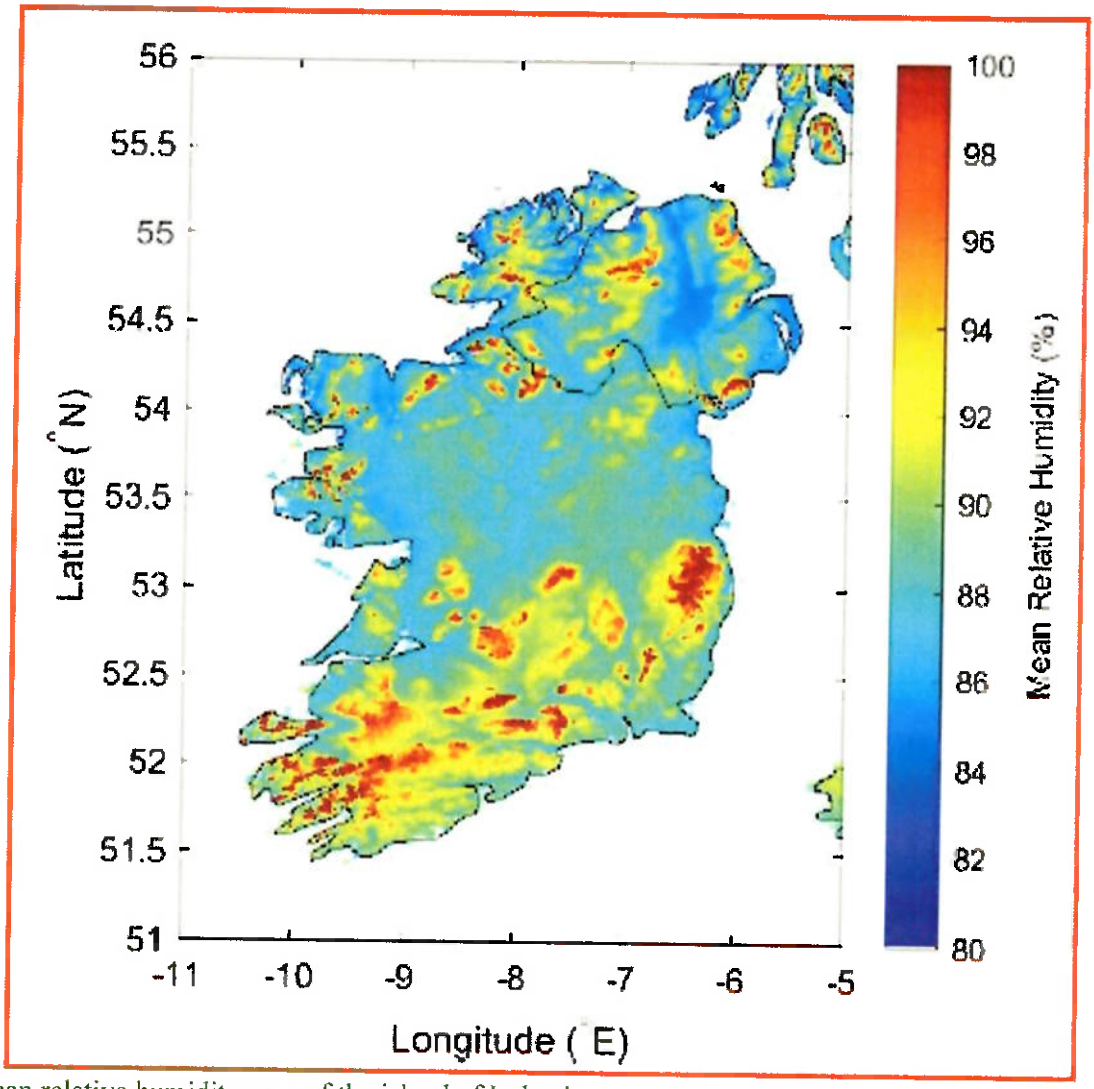


Figure. A mean relative humidity map of the island of Ireland

During impacts from projectiles, heat is generated in the target material. Humidity can enhance the heat transfer from materials into the surrounding air, influencing the erosion process, particularly with high impact rates. Humidity is a problem for polymers, causing degradation through hydrolysis and water ingress. This process can be catalysed by salts, reducing the mechanical properties of wind turbine blade materials and enhancing erosion damage. Seasonal variations in both rain kinetic energy, temperature, humidity and chemical composition indicate that erosion occurs differently depending on the time of year.

Rainfall amounts are significantly reduced in the summer and enhanced in the winter in terms of rain events. Rainfall intensities peak in the summer; however, this is usually with suboptimal wind speeds. The majority of rainfall intensities are low and, according to the analysed data, rated speed, high intensity events, at >10 $mmhr^{-1}$, are unlikely to occur, especially in winter. At rated speed, temperatures and humidities are often much lower during winter than summer, which will influence material performance. Sea salt aerosols are much more prevalent during winter months, which, when combined with the decreased humidity at rated speeds, could lead to increased depositions and therefore enhance damage processes. The results here indicate that the erosion process is much more severe during winter.

All of these erosion issues increase friction & noise

Reference Number 143:

Characterizing the Wake Effects on Wind Power Generator Operation by Data-Driven Techniques. Astolfi, D.; De Caro, F.; Vaccaro, A., Energies 2023, 16, 5818. https://dx.doi.org/10.3390/en16155818

Wake interactions between nearby wind turbines represent the most important cause of producible energy loss in an operating wind farm. It is well known that the wind intensity downstream of a rotor gets reduced and that, **if nearby**

wind turbines are not sufficiently spaced, the velocity deficit does not completely recover, thus affecting power production. In particular, on the one hand for offshore installations, it is convenient to maintain the layout of a wind farm as sufficiently compact to reduce Operation and Maintenance (OandM) costs but, on the other hand, if the layout is too compact the wake losses might reach 10–20% of the Annual Energy Production (AEP)

Reference No. 144 : Auditory and non-auditory effects of noise on health. The Lancet. Volume 383, Issue 9925p1325-1332April 12,-2014
Dr Mathias Basner, MD basner@upenn.edu, Wolfgang Babisch, PhD, Prof Adrian Davis, PhD, Mark Brink , PhD, Charlotte Clark, PhD, Sabine Janssen, PhD, Prof Stephen Stansfeld, PhD.

Noise is pervasive in everyday life and can cause both auditory and non-auditory health effects. Noise-induced hearing loss remains highly prevalent in occupational settings, and is increasingly caused by social noise exposure (eg, through personal music players). Our understanding of molecular mechanisms involved in noise-induced hair-cell and nerve damage has substantially increased, and preventive and therapeutic drugs will probably become available within 10 years. Evidence of the non-auditory effects of environmental noise exposure on public health is growing. Observational and experimental studies have shown that noise exposure leads to annoyance, disturbs sleep and causes daytime sleepiness, affects patient outcomes and staff performance in hospitals, increases the occurrence of hypertension and cardiovascular disease, and impairs cognitive performance in schoolchildren. In this Review, we stress the importance of adequate noise prevention and mitigation strategies for public health.

Reference No. 145 : Health Effects Related to Wind Turbine Sound, Including Low-Frequency Sound and Infrasound. Irene van Kamp, Frits van den Berg. Acoust Aust (2018) 46:31–57 https://doi.org/10.1007/s40857-017-0115-6

A narrative review of observational and experimental studies was conducted to assess the association between exposure to wind turbine sound and its components and health effects in the general population. Literature databases Scopus, Medline and Embase and additional bibliographic sources such as reference sections of key publications and journal databases were systematically searched for peer-reviewed studies published from 2009 to 2017. For the period until early 2015 only reviews were included, while for the period between January 2015 and January 2017 all relevant publications were screened. Ten reviews and 22 studies met the inclusion criteria. Most studies examined subjective annoyance as the primary outcome, indicating an association between exposure levels and the percentage highly annoyed. Sound from wind turbines leads to a higher percentage of highly annoyed when compared to other sound sources. Annoyance due to aspects, like shadow flicker, the visual (in) appropriateness in the landscape and blinking lights, can add to the noise annoyance. There is no evidence of a specific effect of the low-frequency component nor of infrasound. There are indications that the rhythmic pressure pulses on a building can lead to additional annoyance indoors. Personal characteristics such as noise sensitivity, privacy issues and social acceptance, benefits and attitudes, the local situation and the conditions of planning a wind farm also play a role in reported annoyance. Less data are available to evaluate the effects of wind turbines on sleep and long-term health effects. Sleep disturbance as well as other health effects in the vicinity of wind turbines was found to be related to annoyance, rather than directly to exposure.

Reference No. 146 : The multiple understandings of wind turbine noise: reviewing scientific attempts at handling uncertainty. Julia K. Kirkegaard, Tom H. Cronin, Sophie Nyborg, and Daniel N. Frantzen. European Academy of Wind Energy. Volume 10, issue 5. WES, 10, 907–924, 2025. https://doi.org/10.5194/wes-10-907-2025

The noise from wind turbines has been an issue in the planning and development of wind power for many years, giving rise to both controversies during the deployment of onshore wind farms and a significant amount of research by various communities of scientists or what we treat here as epistemic communities founded in engineering and acoustics engineering, psychology and medicine, and the social sciences. Despite iterative attempts at fixing the noise issue through investments in technological developments and regulatory determination of allowable decibel noise levels, noise remains a contested and difficult object to find solutions to. In the Co-Green project, we instigated a social-science-based study founded in science and technology studies (STSs) to look at why and how it is that noise continues to be so controversial. We do this through a narrative literature review of three different literatures, namely the technical, health-based, and social acceptance literatures. We trace how these literatures, founded in three different epistemic communities, have produced the knowledge object of wind turbine noise. We illustrate how noise remains a "troublesome (or `unruly') knowledge object" that defies stabilization within and between the three epistemic

communities: instead, noise is understood as fundamentally different things between them, fuelling controversies over the solutions proposed, where the "fixes" might sometimes not address what was intended. We end by pointing to the potential benefits of more interdisciplinary engagement between epistemic communities as well as – in the context of science for policy – by probing the potential value of finding ways to translate qualitative research findings into noise regulations, other legislation and even the operation of wind farms.

9 Water

Chapter 9: Water has been prepared by HES and assesses the likely significant effects that the Proposed Project may have on hydrology and hydrogeology and sets out the mitigation measures proposed to avoid, reduce or offset any potential significant effects that are identified.

The surface of the Proposed Project site is drained by a network of drains that are typically spaced every 15 to 20m. Larger arterial drains connect the smaller field drains and gently slope towards perimeter silt ponds and surface water outfalls. Surface water outflows from the site discharge to small streams and drains located in the lands surrounding the bog.

Regionally, the Proposed Project site is located in total of 3 no. surface water catchments. All surface waters draining the site are directed to the River Shannon via the Boor and Brosna rivers and their associated tributaries. The bedrock geology underlying the Proposed Project site is classified as a Locally Important Aquifer. There are no group or public groundwater abstractions in the vicinity of the Proposed Project site with the potential to be impacted by the Proposed Project. The hydrogeological regime at the Proposed Project site is characterised by high rates of surface water runoff and very low rates of groundwater recharge due to the presence of soils and subsoils of low permeability.

Due to the nature of wind farm developments, being near-surface construction activities, effects on groundwater are generally negligible and surface water is generally the main sensitive receptor assessed during impact assessments. The primary risk to groundwater would be from oil spillage and leakages at turbine foundations or during construction plant refueling. These are common potential impacts to all construction sites (such as road works and industrial sites). These potential contamination sources are to be carefully managed at the site during the construction and operational phases of the development and measures are proposed within the EIAR to deal with these potential minor local impacts.

During each phase of the Proposed Project (construction, operation, and decommissioning) a number of activities will take place at the Proposed Project site, some of which will have the potential to significantly affect the hydrological regime or water quality at or downstream of the Proposed Project site. These significant potential effects generally arise from sediment input from runoff and other pollutants such as hydrocarbons and cement-based compounds.

Surface water drainage measures, pollution control and other preventative measures have been incorporated into the project design to minimise significant impacts on water quality and downstream designated sites. A self-imposed 50m watercourses buffer was used during the design of the Proposed Project, thereby avoiding sensitive hydrological features. The surface water drainage plan will be the principal means of significantly reducing sediment runoff arising from construction activities and to control runoff rates. The key surface water control measure is that there will be no direct discharge of wind farm runoff into local watercourses or into the existing bog drainage network. This will be achieved by avoidance methods (i.e. stream buffers) and design methods (i.e. surface water drainage plan). Preventative measures also include fuel and concrete management and a waste management plan which will be incorporated into the Construction and Environmental Management Plan (CEMP) (Appendix 4-4).

No significant impacts to surface water (quality and flows) and groundwater (quality and quantity, and any local groundwater wells) will occur as a result of the Proposed Project provided the proposed mitigation measures are implemented. This EIAR presents proven and effective mitigation measures to mitigate the release of sediment which will reduce the concentration of suspended solids to acceptable levels. The storage and handling of hydrocarbons/chemicals will be carried out using best practice methods which will ensure the protection of surface and groundwater quality. The Proposed Project drainage system will be designed to slow surface water runoff from the site by providing greater attenuation. This will ensure that the Proposed Project does not alter downstream surface water flows and will not contribute to downstream flooding.

A hydrological assessment of potential impacts on local designated sites was undertaken. The River Shannon Callows SAC/pNHA (Site Code: 000216) and the Middle Shannon Callows SPA (Site Code: 004096) are considered to be hydrologically connected to the Proposed Project site. Following implementation of the appropriate mitigation measures as outlined in the EIAR no significant impacts on this designated site will occur as a result of the Proposed Project.

A Site-Specific Flood Risk Assessment (Appendix 9-1) has been completed for the Proposed Project and concludes that the Proposed Project has no potential to increase the downstream flood risk.

A Water Framework Directive (WFD) Compliance Assessment (Appendix 9-3) has been completed for all waterbodies (surface water and groundwater bodies) with the potential to be impacted by the Proposed Project. With the implementation of the mitigation measures detailed in this EIAR there will be no change in the WFD status of the underlying groundwater body or downstream surface waterbodies as a result of the Proposed Project. The Proposed Project has been found to be fully compliant with the WFD and will not prevent any waterbody from achieving its WFD objectives.

An assessment of potential cumulative effects associated with the Proposed Project and other developments on the hydrological and hydrogeological environment has been completed. With the implementation of the mitigation measures detailed in this EIAR, the cumulative assessment found that there will be no significant effects on the hydrological and hydrogeological environments. The assessment found that the cumulative effect with the Draft Rehabilitation Plan (Appendix 2-4) will result in an overall positive effect as the rehabilitation plans will improve surface water quality and attenuation within the Proposed Project site.

Reference No 147 : Maintenance of Wind Turbine Blades and Microplastic Emission: How to Mitigate Environmental Risks. Leon Mishnaevsky Jr. *Wind Energy*, 2025; 28:e70072. https://doi.org/10.1002/we.70072

Blade repair can be needed as early as 1–2 years after the wind turbine installation and can be required quite often, every 2 years. This repair frequency and high costs apparently mean that the technology should be drastically improved.

Maintenance and repair of wind turbine blades include typically the following steps: finding damage, assessing the degree and type of the damage, designing the repair scheme, removing the damaged region and surface preparation, fabricating repairing parts, and attaching it, inspection. The steps where any plastic particle emission can be expected are removal of the damaged region (typically, by griding), surface preparation (grinding), bonding, and finally surface polishing.

Different repair procedures are applied to wind turbine blades, depending on specific conditions and blade damage mechanisms. According to the estimations from [2], the most common blade damage mechanism is the leading edge erosion. While it is a minor damage of the blade and not so spectacular as blade collapses (which are widely reported in newspapers), erosion repair constitutes 90% of all blade damages requiring repair. The costs for repair of minor blade damage (erosion) are also 12 times higher than those of structural failure. Moreover, structural blade repair requires a blade replacement or factory repair, while the surface erosion can be repaired onsite, thus adding to the risk of onsite plastic emission.

Using the data of wind turbine service companies, it was determined that the volume of emitted particles due to erosion is about 75g per year per blade for onshore wind turbines.

Microplastic shedding from turbine blades, known as Leading Edge Erosion, is a great concern to manufacturers who are forced to repair the damage that occurs after only a couple of years. The particles eroded from blades include epoxy which is 40% Bisphenol-A (BPA), a frequently banned endocrine disruptor and neurotoxin. Academic research has shown the potential for 137 pounds of epoxy microparticles to be shed per turbine per year.

Recent reports from Germany and other countries have highlighted a disturbing issue: the degradation of wind turbine rotor blades. These blades, made from composite materials such as carbon-fibre-reinforced polymers (CFRP), are not only prone to breaking but also to releasing fine, respirable fibres—referred to as "nasty fibres"—into the air. According to experts, these fibres are as carcinogenic as asbestos.

Asbestos, once widely used in construction for its heat-resistant properties, was later discovered to cause serious respiratory illnesses, including lung cancer and mesothelioma. The material's dangers became so apparent that its use was eventually banned in many countries. Now, the similarities between asbestos and the fibres released from wind turbine blades are raising alarms. Like asbestos, these carbon fibres are chemically non-reactive and difficult to break down in the lungs, posing long-term health risks to those exposed.

The problem doesn't stop with human exposure. Animals and the broader environment are also at risk. In incidents where turbine blades have snapped or caught fire, fine fibres have been scattered across surrounding areas, contaminating soil and potentially entering the food chain. The long-term effects of this contamination are still unknown, but the potential for widespread ecological harm is significant.

What makes this situation even more concerning is the apparent lack of regulatory oversight. There are no strict guidelines in place to manage the risks associated with these fibres. In some cases, local fire brigades have been tasked with clearing debris from damaged turbines without proper protective gear or awareness of the hazards involved. This lack of preparedness is reminiscent of the early days of asbestos use when the dangers were either unknown or deliberately downplayed.

Moreover, the issue of recycling turbine blades adds another layer of complexity. Unlike other materials, CFRP is difficult to recycle, often ending up in landfills where it can continue to pose risks. The sheer volume of blades that will need disposal in the coming years is staggering, and without effective recycling solutions, we could be facing a significant environmental disaster.

Reference No 148 : Asbestos found in wind farm lift brake pads prompts safety response : Tamara Clark, ABC Wimmera · 20 Nov 2025 · abc.net.au ~~
The discovery of asbestos-ridden lift brake pads has sparked an urgent safety response at wind farms across the country. WorkSafe Victoria and renewable energy company Goldwind Australia, a subsidiary of Chinese firm Goldwind Science and Technology Co. Ltd, said white asbestos was found in brake pads used in wind turbine lifts at its facilities.
The brake pads were supplied by 3S Industry, a major Chinese-based supplier to Australia. 3S Industry is one of a few brake pad suppliers to Australia, meaning a significant percentage of the country's wind turbines could be affected. Interstate regulators have united to form a coordinated safety response. The importation of asbestos, or goods containing asbestos, has been illegal in Australia since 2003.

Reference No 149 : Microplastics Emission from Eroding Wind Turbine Blades: Preliminary Estimations of Volume Leon Mishnaevsky, Jr., Antonios Tempelis , Yauheni Belahurau and Nicolai Frost-Jensen Johansen. Energies 2024, 17, 6260. https:// doi.org/10.3390/en17246260

In this article, the volume of removed plastic due to the leading-edge erosion of wind turbine blades is evaluated using different approaches. A probabilistic model of material removal due to successive rain droplet impacts was developed and applied to the determination of the volume loss of blades due to erosion. As a result, it was shown that for the case of an average tip speed of 90 m/s, 1000 mm of rain annually, and a mean rain intensity of 1 mm/h, the volume loss is at the level of 15 mm3/cm2 per year. For the area 10 m×50mm(fullleading-edge surface), it leads to 75 cm3 or 75 g per blade per year.

Reference No 150 : 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 No 151 : 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 No 152 : 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; Chapmanetal.,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 Number 153 : 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 P0 sinωmt, where P0 = magnitude of the unbalanced force from the machine during its operation and ωm = 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 (ωn) 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.

1)

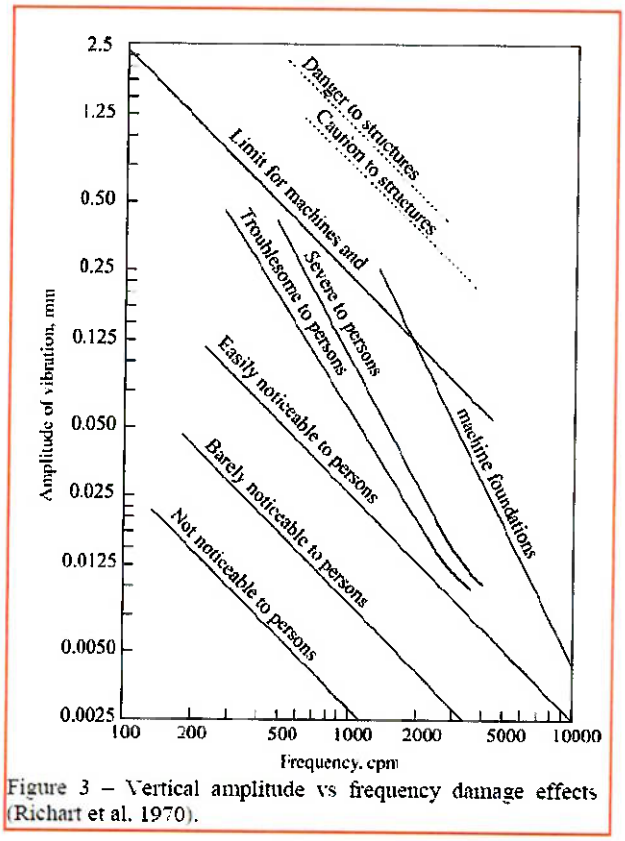


Figure 3 – Vertical amplitude vs frequency damage effects (Richart et al. 1970).

3 LOADING AND VIBRATION

CHARACTERISTICS OF ONSHORE WIND TURBINES

There are several loads and unbalanced forces acting on the wind turbine tower which are ultimately transferred to the foundation and can be classified into two types: static (or dead load) due to the self-weight of the components and the dynamic loads (which in some instances can be cyclic).

3.1 *Self-weight loads*

These include the dead loads of the nacelle, the rotor's self-weight and tower's self-weight. Gravity forces on the blades generally cause sinusoidal loading due to their rotation. This kind of load is important for fatigue analysis since wind turbines are designed to produce electricity for a minimum of 20 years. Thus, a turbine with blades rotating at an average of 11.2 rpm will be subjected to 1.1773×10^8 stress cycles over its lifetime (Sassi, 2016). In the average life of a wind turbine tower it is therefore subjected to an order of magnitude higher number of loads than a bridge receiving daily traffic would.

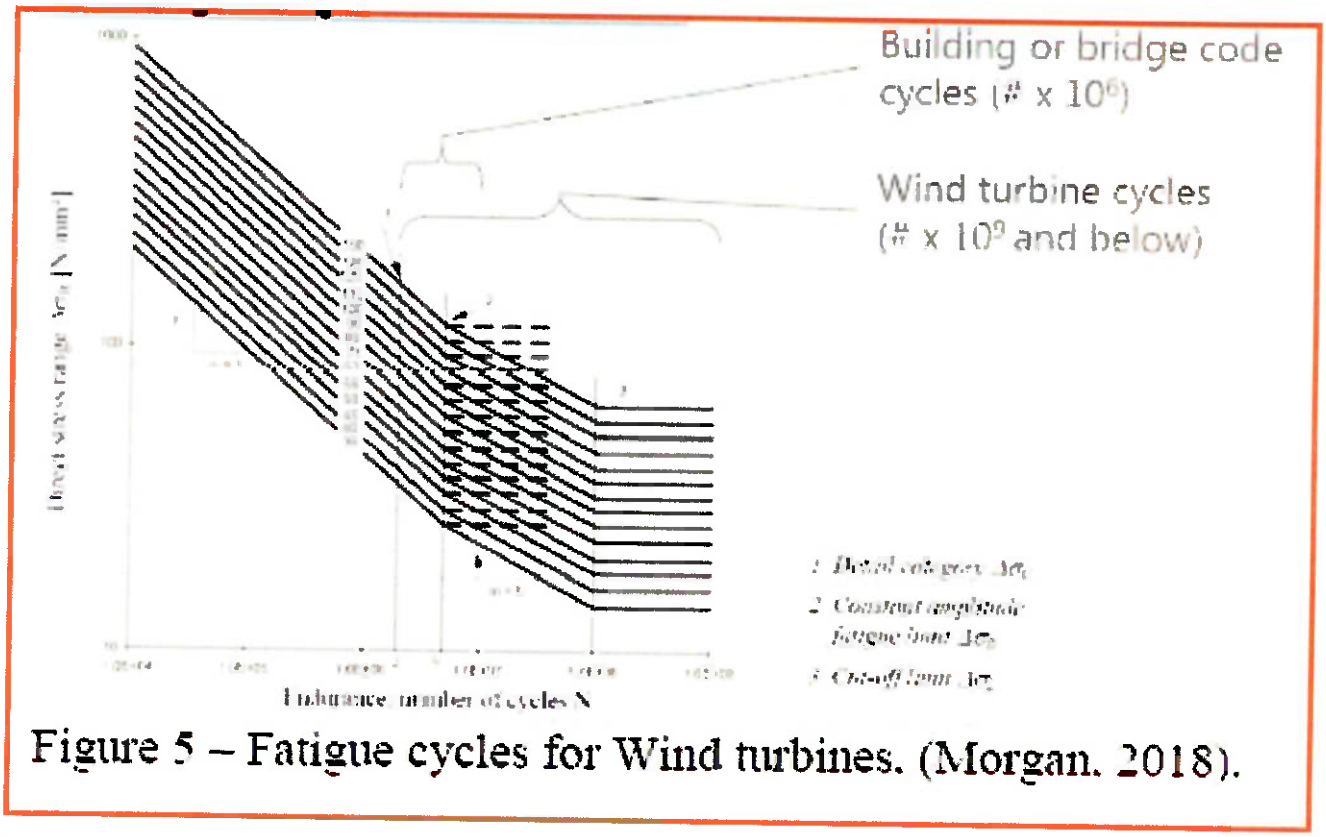


Figure 5 – Fatigue cycles for Wind turbines. (Morgan, 2018).

3.2 *Dynamic loads*

Any machinery with a rotating component causes forces on its foundation. The amplitude of the centrifugal force F depends on the rotating mass m, the mass unbalance e and the angular frequency ω as follows:

$F = me\omega 2$ (1)

Foundations carrying machinery on soil with or without foundation piles can be analyzed as one or two mass-spring systems (van Koten, 2012). The harmonic loading by rotating machines can be accurately determined. Concise formulas are available for the stiffness, equivalent mass and damping calculations.

The natural system frequencies and displacement amplitudes can be obtained by hand calculations, without the use of complex software. The amplitude can then be evaluated as acceptable or not.

Soil at the sides of foundations has been found to considerably increase the damping and strongly reduce the displacement amplitudes (van Koten, 2012). The vertical vibrations are well damped by the soil, but the horizontal vibrations can be disturbing even at a large distance from the foundation. The challenging part of the analysis is

therefore the understanding of the dynamic loads acting on the wind turbine which are discussed below (Bhattacharya, 2014):

(a) The lateral load acting at the level of the hub (top of the tower) from the rotating blades produced by the turbulence in the wind. The magnitude of this dynamic component will depend on the turbulent wind speed.

(b) The load caused by the vibration at the hub level due to the mass and aerodynamic imbalances of the rotor. This load has a frequency equal to the rotational frequency of the rotor (referred to as 1P loading in the literature). This is the known as the Primary system excitation frequency. Since most industrial wind turbines are variable speed drive machines, 1P is therefore not a single frequency but rather a frequency band between the frequencies associated with the lowest and the highest rpm.

(c) Loads in the tower due to vibrations caused by blade shadowing effects (this is referred to as 2P/3P in the literature). The blades of the wind turbine passing in front of the tower itself cause a 'shadowing effect' and consequently inflict a loss of wind load on the tower. This is also a dynamic load having frequency equal to three times the rotational frequency of the turbine (3P) for three bladed wind turbines, and two times (2P) the turbine rotational frequency for a two bladed turbine. The 2P/3P loading is also a frequency band such as 1P and is simply obtained by multiplying the limits of the 1P band by the number of the turbine blades.

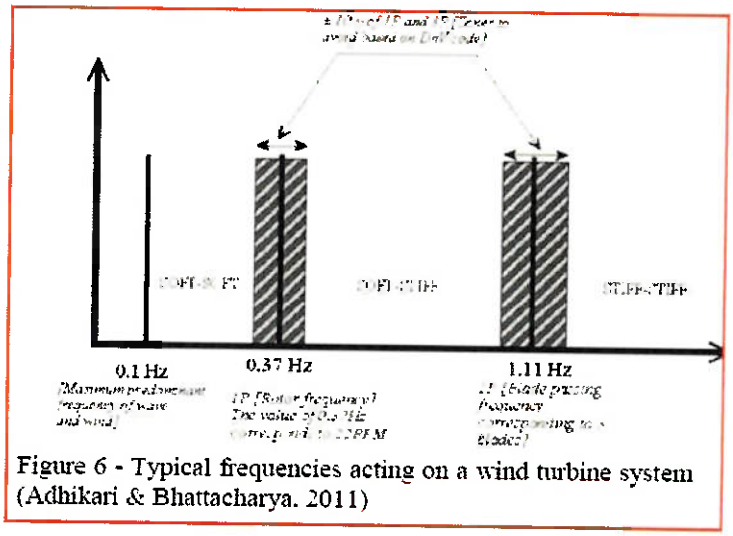


Figure 6 - Typical frequencies acting on a wind turbine system (Adhikari & Bhattacharya, 2011)

It is worth noting that the DnV (2001) Code of Practice states the following: 'If it is confirmed that the tower frequency is kept outside ranges defined as the rotor frequency ±10% and the blade passing frequency ±10%, respectively, then there will normally not be any problems due to load amplification arising from vibrations at or near the natural frequency'. The Code furthermore states that special attention should be given to variable-speed turbines, 'in which cases the turbine should not be allowed to operate in a frequency interval defined as the eigenfrequency of the tower ±10%'. It is also specified that the global frequency of the system should be at least ±10% away from operational 1P and 2P/3P frequencies.

Due to their slender nature, it is no surprise that wind-turbines are dynamically sensitive at low frequencies, the first modal frequency of the system (often less than 1Hz) being very close to the excitation frequencies imposed by environmental and mechanical loads. As an example, the predominant frequencies of wind are about 0.1 Hz whilst the rotor frequencies are in the range from 0.15 – 0.5 Hz. Figure 6 shows the main frequencies for a three-bladed standard wind turbine. It is clear from the frequency content of the applied loads that the designer of the turbine and foundation has to select a system frequency (the global frequency of the overall wind turbine foundation system) which lies outside the range of environmental frequencies in order to avoid system resonance.

From the point of view of the first natural frequency (fo) of the structure, three types of designs are possible (Bhattacharya, 2014):

(1) Soft-Soft design where fo is placed below the 1P frequency range which is a very flexible structure and almost impossible to design for a grounded system.

(2) Soft-Stiff design where fo is between 1P and 3P frequency ranges. This is generally the most commonly used design in the industry.

(3) Stiff-Stiff designs where fo has a higher natural frequency than the upper limit of the 3P band which would therefore require a very stiff support structure. The usual choice for fixed wind turbines would lie in the interval between turbine and blade passing frequencies (referred to as a 'soft-stiff' structure). Other definitions of "soft-soft" and "stiff-stiff" can be found in Bhattacharya (2014).

4 SIMPLE DYNAMIC TOWER MODEL

It is therefore essential to perform a free vibration analysis of the structure with consideration for the flexibility of the foundation. The comparison of the natural period of the structure with the various loading frequencies (Figure 6) can provide us with useful information on the dynamic sensitivity. Often the first natural frequency of a structure is considered as the primary indicator of the dynamic responses.

A flexible wind turbine tower often presents a natural frequency that is greater than the natural frequency of the rotor but lower than the rotating rotor blades frequency. Flexible towers are typically less expensive than rigid towers, as they have less mass and require less material for their construction. Since these towers are normally exposed to complex distributions of aerodynamic loads, the risk of resonance is high. The simplified structural system is a tall, flexible and slender tower that supports at its top a nacelle and set of rotor blades. This system can be modelled as a cantilever beam with a tip mass at the end (Avila & de Morais, 2013), as shown in Figure 7.

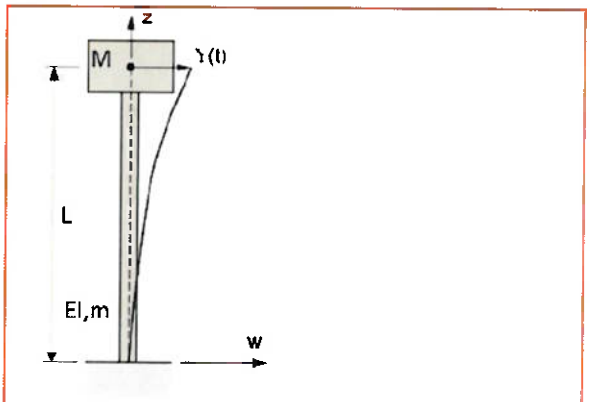


Figure 7 – Cantilever beam with tip mass at the top end (Avila & de Morais, 2013).

2)

Although the real structure is a system with infinite degrees of freedom, it can be modelled as a discrete system with multi degrees of freedom (MDOF) in a Finite Element approach.

$$M\ddot{y}(t) + C\dot{y}(t) + Ky(t) = F(t) \quad (2)$$

where M, C and K are mass, damping and stiffness matrices, respectively. $\ddot{y}(t)$, $\dot{y}(t)$ and $y(t)$ are acceleration, velocities and displacements vectors, respectively. F(t) is the dynamic load vector. The generalized mass and the generalized stiffness of the tower are computed, respectively as:

$$K = \int_0^L EI \frac{\pi^4}{16L^4} cos^2\left(\frac{\pi z}{2L}\right) dz \therefore K \frac{\pi^4}{32L^3} EI \quad (3)$$

$$M = \frac{mL}{2\pi}\left[\pi\left(3 + 2\frac{Le}{L}\right) - 8\right] \quad (4)$$

3)

Where the tip mass M = mLe, is defined proportionally as an equivalent length L.

Tempel and Molenaar (2002) proposed a method to carry out dynamic analysis of a flexible wind turbine system. The wind turbine is modelled as a structure of length L, with mass per unit length m, having bending stiffness EI and a top mass M. The tower structure is assumed to be fixed at the bottom. The first natural frequency (f1) of the system is proposed as:

$$f_{1=}\sqrt{\frac{3.04EI}{(M+0.227mL)4\pi^2L^3}} \quad (5)$$

While Eqn. (5) is simple to use, it does not consider the flexibility of the foundation and stiffness softening effect due to the axial load arising from the mass of the rotor and blade system (Adhikari, S. & Bhattacharya, S. 2011).

5 EFFECTS OF SOIL CHARACTERISTICS ON THE WIND TURBINE SYSTEM

Wind turbine foundations are considered to operate within two distinct domains of soil shear strain: (1) low (<10-3 %) where the soil is assumed to act as an elastic material and (2) intermediate (10-3 to 10-2 %) which is regarded as elasto-plastic behaviour with some stiffness degradation (Warren-Codrington, 2013).

Small scale 1-g tests reported by Bhattacharya et al (2011) and Cox et al (2011) showed that the natural frequency of a wind turbine system changes with its cycles of loading. The main reason for this change is due to the alteration of the foundation stiffness from strain-hardening or strain-softening behaviour of the soil supporting the foundation due to the loading cycles.

The main conclusions drawn from this study can be summarized as follows:

a) For strain-hardening sites (typically - loose to medium dense sand) where the stiffness of the soil increases with cycles of loading, the natural frequency of the overall system will increase.

b) For strain-softening sites (clay sites) where the stiffness of the soil may decrease with cycles of loading, the natural frequency of the overall system will also decrease correspondingly. This depends on the strain level in the soil next to the pile and the number of cycles.

These conclusions have been supported by evidence in limited field measurements. Cyclic element tests on soil showing stiffness increase, and cyclic tests on foundations alone have also corroborated these conclusions. The above points beg the question

- how much frequency change is acceptable?

The norm would be that high quality geotechnical testing can provide us with guidance on the nature of the site, i.e. whether it will be a strain-hardening or strain-softening under cyclic loading type site. Three cases may arise in practice:

(a) The site is known to be strain-hardening. Theoretically, the best design for such a site is to place the natural frequency of the system 10% higher than the highest 1P frequency, leading to the maximum allowable frequency change interval spanning up to the next resonance limit at the 2P/3P frequency.

(b) The site is known to be strain-softening. Here, the designer may aim to place the natural frequency at 10% lower than the lowest 2P/3P frequency value.

(c) The site is unknown and the behaviour cannot be predicted. The design is best optimized if the natural frequency is in the centre between 1P and 2P/3P frequencies.

It has been shown that a certain amount of change in natural frequency is acceptable without seriously compromising the performance of a wind turbine. In this respect there are three challenges to the designer:

(a) The foundation stiffness needs to be estimated very accurately from the available soil data for estimation of natural frequency of the system.

(b) The potential for change in foundation stiffness with time (as a consequence of cyclic loading) must be understood so that the risk of the system frequency coinciding with a loading frequency can be minimized.

(c) While a given change in natural frequency may be acceptable over the life time of the structure, it is necessary to understand if that change is gradual or sudden. This will have a large influence in accurately estimating the corresponding response amplitudes and the structure's subsequent life expectancy.

6 LUMED STIFFNESS PARAMETER MODEL

Many pile types are designed with a reliance on skin friction effects, however piles that are subjected to vibrations can potentially lose their frictional bond with the surrounding soil (particularly with coarse grained materials). Furthermore, the presence of lateral loads to the pile shaft can also often cause compaction of the soil which also results in further diminishment of the pile frictional resistance. The recommendation therefore is that an unrestrained

shaft be assumed and that the frictional resistance along the shaft should be ignored in piles that are subjected to vibrations (Tomlinson, 1987).

Under dynamic conditions, the influence of the surrounding soil medium is greatest at the beginning stages of vibration loading, but this tends to reduce with time as the soil becomes more compacted, potentially creating a gap around the shaft.

Gohnert et al. (2008) considered a simplified approach using a lumped parameter model with stiffness equations (piles as springs) that are adapted from CP 2012 (subsequently withdrawn in 2015) – the design code was for many years adopted worldwide for the design of foundations with machine vibrations. The simplified model required effective length and boundary conditions to be calculated or assumed and this relied on the calculation of four coefficients representing the pile group stiffness – the coefficient of uniform compression (cu), the coefficient of non-uniform compression (cO), the coefficient of uniform shear (cr) and the coefficient of non-uniform shear (cs). These coefficients were expressed in the same form as coefficients of subgrade reaction

In general, piles that are used in foundations with vibrations should be of the end-bearing type. To achieve minimal settlement of the toe of the pile, the pile should preferably be founded on rock, or be sufficiently far into dense/stiff stratum so that an effective length for the pile may be estimated. Shear and moment fixities for the pile toe are achieved with sufficient embedment of the toe into a sufficiently stiff stratum (1.5 diameters into the rock stratum).

7 PILE LAYOUT VS DYNAMIC RESPONSE

Ali Ahmed (2015) defined a dimensionless parameter ao ($ao = \omega ro/\sqrt{Gsoil/\rho}$) and after conducting various experiments, made the following observations in regards the dynamics of pile groups:

i) The vertical dynamic stiffness and damping of a pile group was found to depend on the pile spacing as well as the dynamic properties of the soil between the piles. The dynamic stiffness of pile groups was reduced by 50%, 33% and 25% for pile groups spaced at 2Dpile, 4Dpile and 6Dpile respectively when the dimensionless frequency parameter was increased from 0.20 to 2.0.

ii) Pile groups with a larger spacing of 6Dpile had higher stiffness and damping than pile groups spaced at 4Dpile and 2Dpile due to the larger contribution of the soil between the piles to the groups. In the case of the pile group spaced at 6Dpile (with larger soil volume), the stiffness increased as well as the damping.

iii) As the spacing between the piles was reduced, the pile group behaved like an isolated embedded foundation, i.e., the soil mass between the piles tended to vibrate in phase with the piles and so the pile group soil system responded as one block.

iv) At resonance, for weak soils, all piles carried the same load whilst for strong soils, the corner piles carried the largest loads.

8 CONCLUSION

This paper examined the limitations of various methods of dynamic analysis for a typical onshore piled wind turbine foundation. It would be suggested that both a typical soil-structure interaction model as well as a lumped parameter model be considered, given the various effects that are described above, to arrive at a lower bound/upper bound solution.

Reference Number 154: Wind farms and groundwater impacts, A guide to EIA and Planning considerations, Version 1.1 / April 2015. Northern Ireland Environment Agency

Why is it important to protect groundwater?

Groundwater has three major uses in Northern Ireland:

- *Abstractions for agricultural and industrial purposes, food and beverage production (including bottled water);*
- *Public and private drinking water supply; and*
- *Maintenance of flow and water levels in rivers, lakes and wetlands, particularly during times of low rainfall.*

The protection of groundwater from the risk of possible contamination is important because pollutants could cause health problems in human beings, reduce the quality of agricultural products, make water unsuitable for certain industrial processes, and pose a threat to our countryside and environment including their suitability for recreational purposes. In summary, the contamination of groundwater can not only have health and environmental impacts, but also serious economic consequences.

What impact can a wind farm have on groundwater?

The development of a wind farm has the potential to impact on groundwater quality, groundwater quantity and/or the established groundwater flow regime. Figure 1 overleaf shows the scale and extent of the foundation of a single wind turbine which could potentially impact on the aquatic environment. Changes to the local water environment can affect receptors such as wells/boreholes, springs, wetlands and waterways, and can also have implications for groundwater dependent ecology and/or land stability

Potential impacts on groundwater from wind farms.

	Construction Phase	Operational Phase	Decommissioning Phase
Groundwater Flow Regime	**Earthworks and site drainage:** ▪ Reduction in water table if dewatering is required for turbine foundation construction or borrow pits; ▪ Changes to groundwater distribution and flow.	**Physical presence of turbines and tracks:** ▪ Possible changes to groundwater distribution; ▪ Reduction in groundwater storage. **Reduction of forestry in site area:** ▪ Changes to infiltration and surface runoff patterns, thereby influencing groundwater flow and distribution.	**Physical presence of former turbines and tracks:** ▪ Possible changes to groundwater distribution; ▪ Reduction in groundwater storage.
Groundwater Quality	**Earthworks:** ▪ Disturbance of contaminated soil and subsequent groundwater pollution **Materials Management:** ▪ Pollution from spills or leaks of fuel, oil and building materials.	**Materials Management:** ▪ Pollution from spills or leaks of fuel or oil.	**Use of vehicles and machinery to remove infrastructure:** ▪ Pollution from spills or leaks of fuel or oil.

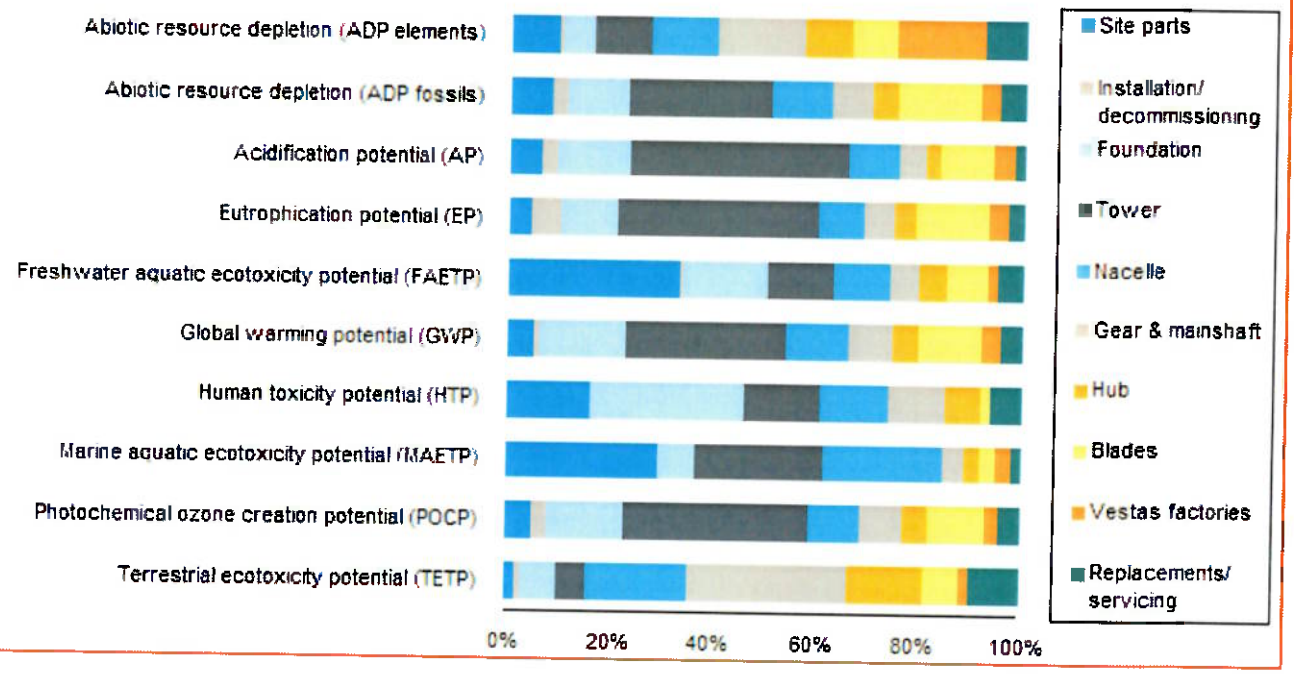
Reference Number 155: Life cycle assessment of electricity production from an Onshore V117-42MW wind plant. Priyanka Razdan, Peter Garrett Version: 1.1 Date: 01.11.2019

Whole-life environmental impacts of V117-4.2 MW plant (shown in g, mg or MJ per functional unit of 1kWh)

Environmental impact categories:	Unit	Quantity
Abiotic resource depletion (ADP elements)	mg Sb-e	0.05
Abiotic resource depletion (ADP fossils)	MJ	0.06
Acidification potential (AP)	mg SO2-e	16
Eutrophication potential (EP)	mg PO4-e	2.0
Freshwater aquatic ecotoxicity potential (FAETP)	mg DCB-e	33
Global warming potential (GWP)	g CO2-e	4.4
Human toxicity potential (HTP)	mg DCB-e	3857
Marine aquatic ecotoxicity potential (MAETP)	g DCB-e	553
Photochemical oxidant creation potential (POCP)	mg Ethene	1.3
Terrestrial ecotoxicity potential (TETP)	mg DCB-e	29

Note: impact indicators are based on CML impact assessment method Version 2016 (CML, 2016)

Production and use-phase environmental impacts of V117-4.2 MW



Sulphur hexafluoride (SF6) gas

Sulphur hexafluoride is a very potent greenhouse gas which is used in switchgears for medium- and high-voltage applications. The gas acts as an electrical insulator for the operation of the switchgear. Each turbine contains switchgear, and they are also used onsite for connecting the turbines and transformer substation. For the switchgear application this usually only becomes an issue if the gas is released into the environment during a blow-out. Occurrences of blow-outs are extremely rare and have not been modelled in this study. During normal operation the turbine switchgear may potentially release up to 0.1% w/w of the sulphur hexafluoride per year, accounting for a potential 2% w/w total release over 20 years of operation. The potential effect of a blow-out is assessed in the sensitivity analysis, as shown in Section 6.7.

At end-of-life the switchgears are collected, and the sulphur hexafluoride gas is reclaimed for reuse in new equipment. Vestas has established procedures and is working in partnership with customers and suppliers to assure the safe disposal of switchgears used in Vestas power plants. Based on supplier data it is estimated that

a maximum of 1% w/w of the SF6 gas may be released to atmosphere during the reclamation and recycling process at end-of-life. Vestas estimates that 95% of all switchgears will be returned for reclamation at end-of-life. The remaining 5% are assumed to have all the sulphur hexafluoride gas released to atmosphere at end-of-life.

Reference No. 156 : 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.
www.elsevier.com/locate/jenvman

Excessive sedimentation derived from anthropogenic activities is a main factor in habitat and biodiversity loss in freshwater ecosystems. To prevent offsite movement of soil particles, many environmental regulatory agencies mandate the use of perimeter silt fences. However, research regarding the efficiency of these devices in applied settings is lacking, and fences are often ineffective due to poor installation and maintenance. Here, we provide an overview of the current state of research regarding silt fences, address the current culture surrounding silt fence installation and maintenance, and provide several recommendations for improving the knowledge base related to silt fence effectiveness. It is clear that there is a need for integrated long-term (i.e., extending from prior to fence installation to well after fence removal) multi-disciplinary research with appropriate controls that evaluates the effectiveness of silt control fences. Through laboratory experiments, in silico modelling and field studies there are many factors that can be experimentally manipulated such as soil types (and sediment feed rate), precipitation regimes (and flow rate), season, slope, level of site disturbance, fence installation method, type of fence material, depth of toe, type and spacing of support structures, time since installation, level of inspection and maintenance, among others, that all require systematic evaluation. Doing so will inform the practice, as well as identify specific technical research needs, related to silt fence design and use. Moreover, what constitutes "proper" installation and maintenance is unclear, especially given regional- and site-level variation in precipitation, slope, and soil characteristics. Educating and empowering construction crews to be proactive in maintenance of silt fencing is needed given an apparent lack of compliance monitoring by regulatory agencies and the realities that the damage is almost instantaneous when silt fences fail. Our goal is not to dismiss silt fences as a potentially useful tool. Instead, we question the way they are currently being used and call for better science to determine what factors (in terms of fence design, installation and site-characteristics) influence effectiveness as well as better training for those that install, maintain and inspect such devices. We also encourage efforts to "look beyond the fence" to consider how silt fences can be combined with other sediment control strategies as part of an integrated sediment control program.

10 Air Quality

Chapter 10: Air Quality identifies, describes and assesses the potential significant direct and indirect effects on air quality arising from the construction, operation and decommissioning of the Proposed Project.

The air quality zone for the site was selected, followed by a review of EPA collated baseline air quality data namely Sulphur Dioxide (SO2), Particulate Matter (PM10), Nitrogen Dioxide (NO2), Carbon Monoxide (CO) and Ozone (O3) for the selected air quality zone to determine the representative levels of such emissions for the Proposed Project.

The EPA has designated four Air Quality Zones for Ireland:

- Zone A: Dublin City and Environs
- Zone B: Cork City and Environs
- Zone C: 16 urban areas within population greater than 15,000
- Zone D: Remainder of the country

These zones were defined to meet the criteria for air quality monitoring, assessment and management as described in the Cleaner Air for Europe (CAFE) Directive. The Proposed Project site lies within Zone D, which represents rural areas located away from large population centres.

The air quality in the vicinity of the Proposed Project is typical of that of rural areas of Ireland, i.e., Zone D. Prevailing south-westerly winds carry clean, unpolluted air from the Atlantic Ocean onto the Irish mainland. The EPA publishes Air Monitoring Station Reports for monitoring locations in all four Air Quality Zones. The most recent report on air quality in Ireland, 'Air Quality in Ireland 2023' was published by the EPA in 2024. The EPA reports provide SO2, PM10, NO2 and O3 concentrations for areas in Zone D.

The Institute of Air Quality Management in the UK (IAQM) guidance document 'Guidance on the Assessment of Dust from Demolition and Construction' (2024) was considered in the dust impact assessment. The guidance document outlines an assessment method for predicting the impact of dust emissions from construction activities based on the scale and nature of the works and the sensitivity of the area to dust impacts. This methodology has been used to predict the likely risk of dust as a result of the construction phase works, operational phase activities and decommissioning phase.

The production of energy from wind turbines has no direct air emissions as is expected from fossil fuel-based power stations. Harnessing more energy by means of renewable sources will reduce dependency on fossil fuels, thereby resulting in a reduction in harmful emissions that can be damaging to human health and the environment. Some temporary or short-term indirect emissions associated with the construction of the Proposed Project will include vehicular and dust emissions.

A CEMP will be in place throughout the construction phase (see Appendix 4-4). The CEMP includes dust suppression measures. In addition, turbines and construction vehicles will be transported to the site on specified haul routes only, which will be regularly inspected for cleanliness and cleaned as necessary.

During the construction phase of the Proposed Project and other permitted or proposed projects and plans in the area, there will be exhaust emissions from construction plant and machinery and potential dust emissions associated with construction activities. However, once the mitigation proposals, as outlined in Chapter 10, are implemented during the construction phase of the Proposed Project, there will be no cumulative negative effect on air quality.

Exhaust emissions of carbon dioxide (CO2), oxides of nitrogen (NOx), sulphur dioxide (SO2) or dust emissions during the operational phase of the Proposed Project will be minimal, relating to the use of operation and maintenance vehicles onsite, and therefore there will be no measurable negative cumulative effect with other developments on air quality. The nature of the Proposed Project is such that, once operational, it will have a long-term, moderate, positive impact on air quality. There will be no measure negative cumulative effect with other developments on air quality.

There will be a net reduction in carbon dioxide (CO2) emissions from the operation of the Proposed Project. By providing an alternative to electricity derived from coal, oil or gas-fired power stations, the Proposed Project will

result in emission savings of carbon dioxide (CO2), oxides of nitrogen (NOx), and sulphur dioxide (SO2). The production of renewable energy from the Proposed Project will have a Long-Term Moderate Positive effect on air quality due to the offsetting of approximately 56,375 tonnes of Carbon Dioxide (CO2) per annum, or 1,973,125 tonnes of carbon dioxide over the proposed 35-year lifecycle of the Proposed Wind Farm.

5.8.3.2.2 ***Air Quality: Dust and Exhaust Emissions***

Pre-Mitigation Impact

Proposed Project

The sources of dust and other emissions generated during the operational phase will be from visits by maintenance staff in light good vehicles (LGVs) approximately 1-2 visits per day, and private LGVs from tourists who may use the amenity car parks that will be provided to the public to utilise the internal amenity tracks within the site and the greater connectivity of the site to the Midlands Trail Network. Pre-mitigation impacts are considered to be slight, negative and long term, which is Not Significant.

11 Climate

This chapter identifies, describes, and assesses the potential significant direct and indirect effects on climate arising from the construction, operation and decommissioning of the Proposed Project.

The production of energy from wind turbines has no direct emissions as is expected from fossil fuel-based power stations. Harnessing more energy by means of wind farms will reduce dependency on fossil fuels, thereby resulting in a reduction in harmful emissions that can be damaging to human health and the environment.

Climate change is one of the most challenging global issues facing us today and is primarily the result of increased levels of greenhouse gases in the atmosphere. These greenhouse gases come primarily from the combustion of fossil fuels in energy use. Moving away from reliance on coal, oil and other fossil fuel-driven power plants is essential to reduce emissions of greenhouse gases and combat climate change.

A methodology for calculating carbon losses was published in June 2008 by scientists at the University of Aberdeen and the Macauley Institute with support from the Rural and Environment Research and Analysis Directorate of the Scottish Government, Science Policy and Co-ordination Division. The document, 'Calculating Carbon Savings from Wind Farms on Scottish Peat Lands', was developed to calculate the impact of wind farm developments on the soil carbon stocks held in peat. The tool provides a transparent and easy to follow method for estimating the impacts of wind farms on the carbon dynamics of peatlands.

In addition to the Macauley Institute methodology, where possible, CO2 emissions or losses associated with embodied carbon of materials used in the construction, operational and decommissioning phase of the Proposed Project have been identified using the Transport Infrastructure Ireland (TII) Carbon Tool (TII 2022)5. The TII Carbon Tool is customised for road and light rail projects in Ireland, using emission factors from recognised sources during the construction, maintenance and operation of TII projects in Ireland. Embodied carbon refers to the emissions associated with procuring, mining and harvesting raw materials, the transformation of those materials into construction products, transporting them to site, installation of these materials during a construction phase, and the subsequent replacement, removal, and disposal of these materials upon decommissioning.6

The full lifecycle and embodied carbon of the proposed turbines have been taken account of in the Macauley Institute model. The emissions associated with the embodied carbon, along with the construction phase transport movements, of the remaining features of the site are considered within the TII Carbon Tool.

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. However, the Proposed Wind Farm predominately comprises cutover peatland which has been subject to industrial peat extraction and drainage over several decades and consequently the peatland habitats and hydrology are highly degraded and modified from their original state. As such, the peatland habitat loss would not be as significant as that of an intact peatland.

5 Transport Infrastructure Ireland Carbon Tool for Road and Light Rail Projects: User Guidance Document https://www.tiipublications.ie/library/GE-ENV-01106-01.pdf

6 Irish green Building Council – What is embodied carbon? https://www.igbc.ie/what-is-embodied-carbon/

The Proposed Project will result in the loss of 261,360 tCO2e: the details of these carbon losses are provided in Table 11-5 of Chapter 11 of the EIAR. Please note that in completion of these calculations a number of assumptions have been made under theoretical precautionary conditions; all assumptions are detailed in Appendix 11-2 Carbon Calculations. Therefore, it can be determined that the actual carbon losses associated with the Proposed Project will likely be less than the values provided in Table 11-5 of Chapter 11.

During the construction and operation phase, the lands beneath the Proposed Project footprint will not be available to develop into carbon sequestering habitat. In addition, lands adjacent to the Proposed Wind Farm footprint may also be indirectly impacted through drainage and therefore also not reach their carbon sequestration potential. The permanent

infrastructure footprint of the Proposed Project measures approximately 34.3ha, which represents approximately 3% of the site (1,258ha). As such, it is the intention of the BnM to integrate the peatland rehabilitation measures associated with the Draft Rehabilitation Plan (Appendix 2-4) with the Proposed Project.

The Proposed Project will have an export capacity of approximately 90MW and therefore will help contribute towards the achievement of national and international emission reduction targets, provide much needed grid infrastructure, and the capacity to offset 56,375 tCO2e per annum, or 1,973,125 tCO2e over the proposed 35-year operational life. Carbon losses to the atmosphere will be offset by the Proposed Project in approximately 56 months (4.6 years) of operation.

Following construction of the Proposed Project, there will be a Permanent, Imperceptible Negative effect on Climate as a result of greenhouse gas emissions from construction plant and vehicles, and embodied carbon associated with the turbines and construction materials. During the operational phase of the Proposed Project, there will be a Long-term, Moderate, Positive effect on Climate as a result of reduced greenhouse gas emissions from the operation of the Proposed Project and the enhancement areas proposed.

Reference No 157 : Calculating potential carbon losses and savings from wind farms on Scottish peatlands: Note – Version 2.10.0.

The Applicant quotes this reference in the Planning Application & then ignores the equations for calculations that it provides.

Carbon emission savings from wind farms 12. Carbon emission savings are calculated using the emission factor, Efuel, for the counterfactual case for power generation. . Identifying the generation that would have been used had the wind farm not generated is difficulty, particularly when considering operation of the wind farm stretching 20 – 25 years into the future. For this reason a number of assumption need to be made regarding the generation that a new wind farm will displace across its lifetime. At present, additional wind generation tends to displace with Gas and Coal generation depending on which technology is currently marginal. Therefore at present, the carbon saving of wind would be calculated from an appropriate weighted average of these technologies. However, within five to fifteen years, projections of the installed capacities and the dispatch of that capacity suggests this assumption will no longer be valid. Therefore carbon emission savings from wind farms should be calculated using the fossil fuel sourced grid mix as the counterfactual, rather than the grid mix. The fossil fuel mix emission factor to use could be either the average fossil fuel mix, revised on an annual basis, or a range calculated from a 5 year average (2010-2014 = 0.648 tCO2 MWh-1 – Digest of the United Kingdom Energy Statistics, 2013; 2014; 2015). 13. This Technical Note follows the example given by The Carbon Trust (2004) adapted for coal fired generation, fossil fuel mix generation and the overall generating grid mix. A

renewable energy development will have a maximum potential to 'save' carbon emissions if it is substituting coal fired generation. However, in most circumstances it is not possible to define the electricity source for which a renewable electricity project will substitute. The calculations in this Note include options for three sets of figures i.e. substitution for coal generated electricity, substitution for fossil fuel generated electricity and substitution for grid mix.

14. Because of the variability of the wind, the amount of energy a wind farm actually produces, εout (MWh yr-1), is a function of the capacity factor at the site, $p$cap (%), as well as the number of turbines, $n$turb, and the turbine capacity, $c$turb (MW).

$$\varepsilon_{out} = 24 \times 365 \times \frac{p_{cap}}{100} \times n_{turb} \times c_{turb}$$

Capacity factors for Scotland range between 22.7% and 29.2% (DECC,2015;https://www.gov.uk/government/statistics/regional-renewable-statistics). Site specific capacity factors may be determined at the site planning stage, and should be used preferentially in these calculations. If these are not available, calculations for Scotland should be repeated with capacity factors 20% and 30% to give estimates of the lowest and highest carbon emission savings. For calculations in other countries, the appropriate published range of capacity factors should be used.

15. The annual emission savings, *S*fuel (tCO2 yr-1), are estimated by multiplying the total annual energy output, *ε*out (MWh yr-1), by the emission factor, *E*fuel (t CO2 MWh-1), for the counterfactual case (i.e. coal fired generation, fossil fuel mix generation and average UK grid mix – see paragraph 9)

$$S_{\text{fuel}} = \varepsilon_{\text{out}} \times E_{\text{fuel}}$$

Loss of carbon due to production, transportation, erection, operation and decommissioning of wind farm

16. Ideally, a full life cycle analysis should be carried out to calculate the total loss of C due to the infrastructure overhead of the wind farm, *L*life (t CO2). This analysis may be prohibitively expensive on a site-by-site basis, so generic data are provided as an alternative.

17. Carbon emissions from the full life cycle of a wind farm include CO2 emissions that occur during production, transportation, erection, operation, dismantling and removal of turbines, foundations and the transmission grid from the existing electricity grid, *E*life (t CO2 MW-1). Appropriate values reported in the peer-reviewed literature range from 0.006 (White & Kulcinski 2000) to 0.034 t CO2 MWh-1 (White 2007), unless the turbines are produced in countries with very high-emission grid mixes such as Japan (infrastructure overhead 1.237 t CO2 MWh-1; Lenzen & Munksgaard 2002).

18. Defensible figures for the specific type of turbine and its place of manufacture should be used wherever possible, but if these are unavailable, CO2 emissions due to the infrastructure overhead, *L*life (t CO2), can be estimated from the turbine capacity, *c*turb (MW), using the following equation for turbines of capacity less than 1MW

Llife = 517.62 × cturb – 0.1788

and equal to or greater than 1MW

Llife = 934.35 × cturb – 467.55

These equations were derived from data for 21 European sites (Lenzen & Munksgaard 2002, Vestas 2005, Ardente et al. 2006). The equation for turbines of capacity less than 1 MW was derived from 14 measurements by regression analysis, and has an associated R2 value of 63%, $P < 0.001$. By statistical convention, the relationship can be considered to be highly significant if $P < 0.01$. The equation for turbines of capacity equal to or greater than 1 MW was derived similarly from seven measurements; the associated R2 value is 85%, $P < 0.01$, and thus again highly significant.

Emissions due to use of concrete in construction, *L*concrete (t CO2), are calculated from the entered volume of concrete used, *V*concrete (m3), and the emission factor for reinforced foundations, *E*concrete (t CO2 m-3 concrete), as ***Lconcrete=Vconcrete×Econcrete***

The value for *E*concrete is assumed to be 0.316 t CO2 m-3 concrete (The Concrete centre, 2013)

Change in carbon dynamics of peatlands

23. Peatlands (which include mires, fens, bogs and other wetlands associated with peatland) contain huge reservoirs of carbon. Globally, they represent over one-third of the carbon in all soils (Hargreaves et al., 2003). The total amount of carbon held in organic soils in Scotland is 2735 Mt C, with 1778 Mt C being held in peats (including blanket peats, basin peats, and semi-confined peats; Smith et al, 2007). In their undisturbed state, peatlands emit the greenhouse gas methane, but accumulate carbon derived from the atmosphere. Emissions of the greenhouse gas nitrous oxide are usually negligible in unfertilised peatlands (IPCC, 1997). Overall, peats represent a large reservoir of CO2 captured by plants and held in soils. The first step in the accumulation of carbon in soil is sequestration from the atmosphere by vegetation through photosynthesis. The second step is storage in soil organic matter. Organic matter accumulates primarily in response to anaerobic, waterlogged conditions and low potential for decomposition either through temperature or acidity constraints in the soil. Wind farm development on peatlands will result in a change in the carbon dynamics by changing the carbon inputs and altering peatland hydrology, which affects soil organic matter turnover. This Note calculates both the direct and indirect impacts of a wind farm development on the carbon dynamics of peatlands. Changes in carbon due to habitat improvement and site restoration are also included to give a holistic measure of the effect of wind farm development on the carbon dynamics of peatland.

Loss of carbon fixing potential of peatlands

24. The development of a wind farm requires the construction of infrastructure such as turbine foundations, crane hard standings, access tracks and works compounds. Generally, peat is removed from these areas and as a result there is a loss of the carbon fixing potential of the associated vegetation. During construction and operation of a wind

farm, the soil may be drained by design or unintentionally. Drainage has significant effects on the vegetation of peatlands (Stewart and Lance, 1991). Here, the loss of the carbon fixing potential of the peatland is calculated for the area from which peat is removed and also for the area affected due to drainage.

25. The estimated global average for the apparent carbon accumulation rate in peatland ranges from 0.12 to 0.31 t C ha-1 yr-1 (Turunen et al., 2001; Botch et al., 1995). If it is available, site specific data can be used. However, this loss represents a very small proportion of the total emissions, so the mid-range value used in the previous guidance (0.25 t C ha-1 yr-1 = 0.92 t CO2 ha-1 yr-1) provides an adequate estimate. Loss of carbon fixing potential of peatland, *L*fix (t CO2), is calculated from the area affected by wind farm development (both directly by removal of peat, *A*direct (ha – see paragraph 32), and indirectly by drainage *A*indirect (ha – see paragraph 40)), the annual gains due to the carbon fixing potential of the peatland, *G*bog (*G*bog = 0.92 t CO2 ha-1 yr-1), and the time required for habitat restoration, *t*restore (years

$$L_{fix} = (A_{direct} + A_{indirect}) \times G_{bog} \times t_{restore}$$

Changes in carbon stored in peatlands

Note: this carbon represents the greatest risk in terms of potential loss of carbon dioxide because peat takes a long time to accumulate in temperate regions and hence site restoration and carbon savings need to reflect this.

26. During wind farm construction, carbon is lost directly from the excavated peat and indirectly from the area affected by drainage.

27. The potential impact of peat removal is estimated from the volume of peat removed by different practices. Loss of carbon from the excavated peat is assumed to be 100%. If the excavated carbon is later restored, so potentially reducing the carbon losses from excavated peat, this is added to the area and depth of the improved site. This allows good peat preservation practices to be accounted for in the C emission savings.

28. Indirect loss of carbon due to drainage is estimated using default values from the Intergovernmental Panel on Climate Change (IPCC) (IPCC, 1997) as well as by more site specific equations derived from the scientific literature (Smith et al., 2007; Nayak et al., 2008).

29. Carbon gains due to habitat improvement are similarly estimated using IPCC default values (IPCC, 1997) and the more site specific equations derived from the scientific literature (Smith et al., 2007; Nayak et al., 2008).

Loss of carbon from removed peat

30. The total volume of peat removed during construction, *V*direct (m3), is calculated from the dimensions of structures introduced to the site during development (average length, *l*i (m), width, *w*i (m), and depth, *d*peat,i (m) of each construction, *i*). Borrow pits, turbine foundations, hard-standing area and access tracks are currently included in the spreadsheet.

$$V_{direct} = \sum (l_i \times w_i \times d_{peat,i})$$

The total area of peat removed, *A*direct (m2), is calculated similarly using average length and width.

If the length and width at the bottom is less than at the surface, this is accounted for in the calculation of volume.

The volume and area of any additional peat excavated can also be entered directly.

31. Loss of carbon from the removed peat, *L*direct (t CO2), is assumed to be 100%. If peat is later returned to the site with full restoration of the habitat and hydrological conditions, the volume of restored peat is added to the calculation of C emission savings due to site improvement. However, for this option to be used, the restoration plan should demonstrate a high probability that peat hydrology will be restored and disturbance of peat minimised.

32. Loss of carbon from the removed peat, *L*removed (t CO2), is calculated from the carbon content of dry peat, *pC*drypeat (%), the dry soil bulk density (dried to a constant weight at 105^0 C), *BD*drysoil (g cm-3), and the volume of peat removed, *V*direct (m3).

$$L_{\text{removed}} = \frac{3.667}{100} \times pC_{\text{dry peat}} \times BD_{\text{dry soil}} \times V_{\text{direct}}$$

When flooded, peat soils emit less carbon dioxide but more methane than when drained. In flooded soils, carbon dioxide emissions are usually exceeded by plant fixation, so the net exchange of carbon dioxide with the atmosphere is negative and soil carbon stocks increase. When soils are aerated carbon dioxide emissions usually exceed plant fixation, so the net exchange of carbon dioxide with the atmosphere is positive. To calculate the carbon emissions attributable to removal of the peat only, *L*direct (t CO2 eq.), any emissions occurring if the soil had remained in situ and undrained are subtracted from the emissions occurring after removal.

$$L_{\text{direct}} = L_{\text{removed}} - L_{\text{undrained}}$$

Calculation of the losses from undrained soil is described in paragraph 45.

Loss of carbon from drained peat

Estimation of volume of peat affected by drainage

33. The extent of drainage around the site of construction strongly influences the total volume of peat impacted by the construction of the wind farm. Where sufficient measurements are available to describe the hydrological features of the wind farm area, this should be used together with a detailed hydrological model to simulate the likely changes in peat hydrology. If insufficient measurements are available, a worst case estimate of extent of drainage around the development features should be used.

34. The volume of peat affected by drainage is calculated assuming the additional drained zone of *e*drain (m) on each side of the construction. The depth of drainage is assumed to show a linear decline from the edge and depth of the drainage feature to the water table depth at the extent of drainage. Note that the area where peat is removed should not be included because carbon loss from removed peat has already been counted in direct losses. The calculation of volume affected by drainage, *V*indirect,i (m3), uses the extent of drainage, *e*drain (m), average length, *l*i (m), width, *w*i (m), and depth of drainage, *d*drain,i (m) for each construction feature, *i*.

35. For borrow pits, and turbine and hard-standing foundations, the depth of drainage, *d*drain,i (m), is assumed to be equivalent to the depth of the construction. The calculation uses the following equation.

$$V_{\text{indirect,i}} = 0.5 \times d_{\text{drain,i}} \times ((((2 \times e_{\text{drain}}) + l_i) \times ((2 \times e_{\text{drain}}) + w_i)) - (l_i \times w_i))$$

(equation for turbine and hard-standing foundations)

The volume drained around switching stations, site compounds and lay-down areas can be calculated similarly. If permanent drainage around foundations and hard-standing is not required, the area should be assumed to be drained only up to the time of completion of backfilling, removal of any temporary surface drains, and full restoration of the hydrology. The carbon losses are then reduced from the restored area as discussed in paragraphs 42 to 56.

36. For access tracks, the depth of any drainage and the area included is dependent on the type of track. For excavated and rock-filled roads, the depth of drainage, *d*drain,i (m), is assumed to be equivalent to the depth of the track. The peat removed or displaced by construction of the track is not included in the drained volume. The volume affected by drainage is calculated using the following equation.

$$V_{\text{indirect},i} = 0.5 \times d_{\text{drain},i} \times (l_i \times (2 \times e_{\text{drain}}))$$

(equation for cable trenches, excavated and rock-filled roads)

The volume affected by drainage around cable trenches with permeable linings (e.g. sand) that deviate from the lines of tracks should also be calculated using the above equation.

37. For floating roads, drainage is only included for the length of track that has been specifically drained, and the depth of drains is taken to be as specified for the drains. Since floating roads are known to sink in many cases, evidence should be provided about the risk of requirements for additional drainage. The volume affected by drainage is calculated using the following equation.

$$V_{\text{indirect},i} = 0.5 \times d_{\text{drain},i} \times (l_i \times ((2 \times e_{\text{drain}}) + w_i))$$

(equation for floating roads)#

38. The total volume of peat affected by drainage, *V*indirect (m3), is the sum of the volumes of peat affected around each type of construction, *V*i,indirect (m3).

$$V_{\text{indirect}} = \sum_i V_{\text{indirect},i}$$

The total area of peat affected by drainage, *A*indirect (m2), is calculated similarly from the length and width of constructions and the estimated extent of drainage.

Loss of carbon from drained peat if the site is not restored after decommissioning

39. When flooded soils are drained, loss of soil carbon continues until a new stable state is reached. For peats, this is close to 0% carbon (IPCC, 1997). Therefore, if the site is not restored after decommissioning of the wind farm, it is assumed that 100% of the carbon will be lost from the drained volume of soil. The loss of carbon from the drained peat, *L*drained (t CO2), is calculated from the carbon content of dry peat, *pC*dry peat (%), the dry soil bulk density (dried to a constant weight at 105 C), *BD*dry soil (g cm-3), and the volume of peat drained, *V*indirect (m3).

$$L_{\text{drained}} = \frac{3.667}{100} \times pC_{\text{dry peat}} \times BD_{\text{dry soil}} \times V_{\text{indirect}}$$

Loss of carbon from drained peat if the site is restored after decommissioning

40. Restoration of the site could potentially halt carbon loss processes, allowing carbon dioxide emissions to be limited to the time before the habitat and hydrological conditions are restored. The amount of carbon lost is then calculated from the annual emissions of methane, *E*CH4 (t CO2 eq. ha-1 yr-1), and carbon dioxide, *E*CO2 (t CO2 ha-1 yr-1), the area of drained peat, *A*indirect (ha), and the time until the site is restored, *t* (years). However, for this option to be used, the restoration plan should demonstrate a high probability that peat hydrology will be restored across the site (water table at the surface for over 50% of the year), disturbance of the remaining peat will be minimised, and peat forming vegetation will develop in areas from which peat was removed or drained. If restoration of the site is inadequate, the amount of carbon lost will be in between the range of values calculated for restored (paragraph 46) and non-restored sites (paragraph 41).

41. Methane emissions are calculated using the following equation:

$$E_{\text{CH4}} = R_{\text{CH4}} \times \frac{D_F}{365} \times C_{\text{CH4-C}\rightarrow\text{CO2}}$$

where *ECH4* is the total annual emissions of CH4 (t CO2 eq. ha-1 yr-1), *RCH4* is the annual rate of CH4 emissions (t CH4-C ha-1 yr-1), *DF* is the number of days in the year that the land is flooded, and *CCH4-C CO2* converts CH4-C

to CO2 equivalents (*CCH4-C CO2* = 30.67 CO2 eq. (CH4-C)-1). The emission factors used (*R*CH4, and *D*F) differ between drained and undrained conditions as described in paragraphs 49 to 54.

42. Carbon dioxide emissions are calculated using the following equation:

$$E_{CO2} = R_{CO2} \times \frac{(365 - D_F)}{365}$$

where *E*CO2 is the total annual emissions of CO2 (t CO2 ha-1 yr-1), *R*CO2 is the annual rate of carbon dioxide emission (t CO2 ha-1 yr-1), *D*F is the number of days in the year that the land is flooded. The emission factors used (*R*CO2, and *D*F) differ between drained and undrained conditions as described in paragraphs 49 to 54.

43. The total loss of carbon from the peat before drainage, *L*undrained (t CO2 eq.), is calculated from the annual emissions of methane, *E*CH4 (t CO2 eq. ha-1 yr-1), the annual emissions of carbon dioxide, *E*CO2 (t CO2 ha-1 yr-1), the area to be drained, *A*indirect (ha), and the time to restoration (assumed to be the life time of the wind farm), *t* (years).

$$L_{undrained} = (E_{CH4} + E_{CO2}) \times A_{indirect} \times t$$

44. The total loss of carbon from the drained peat, *L*drained (t CO2 eq.), is calculated, using the same equation, but calculating the annual emissions of carbon dioxide, *E*CO2 (t CO2 ha-1 yr-1) and methane, *E*CH4 (t CO2 eq. ha-1 yr-1) for a drained soil. Methane emissions will be negative or close to zero due to oxidation of methane by the soil.

$$L_{drained} = (E_{CH4} + E_{CO2}) \times A_{indirect} \times t$$

45. Peat soils emit less carbon dioxide but more methane when flooded than drained. In flooded soils, carbon dioxide emissions are usually exceeded by plant fixation, so the net exchange of carbon dioxide with the atmosphere is negative and soil carbon stocks increase. In drained soils, carbon dioxide emissions usually exceed plant fixation, so the net exchange of carbon dioxide with the atmosphere is positive. To calculate the carbon emissions attributable to drainage only, *L*indirect (t CO2 eq.), any emissions occurring if the soil had remained undrained are subtracted from the emissions occurring after drainage.

$$L_{indirect} = L_{drained} - L_{undrained}$$

46. The annual emissions of methane and carbon dioxide can be estimated either using the IPCC default methodology (IPCC, 1997), or using more site specific equations derived from the scientific literature (Nayak et al., 2008).

Calculation of changes in methane and carbon dioxide emissions from drained peat based on IPCC Guidelines

47. The IPCC default factors for acid bogs and fens in cool temperate zones used in paragraphs 43 and 44 are given in Table 3. When the soil is undrained, the period of flooding is based on the monthly mean temperature and the length of inundation. When the soil is drained, the period of flooding is assumed to be zero (*DF* = 0 days yr-1).

	Acid Bogs	Fens
Number of days in the year that land is flooded, DF	178	169
Annual rate of CO2 emissions from drained soils, *R*CO2 (t CO2 ha-1 yr-1)	35.2	35.2
Annual rate of CH4 emissions from flooded soils, *R*CH4 (t CH4-C ha-1 yr-1)	4.015 x 10-2	0.219

Table 3. IPCC default emission factors used to calculate methane and carbon dioxide emissions

48. These are widely accepted, generic emission factors, but the figures are averaged across cool temperate peatlands and allow no use of site specific information, such as water table depth before wind farm development. Under the impacts of climate change, or if the site is not a pristine peatland, the water table depth may already have been lowered before any drainage associated with the development. In this case, it is recommended that the more site specific factors given below are used as described in the next section.

Calculation of changes in methane and carbon dioxide emissions from drained peat using site specific equations

49. Methane emissions are calculated using the site specific equation described by Nayak et al. (2010). For acid bogs, the annual rate of methane emissions, *R*CH4, (t CH4-C (ha)-1 yr-1) is calculated as shown below.

$$R_{CH4} = \frac{1}{1000} \times \exp(-0.1234 \times (d_{water} \times 100)) + ((3.529 \times T) - 36.67)$$

where *T* is the average annual air temperature (C), *pH* is the soil pH and *d*water is the water table depth (m). This equation was derived from 57 experimental measurements. The equation shows significant correlation with measurements (r2 = 0.54, P>0.05. By statistical convention, if P>0.05 this relationship can be considered to be highly significant. Evaluation against 29 independent experiments shows a significant association (r2=0.81; P>0.05) and an average error of 27 t CH4-C ha-1 yr-1 which is non-significant (P<0.05) (Smith et al., 1997).

50. For fens, the annual rate of methane emissions, *R*CH4, (t CH4-C (ha)-1 yr-1) is calculated as shown below.

$$R_{CH4} = \frac{1}{1000} \times (-10 + 563.62 \times \exp(-0.097 \times (d_{water} \times 100)) + (0.662 \times T))$$

where *T* is the average annual air temperature (^{0}C), *pH* is the soil pH and *d*water is the water table depth (m). This equation was derived from 35 experimental measurements. The equation shows significant correlation with measurements (r2 = 0.41, P>0.05. Evaluation against 7 independent experiments shows a significant association (r2=0.69; P>0.05) and an average error of 164 t CO2 ha-1 yr-1 (significance not defined due to lack of replicates) (Smith et al., 1997).

51. For acid bogs, the annual rate of carbon dioxide emissions, *R*CO2, (t CH4-C (ha)-1 yr-1) is calculated as shown below.

$$R_{CO2} = \frac{3.667}{1000} \times (6700 \times \exp(-0.26 \times \exp(-0.0515 \times ((d_{water} \times 100) - 50))) + (72.54 \times T) - 800)$$

where *T* is the average annual air temperature (C), *pH* is the soil pH and *d*water is the water table depth (m). This equation was derived from 60 experimental measurements. The equation shows significant correlation with measurements (r2 = 0.53, P>0.05. Evaluation against 29 independent experiments shows a significant association (r2=0.21; P>0.05) and an average error of 3023 t CO2 ha-1 yr-1 which is non-significant (P<0.05) (Smith et al., 1997).

52. For fens, the annual rate of carbon dioxide emissions, *R*CO2, (t CO2-C (ha)-1 yr-1) is calculated as shown below.

$$R_{CO2} = \frac{3.667}{1000} \times .(16244 \times \exp(-0.175 \times \exp(-0.073 \times ((d_{water} \times 100) - 50))) + (153.23 \times T))$$

where *T* is the average annual air temperature (^{0}C), *pH* is the soil pH and *d*water is the water table depth (m). This equation was derived from 44 experimental measurements. The equation shows significant correlation with measurements (r2 = 0.42, P>0.05. Evaluation against 18 independent experiments shows a significant association (r2=0.56; P>0.05) and an average error of 2108 t CO2 ha-1 yr-1 (significance not defined due to lack of replicates) (Smith et al., 1997).

53. The experimental data used to derive the above equations were collated during the development and evaluation of the ECOSSE model (Smith et al., 2007). Note that further improvement in a site specific estimate of methane, carbon dioxide and dissolved organic carbon losses could be obtained using measurements taken at the site to run a peer-reviewed and proven model of carbon dynamics, such as ECOSSE.

54. These more site specific annual emission rates are used in the equations given in paragraphs 43 and 44, assuming days of flooding, *DF*, given in Table 2 to estimate annual emissions of carbon dioxide and methane.

Loss of carbon dioxide due to leaching of dissolved and particulate organic carbon

55. Lowering the water table by drainage may reduce the potential for dissolved and particulate organic carbon retention within the soil (e.g. Holden et al., 2004; Worrall et al., 2004) as well as increasing the decomposition rates (due to increased aeration). A recent study by Wallage et al. (2006) confirms that losses of dissolved organic carbon are higher from drained than undrained peats. Losses of carbon dioxide due to leaching of dissolved organic carbon, LDOC (t CO2), are calculated by multiplying the sum of the gaseous losses of carbon from the different sources in the soil, Lgas (t C), by the percentage of the total gaseous loss of carbon that is leached as dissolved organic carbon, pDOC (%), and the percentage of leached dissolved organic carbon that is emitted as carbon dioxide, Pdoc➡CO2 (%).

$$L_{DOC} = 3.667 \times \frac{p_{DOC \rightarrow CO2} \times p_{DOC}}{100} \times L_{gas}$$

56. Losses due to leaching of dissolved organic carbon are assumed to be less than 26% of total gaseous carbon loss from the drained, restored and improved habitat peat land (pDOC = 10) following the work of Worrall et al. (2009). It is assumed that 100% of the dissolved organic carbon is emitted as carbon dioxide (pDOC CO2 = 100). Losses of particulate organic matter are calculated similarly, assuming the percentage loss is less than 8% of the total gaseous carbon losses after Worrall et al. (2009).

57. In the example, total gaseous emissions of carbon were small, resulting in low losses of dissolved organic carbon. This was due to the large proportion of the site that was improved.

Loss of carbon due to peatslide

58. The Scottish Executive (2006) has established a rigorous procedure for identifying existing, potential and construction induced peat landslide hazards. This should lead to a reduced likelihood of peat landslides occurring due to the wind farm development. Any drainage measures used to mitigate the risk should be accounted for using the methods described in paragraphs 42 to 56. It is assumed that the required measures to avoid peat landslides have been taken, so that the risk of peat landslide is minimal. Therefore this potential source of carbon loss is omitted from the guidance. Note that less catastrophic erosion losses, such as those due to collapse of gullies, is not covered by the procedures to reduce peat landslides, but has not yet been included in this guidance.

Changes of carbon due to forestry clearance

59. The presence of extensive areas of forestry on and in the vicinity of the wind farm site can significantly reduce the yield of wind energy, so it may be necessary to clear existing forestry. The losses of carbon from tree biomass depend on the fate of wood products following felling. Forestry may be felled earlier than planned due to the wind farm development, so limiting the nature and longevity of wood products. If a forestry plantation was due to be felled with no plan to replant, the effect of the land use change is not attributable to the wind farm development and should be omitted from the calculation. If, however, the forestry is felled for the development, changes in timber, residues and changes in soil conditions are attributable to the wind farm and should be accounted for.

60. The amount of carbon loss from timber and residues depends on the type of tree, the age of crop on felling, the end use of the timber and how quickly any stored carbon is returned to the atmosphere (Cannell, 1999). Losses from forestry are calculated from either a simple forest C loss calculation (Sheet 7i) or a more detailed forest C loss calculation (Sheet 7ii). The advantages of the detailed method of forest carbon accounting can be summarised as (1) an enhanced calculation of forest growth forgone, including broad-scale capture of influence of site, and calibration for two conifer species, (2) the ability to grow short rotation forestry after forest clear-felling, (3) the potential to account for felled woody biomass, as a net gain to the developer, through provision as woody biomass for biofuel (a consistent approach with an immediate short-term carbon benefit) and (4) an incorporation of forest management (tree height impact) on turbine output via a simple wind speed ratio approach.

61. Loss of carbon dioxide due to forestry clearance, Lforest (t CO2) is calculated in both methods from the area of forestry to be felled, Aforest (ha), the average carbon sequestered per year, Gforest (t CO2 ha-1 yr-1) and the lifetime of the wind farm, t (years).

$$L_{forest} = A_{forest} \times G_{forest} \times t$$

The methods differ in the approach used to calculate Gforest.

***Simple* method for calculating carbon sequestered in forestry**

62. In the simple method, *G*forest is obtained from estimates provided by Cannell (1999) for the amounts of carbon sequestered by fast growing trees (~26 yr rotation, e.g. poplar), medium (55 yr rotation, e.g. Sitka spruce), and slow growth (92 yr rotation, e.g. beech). The amount of carbon sequestration by different species of tree is shown in Table 4.

	Poplar	**Sitka**	**Beech**
Yield Class (m3 ha-1 yr-1)	12	16	6
Carbon sequestered, *G*forest (t CO2 ha-1 yr-1)	26.8	13.2	8.8
Crop rotation, *t*forest (years)	26	55	92
CO2 sequestered per crop rotation (t CO2 ha-1)	694.66	724.68	808.86

Table 4. Carbon sequestration for different species of tree

Accumulated temperature				
		Less than 1050 ^{0}C yr-1	*1050 to 1350 ^{0}C yr-1*	*More than 1050 ^{0}C yr-1*
Soil type	*Code*	*1*	*2*	*3*
Peaty Gley	*1*	0.3178	0.3551	0.3720
Deep Peat	*2*	0.3177	0.3569	0.3679

Detailed method for calculating carbon sequestered in forestry

Environmental modifier used in simplified 3PGN

63. The detailed method, *G*forest is calculated using a simplified version of 3PG tree growth model and incorporates differences due to age of forestry at felling (Xenakis et al, 2008). This simplified version of 3PGN does not require site specific climate data as no explicit site environmental modifier is calculated. Instead, it uses a factor (from 0 to 1) representing the total effect of environment on growth (Xenakis, 2007).

Light Interception

64. The photosynthetically active radiation absorbed by the forestry, Øpa(forest) (MJ m-2 yr-1), is obtained from the leaf area index of the forestry, *LAI*forest (m2 m-2) as

$$\emptyset_{pa(forest)} = \emptyset_p \times \left(1 - \exp(-k_{ext} \times LAI_{forest})\right)$$

where Øp is the average annual photosynthetically active radiation (MJ m-2 yr-1), and *k*ext is the light extinction coefficient. The average annual sum of solar irradiance of 800kWh was obtained from http://re.jrc.ec.europa.eu/pvgis/countries/europe.htm (solar irradiance map of UK), which converts to Øp= 2880 MJ m-2 yr-1. The light extinction coefficient, *k*ext, is set to 0.5 (Xenakis et al., 2008). The leaf area index of the forestry, *LAI*forest (m2 m-2), is obtained from the specific leaf area for the species, *SLA* (m2 kg-1 C), and a lookup table of foliage biomass with respect to age of the stand, *W*f (kg C m-2),

$$LAI_{forest} = W_f \times S_{LA}.$$

The value of *SLA* is set to 6 m2 kg-1 C for Scots Pine (Xenakis et al., 2008), and 8 m2 kg-1 C for Sitka Spruce (fitted to data). The value of *W*f(t) (kg C m-2) (the foliage biomass at any time (t)) is calculated from value *W*f(t−1) (kg C m-2) (the foliage biomass in the previous timestep (t-1)), the proportion of foliage thinned in that time-step, *p*thin, the proportion of the carbon allocated to the foliage, *p*foliage, and the leaf longevity, *l*foliage (years), as

$$W_{f(t)} = W_{f(t-1)} \times (1 - p_{thin}) + \left(n_{step} \times \left((NPP_{trees(t-1)} \times p_{foliage}) - p_{loss} \left(\frac{W_{f(t-1)}}{l_{foliage}} \right) \right) \right)$$

where *p*lossis the proportion of potential leaf loss occurring. Up to 6 years after replanting, *p*loss is set to 0, after 6 years, foliage loss due to age is assumed to start and *p*lossis set to 1. The proportion of carbon allocated to the foliage, *p*foliage, is assumed to be 0.25 (Magnani et al., 2007), and the leaf longevity, *l*foliage, is calibrated from observed data to be 4 years for Scots Pine and 7 years for Sitka Spruce. To avoid the need for lengthy inputs, the thinning regime is currently assumed as opposed to being entered.

65. The photosynthetically active radiation absorbed by the understorey, Øpa(understorey) (MJ m-2 yr-1), is calculated similarly from the remaining incident radiation, Øp−Øpa(forest) (MJ m-2 yr-1), and the leaf area index of the understorey, *LAI*understorey (m2 m-2),

$$Ø_{pa(understorey)} = (Ø_p - Ø_{pa(forest)}) \times \left(1 - \exp(-k_{ext} \times LAI_{understorey})\right)$$

The leaf area index of the understorey is set to 3.00, (*LAI*understorey=3.00 m2 m-2) after Magnani et al. (2007).

66. The absorbed photosynthetically active radiation that is actually utilised by the forestry, Øpau(forest) (MJ m-2 yr-1), is estimated from Øpa(forest) using the environmental reduction factor described above, fE, and a modifier for age, $f$age,

$$Ø_{pau(forest)} = Ø_{pa(forest)} \times f_{age} \times f_E.$$

The modifier for age, $f$age, is obtained from the age where 50% reduction in light use efficiency, *A*half (yrs), is observed,

$$f_{age} = \frac{1}{\left(1 + \left(A/A_{half}\right)^4\right)}$$

where *A* is the age of the stand (yrs). The value of *A*half is set to 100 years for Scots Pine (Xenakis et al., 2008), and 120 years for Sitka Spruce (Magnani et al., 2007)

67. The absorbed photosynthetically active radiation that is actually utilised by the understorey, Øpau(understorey) (MJ m-2 yr-1), is estimated from Øpa(understorey) using the environmental reduction factor described above, fE, but without a modifier for age as the understorey is assumed to regenerate each year.

$$Ø_{pau(understorey)} = Ø_{pa(understorey)} \times f_E.$$

Primary productivity

68. The gross primary production of trees, *GPP*trees (kg C m-2 yr-1), is calculated from Øpau(forest) (MJ m-2 yr-1) using the maximum light use efficiency for the tree species, ε (kg C MJ-1 day-1),

$$GPPtrees = \varepsilon \times Øpau(forest).$$

The value of ε -is assumed to be 0.00152 kg C MJ-1 day-1 for Scots Pine (Xenakis et al., 2008) and 0.00166 kg C MJ-1 day-1 for Sitka Spruce (Minnuno et al., 2010).

The net primary production of the trees, *NPP*trees (kg C m-2 yr-1), can then be calculated using a standard ratio for NPP:GPP, Y = 0.47 after Waring (2000) and Minnuno et al. (2010).

$$NPPtrees = Y \times GPPtrees.$$

The net primary production of the understorey, *NPP*understorey (kg C m-2 yr-1), is calculated similarly,

$$NPPunderstorey = Y \times \varepsilon \times \emptyset pau(understorey).$$

The maximum light use efficiency, ε (kg C MJ-1 day-1), is currently assumed to be equivalent to the value given for the selected forestry species.

The total net primary production of the forestry and understorey, *NPP*total (t C ha-1 yr-1), is then calculated by adding the net primary production of trees and understorey and multiplying by 10 to convert kg C m-2 yr-1 to t C ha-1 yr-1,

$$NPPtotal = 10 \times (NPPtrees + NPPunderstorey).$$

Cleared Forest Floor Emissions

69. Loss from soils of non-forested land is given by the estimated rate of C loss for two peat depths taken from Zerva et al (2005) for peaty gley (peat depth 5 to 50cm = 3.98 t C ha-1 yr-1), and Hargreaves et al (2003) for deep peat (peat depth>50cm = 5.00 t C ha-1 yr-1).

Emissions from harvesting operations

70. Operational losses due to harvesting are provided by the user. Morison et al (2011) gives emission factors for the UK. If clearfelling is assumed to be performed by harvester and timber is assumed extracted with forwarder, the emissions, *E*harv (g CO2 m-3) are 6657 g CO2 m-3. The total emissions due to harvesting operations, *L*harv (t CO2) are then given by

$$Lharv = Vharv \times Aharv \times Eharv106$$

where *V*harv is the volume harvested in each hectare (m3 ha-1) and *A*harv is the area harvested (ha).

Savings from use of felled forestry as biofuel

71. Carbon savings can be accounted for in the C calculator due to the timber felled being used as a biofuel. The weight of biomass from the felled forestry, *W*felled (t), is given by the area of felled plantation, *A*felled (ha), the carbon content of the felled forestry, *C*felled (t C ha-1) and the C:biomass ratio of the felled forestry, *r*C:Biomass, as shown below

$$Wfelled = Afelled \times CfelledrC:Biomass.$$

Carbon in the felled forestry, *C*felled (t C ha-1), is calculated from the simplified 3PGN model described above. Wood biomass can be converted to dry weight using wood density based values from Lavers (1983) with a subsequent assumption that C:dry matter ratio is 50% (Matthews 1993) giving the C:biomass ratio, *r*C:Biomass. For simplicity an integrated factor, the 'wood density to biomass factor' taken from Mason et al. (2009) can be used to supply the value of *r*C:Biomass.

72. The assumption is for co-firing or delivery to a biomass specific electricity generating station. Therefore, the savings in CO2 emissions associated with using the felled forestry as a biofuel, *S*felled→biofuel (t CO2) is calculated from the weight of biomass from the felled forestry, *W*felled (t), the energy value of the felled forestry as a biomass fuel, ϵfelled (MWh t-1) and the emission factor, *E*fuel (t CO2 MWh-1), for the counterfactual case

$$Sfelled \rightarrow biofuel = Wfelled \times \epsilon felled \times Efuel.$$

The counterfactual case is currently assumed in the C calculator to be fossil fuel-mix.

73. Carbon losses associated with transportation of woody biomass are calculated using transportation distance, *D*transport (km), and CO2 emissions due to transportation, *E*transport (t CO2 km-1), and the weight of biomass from the felled forestry, *W*felled (t)

$$Ltransport = Dtransport \times Etransport \times Wfelled \; Ltransport = Dtransport \times Etransport$$

Assuming 20% of journey distance occurs on forest roads, Etransport can be assumed to be 3.933 t CO2 km-1 t-1 (Morison et al. 2011).

74. Net carbon losses associated with using the felled forestry as a biofuel, Lfelled→biofuel (t CO2), are then given by the difference between the losses associated with transportation, Ltransport (t CO2), and the savings due to using the felled forestry as a biofuel, Sfelled→biofuel (t CO2),

$$Lfelled \rightarrow biofuel = Ltransport - Sfelled \rightarrow biofuel.$$

Savings from use of replanted forestry as a biofuel

75. Replanted forestry productivity is captured using the same simplified 3PGN model output as described above. Productivity is again constrained by soil type and temperature. A wood density to biomass factor is applied as outlined above, as are emissions due to transport. This then allows the weight on felling of biomass from the replanted forestry, Wreplanted (t), to be obtained from the area of replanted forestry, Areplanted (ha), the carbon content of the replanted forestry, Creplanted (t C ha-1) and the C:biomass ratio of the replanted forestry, rC:Biomass, as shown below:

$$Wreplanted = Areplanted \times CreplantedrC:Biomass$$

76. Similarly, the savings in CO2 emissions associated with using the replanted forestry as a biofuel, Sreplanted→biofuel (t CO2) is calculated from the weight of biomass from the replanted forestry, Wreplanted (t), the energy value of the replanted forestry as a biomass fuel, ϵreplanted (MWh t-1) and the emission factor, Efuel (t CO2 MWh-1), for the counterfactual case.

$$Sreplanted \rightarrow biofuel = Wreplanted \times \epsilon felled \times Efuel$$

77. Net carbon losses associated with using the replanted forestry as a biofuel, Lreplanted→biofuel (t CO2), are then given by the difference between the losses associated with transportation, Ltransport (t CO2) (calculated as outlined above), and the savings due to using the felled forestry as a biofuel, Sreplanted→biofuel (t CO2),

$$Lreplanted \rightarrow biofuel = Ltransport - Sreplanted \rightarrow biofuel$$

Total carbon loss associated with forest management

78. The total carbon losses associated with forest management, Lforest(t CO2) is then given by the sum of all the parts described above

$$Lforest = Lharv + Lfloor + Lfelled \rightarrow biofuel + Lreplanted \rightarrow biofuel$$

where Lharv (t CO2) are the losses due to harvesting operations, Lfloor (t CO2) are the emissions from the cleared forest floor, Lfelled→biofuel (t CO2) are the losses associated with using felled forestry as a biofuel, and Lreplanted→biofuel (t CO2) are the losses associated with using replanted forestry as a biofuel.

Impacts of forestry management on windfarm carbon emission savings

Capacity factor

79. The forestry input data is used to determine the capacity factor for the turbines at the site. This is dependent on tree height, forest width and distance of the forest from the turbine. The capacity factor, $p$cap (%), is calculated from the ratio of calculated annual power output from the turbine, Pact (MWh turbine-1 yr-1), and the theoretical power output of the turbine, Pmax (MW turbine-1 yr-1), removing the specified value for estimated downtime for maintenance, $t$down (%)

$$pcap = (100 - tdown) \times PactPmax$$

The theoretical power output of the turbine, Pmax (MWh turbine-1 yr-1), is calculated from the number of hours in a year and the power rating of the turbine, $c$turb (MW), Pmax=24×365×$c$turb

The annual energy output from an individual turbine, Pact (MWh turbine-1 yr-1), is calculated from the average site windspeed, Vupwind (m s-1), and the windspeed ratio ($r$wind) using the following formula:

$$Pact = (\alpha \times Vupwind \times rwind) + b$$

where a is the slope and b is the intercept. For Vestas 2.0 MW Optispeed C2, the values of a and b have been set by regression against collected data to a=1392.5 MW s turbine-1 yr-1 m-1 and b= −4291.9 MW turbine-1 yr-1. The appropriate values of a and b should be entered for other turbine types.

Response from MLavelle: The first turbine will get 8m/s. The prevailing SW wind will revert to zero m/s downwind. The layout for this windfarm indicates that upwind for the 3 westerly wind turbines will be 8m/s & the remaining 12 are at or near zero due to wake effects.

This application is simply to obtain curtailment fees for 15 turbines from the Government & is not sustainable with only 3 turbines producing electricity. There are no carbon savings.

Windspeed ratio

80. The windspeed ratio ($r$wind) is the ratio of the windspeed downwind of the forestry, Vdownwind (m s-1), to the windspeed upwind of the forestry, Vupwind (m s-1),

r wind=Vdownwind$V$upwind

Relative windspeed

81. Windspeed over a particular surface, Vsurface (m s-1), can be calculated for a particular hub-height, Hhub (m), using the following simple relationship (Pal Ayra, 1988; Gardiner, 2004),

$$Vsurface=VHnoeffect\times ln((Hhub-\Delta Hzero)Rsurface)kVon\ Karmen$$

where Rsurface is the aerodynamic roughness of the ground surface(m), kVon Karmen is the Von Karman constant (kVon Karmen=0.4), ΔHzero (m) is the zero plane displacement over the particular surface, and VHIBL (m s-1) is the friction velocity (the windspeed at the height HIBL (m) of the internal boundary layer where there is no effect of the surface roughness).

Relative upwind windspeed

82. Because we are only interested in calculating the windspeed ratio, this can be simplified by calculating the relative windspeed upwind and downwind of the forestry, Vupwind(rel) and Vdownwind(rel) respectively (m), by assuming VHIBL=1 and ΔHzero(surface) = 0.

$$Vupwind(rel)=ln(HhubRupwind)kVon\ Karmen$$

where Rupwind is the aerodynamic roughness of ground upwind of the forestry (m), assumed to be rough grass, giving an aerodynamic roughness of 0.03 m (Pal Ayra, 1988).

Relative downwind windspeed

83. If the hub-height, Hhub (m), is greater than the tree height at the end of the windfarm life, Htree (m), the windspeed downwind of the forestry, replanted forest or felled forestry, Vdownwind(rel) (m), is calculated as

$$Vdownwind(rel)=VHIBL\times(ln((Hhub-\Delta Hzero)Rsurface)ln((HIBL-\Delta Hzero)Rsurface))$$

where Rsurface (m) is the aerodynamic roughness of the surface, ΔHzero (m) is the zero plane displacement over the ground surface, and VHIBL is the windspeed at the height where there is no effect of the roughness of the ground surface, HIBL (m) (i.e. the height of the new internal boundary layer). For forestry, Rsurface is given by the aerodynamic roughness of forestry, Rforest (m), and is assumed to be 7.5% of the tree height, Htree (m), at the end of the windfarm life, Rforest=0.075×Htree (m). Tree height is obtained from Forestry Commission growth and yield tables (Edwards and Christie, 1981), and averaged over the lifetime of the development. Similarly, for replanted forestry, Rsurfaceis given by the aerodynamic roughness of the replanted forestry, Rreplant=0.075×Htree (m). For the felled area, Rsurfaceis given by the aerodynamic roughness of the felled area, Rfelled (m), which is assumed to be equivalent to the aerodynamic roughness of the ground upwind of the forestry, Rfelled=Rupwind=0.03 The zero plane displacement is assumed to be 65% of the tree height,ΔHzero=0.65 ×Htree, unless tree height is less than 0.1 m, in which case it is assumed to be the aerodynamic roughness of ground upwind of the forestry, ΔHzero= Rupwind (m)). Note for replanted forestry and felled areas, ΔHzero is approximated to zero in the above equation.

84. For forestry, if the hub-height, Hhub (m), is less than the tree height at the end of the windfarm life, Htree (m), then Vdownwind is given by

$$Vdownwind(rel)=VHIBL\times exp((\alpha\times Hhub Htree/)-1)\times(ln((Hhub-\Delta Hzero)Rforest/)ln((HIBL-\Delta Hzero)Rforest/))$$

where α is an exponential decay factor for the wind profile over forest, currently assumed to be 4 (Pal Ayra, 1988; Cionco, 1965).

85. For replanted forestry and felled areas, there is no modification to the equation for Hhub>Htree.

The height of the internal boundary layer, HIBL (m), is calculated as

$$HIBL=((0.75+0.03\times ln(RupwindRsurface))\times Rsurface\times(DwidthRsurface)0.8)+\Delta Hzero$$

where Rupwind (m) is the aerodynamic roughness of ground upwind of the forestry. Rsurface is the aerodynamic roughness of the surface and Dwidth (m) is the width of the area being considered. If HIBL (m) is greater than the height of the maximum allowed top of the internal boundary layer, HIBL(max) (assumed here to be 5000 m, Kaimal and Finnigan, 1994), then HIBL is set to HIBL(max). The value for the friction velocity (VHIBL) is then obtained from the upwind velocity (Vupwind) at height of the internal boundary layer, HIBL (m).

86. In the case of forestry, Rsurface=Rforest, and Dwidth (m) is the width of forest around the felled area i.e.

$$HIBL(forest)=((0.75+0.03\times ln(RupwindRforest))\times Rforest\times(DwidthRforest)0.8)+\Delta Hzero.$$

The height of the internal boundary layer over replanted forestry, HIBL(replant) (m), is calculated similarly, using the height of replanted trees at the end of the windfarm life as Htree (m), the aerodynamic roughness of the unfelled forestry, Rforest (m), as Rupwind, and the aerodynamic roughness of the replanted forestry, Rreplant (m), as Rsurface, i.e.

$$HIBL(replant)=((0.75+0.03\times ln(RforestRreplant))\times Rreplant\times(DwidthRreplant)0.8)+\Delta Hzero.$$

87. Over the felled area, the height of the internal boundary layer, HIBL(felled) (m), is calculated using the aerodynamic roughness of the unfelled forestry, Rforest (m), as Rupwind, the aerodynamic roughness of the replanted felled area, Rfelled (m), as Rsurface, and ΔHzero is obtained from the aerodynamic roughness of the felled area (ΔHzero=Rfelled), i.e.

$$HIBL(felled)=((0.75+0.03\times ln(RforestRfelled))\times Rfelled\times(DwidthRfelled)0.8)+Rfelled.$$

Carbon dioxide saving due to improvement of peatland habitat

88. Habitat improvement at disturbed sites can significantly impact carbon emissions, potentially preventing further losses and increasing carbon stored in the improved habitat. Carbon gains due to habitat improvement are estimated using IPCC default values

(paragraph 49; IPCC, 1997) and site specific equations derived from the scientific literature (paragraphs 51 to 56). Emissions of nitrous oxide are assumed to be negligible in unfertilised peatlands (IPCC, 1997). However, for this option to be used, the improvement plan should demonstrate a high probability that peat hydrology will be restored and disturbance of peat minimised, resulting in rapid decolonisation of the natural vegetation.

89. To calculate the carbon emissions attributable to improvement only, Limprovement (t CO2 eq.), any emissions occurring if the soil had remained drained are subtracted from the emissions occurring after flooding (negative, indicates a net reduction in emissions).

$$L\ improvement = L\ drained - L\ undrained$$

90. The reduction in total greenhouse gas emissions are given below for the example wind farm using the IPCC default methodology and the site specific equations. Using fossil-fuel-mix as the counterfactual, the reduction in payback time amounts to 1.01 years using the IPCC methodology, and 1.78 years using the site specific approach.

Calculation of payback time for the example case-study wind farm

91. The carbon payback time for a wind farm is calculated by comparing the net loss of carbon from the site due to wind farm development, *L*tot (t CO2 eq.), with the carbon savings achieved by the wind farm while displacing electricity generated from coal fired capacity, grid mix or fossil fuel mix.

$$Ltot = Llife + Lback + Lfix + Ldirect + Lindirect + LDOC + Lforest + Limprovement$$

where *L*life is the total loss of C emission savings due to production, transportation, erection, operation and dismantling of the wind farm (t CO2 – see paragraph 18), *L*back is the total loss of carbon emission savings due to backup power generation (t CO2 – see paragraph 23), *L*fix is the loss of carbon fixing potential of peatland (t CO2 – see paragraph 27), *L*direct is the loss of carbon from the removed peat (t CO2 – see paragraph 34), *L*indirect is the loss of carbon due drainage (t CO2 eq. – see paragraph 47), *L*DOC is the loss of carbon dioxide due to leaching of dissolved organic carbon (t CO2 – see paragraph 57), *L*forest is the loss of carbon dioxide due to forestry clearance (t CO2 – see paragraph 63), *L*improvement is the loss (negative = gain) of carbon emissions due to habitat improvement (t CO2 eq., see paragraph 91).

92. The calculation of total carbon dioxide emission savings and payback time for the example wind farm are shown below. Note the very short payback time, due to good practice in the use of floating roads and the large area of habitat improvement.

Table 11-5 CO2 Losses from the Proposed Project – **This Table is not consistent with the Scottish model quoted in the Application**

Origin of Losses	CO2 Losses (tonnes CO2 equivalent)	
Expected	Maximum	
Losses due to turbine life (e.g., manufacture, construction, decommissioning) Response – no details given on decommissioning costs for transfer back to maniufacturer	77,078	78,480
Losses due to backup Response – no details given for calculation	60,293	61,298
Losses from reduced carbon fixing potential – no details given for calculation	1,985	2,646
Losses from soil organic matter and due to leaching of dissolved and particulate organic carbon (CO2 loss from removed and drained peat) – no details given for calculation	37,622	173,231
Losses associated with embodied carbon in construction materials	82,933	82,933
Losses associated with traffic and transport movements – no details given for calculation	1,450	1,450
Total	261,360	400,038

Table 11-6 Assessment of potential loss of carbon sequestration due to the Proposed Project

Description	Windfarm	Windfarm plus 5m Buffer (Note 1)
Total Footprint (Ha)	34.4	74.3
Carbon sequestration factor (tCO2/ha/yr)	3.8261	3.8262
Rewetted Footprint carbon savings (tCO2/ha/35yr) – no details given for calculation	4.599	9.934
Area of the site (Ha) **This is not the area identified in the application**	1.258	1.258
Area of the site assume to actively sequester carbon (Ha) – no details given for calculation	629	629
Proposed Wind Farm carbon savings total (tCO2/35yr)	56,375*	56,375*
% loss of carbon sequestration (30yr)	8.2%	17.6%

11.4.3.2 **Carbon Savings**

According to the model described above, the Proposed Project will give rise to total losses of 261,360 tonnes of carbon dioxide.

A simple formula can be used to calculate carbon dioxide emissions reductions resulting from the generation of electricity from wind power rather than from carbon-based fuels such as peat, coal, gas and oil. The formula is:

CO2 (in tonnes) = (A x B x C x D)/1000

where: A = …… The rated capacity of the wind energy development in MW **This should be the output.**

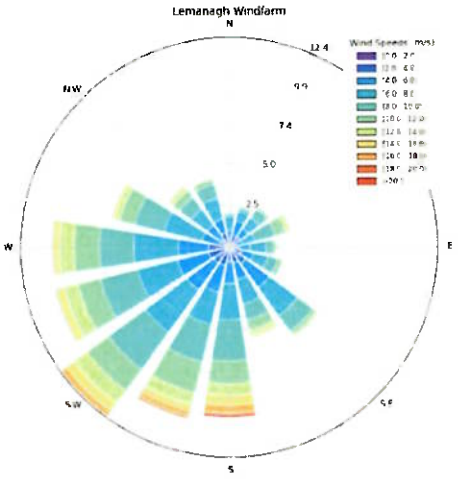
B = …… The capacity or load factor, which takes into account the intermittent nature of the wind, the availability of wind turbines and array losses etc.

C = …… The number of hours in a year

D = …… Carbon load in grams per kWh (kilowatt hour) of electricity generated and distributed via the national grid.

For the purposes of this calculation, the rated capacity of the Proposed Wind Farm is assumed to be 90MW (based on 15 No. 6 MW turbines).

A load factor of 0.35 (or 35%) has been used for the Proposed Project. **This does not agree with the Scottish Model of 22.7-29.2% above. The West-East alignment of wind turbines means that the load factor will be far less due to wake effects on the 12 downwind turbines from the prevailing SW/W winds.**



The number of hours in a year is 8,760.

A conservative figure for the carbon load of electricity generated by natural gas in Ireland was sourced from Sustainable Energy Authority Ireland's (SEAI) Conversion and Emissions Factors for Publication worksheet.64 The emission factor for electricity generated in Ireland in 2024 was 204.3gCO2/kWh.65

The calculation for carbon savings is therefore as follows:

CO2 (in tonnes) = (90 x 0.35 x 8,760 x 204.3) / 1000= 56,375 tonnes per annum.

This should be [45x0.227x8760x204.3]/1000 = 18,281 tonnes per annum & NOT 56,375tonnes per annum. Additionally, 639,851tonnes over 35-year period & NOT 1,973,125 tonnes per annum.. CO_2 losses & gains over the period will be similar. There is no economic or climate change benefit in this application. The 33Mw output is from the Vesta power curve of c3Mw per turbine (above).

Based on this calculation, 56,375 tonnes of carbon dioxide will be displaced per annum from the largely carbon-based traditional energy mix by the Proposed Wind Farm. Over the proposed 35-year lifetime of the development, therefore 1,973,125 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, 261,360 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 13% of the total amount of carbon dioxide emissions that will be offset by the Proposed Wind Farm. The 261,360 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 in approximately 56 months (4.6 years) of operation.

As detailed in Section 11.4.3.1 above, habitat enhancement will take place as part of the Proposed Project, in addition to the restoration requirements required as part Condition 10 of the relevant IPC licence (Ref. P0500-01). These activities, over the lifetime of the Proposed Project has the potential to give rise to carbon savings; please note, this potential has not been quantified and therefore is not considered in Section 11.5.3 below. The carbon storage capacity of restored habitats will vary over time as vegetation matures / rewets and land use and the baseline environment change. Therefore, while it can be assumed that rehabilitation measures on the site will result in an increased capacity of carbon storage due to the carbon storage potential that exists within these habitats66, to ensure the assessment below is identified under a theoretical precautionary scenario, the quantification of these potential carbon savings (via an increase in carbon storage potential) associated with these measures has not been included. Please note, the carbon sequestration potential associated with the replanting of native woodland will be able to be determined in the future

via the Teagasc Forest Carbon Tool67; currently this is not able to be completed due to Teagasc carrying out further analysis and validation on current data and the sequestration potential not being available in the public domain.

Response from MLavelle: The calculations for Carbon savings & losses do not comply with the Scottish Model quoted.

Scottish Government (2018) Carbon Calculator: Technical Guidance <https://www.gov.scot/publications/carbon-calculator-technical-guidance/>

Reference No 158 : Noise and Vibration Standards

IEC 61400-1 International standard, Wind Turbine Generator systems, Edition 3 – Part 1: Design requirements, August 2005, Amended 2010
DNV GL Standard: DNVGL-SE-0441 Type and component certification of wind turbines
Germanischer Lloyd, Rules and regulations, IV - Non-marine Technology, Part 1 – Wind Energy, Regulation for the certification of the Wind Energy Conversion Systems, Chapter 1 – 10, 2010
ISO 2394 General principles on reliability for structures, 2015(E) edition
Standard DNVGL-ST-0437 "Loads and site conditions for wind turbines"
DNV-OS-J-101 "Design of offshore wind turbine structures"
IEC 61400 is an international standard published by the International Electrotechnical Commission (IEC) regarding wind turbines.

Purpose and function

IEC 61400 is a set of design requirements made to ensure that wind turbines are appropriately engineered against damage from hazards within the planned lifetime. The standard concerns most aspects of the turbine life from site conditions before construction, to turbine components being tested,[1] assembled and operated.

Wind turbines are capital intensive, and are usually purchased before they are being erected and commissioned.

Some of these standards provide technical conditions verifiable by an independent, third party, and as such are necessary in order to make business agreements so wind turbines can be financed and erected.[1]

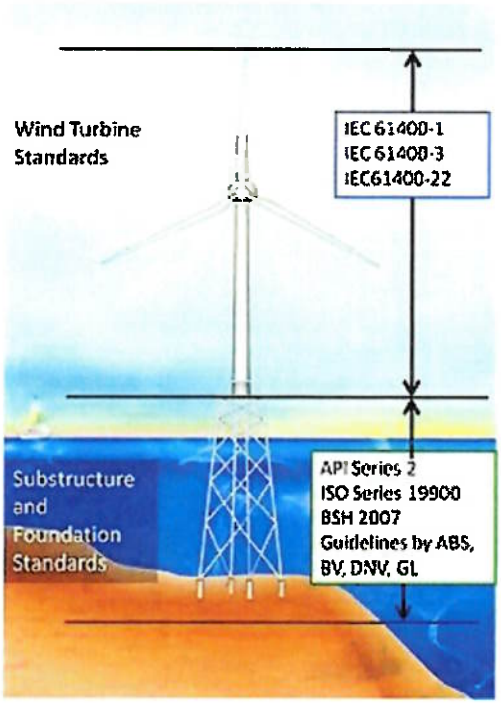
IEC started standardizing international certification on the subject in 1995, and the first standard appeared in 2001.[1]

The common set of standards sometimes replace the various national standards, forming a basis for global certification.[1]

Small wind turbines are defined as being of up to 200 m^2 swept area and a somewhat simplified IEC 61400-2 standard addresses these. It is also possible to use the IEC 61400-1 standard for turbines of less than 200 m^2 swept area.

The standards for loads and noise are used in the development of prototypes at the Østerild Wind Turbine Test Field.[2]

Harmonization



IEC, API, ISO etc. standards used to certify US offshore wind turbines

In the U.S., standards are intended to be compatible with IEC standards,[3] and some parts of 61400 are required documentation.[4][5]

The U.S. National Renewable Energy Laboratory participates in IEC standards development work,[3][6] and tests equipment according to these standards.[7] For U.S. offshore turbines however, more standards are needed, and the most important are :

- ISO 19900, General requirements for offshore structures
- ISO 19902, Fixed steel offshore structures
- ISO 19903, Fixed concrete offshore structures
- ISO 19904-1, Floating offshore structures – mono-hulls, semisubmersibles and spars
- ISO 19904-2, Floating offshore structures - tension-leg platforms
- API RP 2A-WSD, Recommended practice for planning, designing and constructing fixed offshore steel platforms - working stress design.[8]

In Canada, the previous national standards were outdated and impeded the wind industry, and they were updated and harmonized with 61400 by the Canadian Standards Association with several modifications.[9][10]

For small wind turbines the global industry has been working towards harmonisation of certification requirements with a "test once, certify everywhere" objective. Considerable co-operation has been taking place between UK, USA, and more recently Japan, Denmark and other countries so that the IEC 61400-2 standard as interpreted within e.g. the MCS certification scheme (of UK origin) is interoperable with the USA (for example where it corresponds to an AWEA small wind turbine standard) and other countries.

Wind Turbine Generator (WTG) classes

Wind turbines are designed for specific conditions. During the construction and design phase assumptions are made about the wind climate that the wind turbines will be exposed to. Turbine wind class is just one of the factors needing consideration during the complex process of planning a wind power plant. Wind classes determine which turbine is suitable for the normal wind conditions of a particular site. Turbine classes are determined by three parameters - the average wind speed, extreme 50-year gust, and turbulence.[11]

Turbulence intensity quantifies how much the wind varies typically within 10 minutes. Because the fatigue loads of a number of major components in a wind turbine are mainly caused by turbulence, the knowledge of how turbulent a site is of crucial importance. Normally the wind speed increases with increasing height due to vertical wind shear. In flat terrain the wind speed increases logarithmically with height. In complex terrain the wind profile is not a simple increase and additionally a separation of the flow might occur, leading to heavily increased turbulence.[12]

Wind Class/Turbulence	Annual average wind speed at hub-height	Extreme 50-year gust
Ia High wind - Higher Turbulence 18%	10 metres per second (36 km/h; 22 mph)	70 metres per second (250 km/h; 160 mph)
Ib High wind - Lower Turbulence 16%	10 metres per second (36 km/h; 22 mph)	70 metres per second (250 km/h; 160 mph)
IIa Medium wind - Higher Turbulence 18%	8.5 metres per second (31 km/h; 19 mph)	59.5 metres per second (214 km/h; 133 mph)
IIb Medium wind - Lower Turbulence 16%	8.5 metres per second (31 km/h; 19 mph)	59.5 metres per second (214 km/h; 133 mph)
IIIa Low wind - Higher Turbulence 18%	7.5 metres per second (27 km/h; 17 mph)	52.5 metres per second (189 km/h; 117 mph)
IIIb Low wind - Lower Turbulence 16%	7.5 metres per second (27 km/h; 17 mph)	52.5 metres per second (189 km/h; 117 mph)
IV	6.0 metres per second (22 km/h; 13 mph)	42 metres per second (150 km/h; 94 mph)

The extreme wind speeds are based on the 3 second average wind speed. Turbulence is measured at 15 m/s wind speed. This is the definition in IEC 61400-1 edition 2.

List of IEC 61400 parts[14]

- IEC 61400-1:2005+AMD1:2010 CSV Design requirements (Consolidated Version)
- IEC 61400-1:2019 RLV Design requirements (Redline Version)
- IEC 61400-2:2013 Small wind turbines
- IEC 61400-3-1:2019 Design requirements for fixed offshore wind turbines
- IEC TS 61400-3-2:2025 Design requirements for floating offshore wind turbines
- IEC 61400-4:2025 Design requirements for wind turbine gearboxes
- IEC TS 61400-4-1:2026 Reliability assessment of drivetrain components in wind turbines
- IEC TR 61400-4-2:2026 Lubrication of drivetrain components in wind turbines
- IEC 61400-5:2020+AMD1:2025 CSV Wind turbine blades (Consolidated Version)
- IEC 61400-6:2020 Tower and foundation design requirements
- IEC 61400-8:2024 Design of wind turbine structural components
- IEC 61400-9:2025 Probabilistic design measures for wind turbines
- IEC 61400-11:2012+AMD1:2018 CSV Acoustic noise measurement techniques (Consolidated Version)
- IEC TS 61400-11-2:2024 Acoustic noise measurement techniques - Measurement of wind turbine sound characteristics in receptor position
- IEC 61400-12:2022 Power performance measurements of electricity producing wind turbines - Overview
- IEC 61400-12-1:2022 Power performance measurements of electricity producing wind turbines
- IEC 61400-12-2:2022 Power performance of electricity producing wind turbines based on nacelle anemometry
- IEC 61400-12-3:2022 Power performance - Measurement based site calibration
- IEC TR 61400-12-4:2020 Numerical site calibration for power performance testing of wind turbines
- IEC 61400-12-5:2022 Power performance - Assessment of obstacles and terrain
- IEC 61400-12-6:2022 Measurement based nacelle transfer function of electricity producing wind turbines
- IEC 61400-13:2015+AMD1:2021 CSV Measurement of mechanical loads (Consolidated Version)
- IEC TS 61400-14:2005 Declaration of apparent sound power level and tonality values
- IEC 61400-15-1:2025 Site suitability input conditions for wind power plants
- IEC 61400-21-1:2019 Measurement and assessment of electrical characteristics - Wind turbines
- IEC 61400-21-2:2023 Measurement and assessment of electrical characteristics - Wind power plants

- IEC TR 61400-21-3:2019 Measurement and assessment of electrical characteristics - Wind turbine harmonic model and its application
- IEC TS 61400-21-4:2025 Measurement and assessment of electrical characteristics - Wind turbine components and subsystems
- IEC 61400-23:2014 Full-scale structural testing of rotor blades
- IEC 61400-24:2019+AMD1:2024 CSV Lightning protection (Consolidated Version)
- IEC 61400-25-1:2017 RLV Communications for monitoring and control of wind power plants - Overall description of principles and models (Redline Version)
- IEC 61400-25-2:2015 Communications for monitoring and control of wind power plants - Information models
- IEC 61400-25-3:2015 RLV Communications for monitoring and control of wind power plants - Information exchange models (Redline Version)
- IEC 61400-25-4:2016 RLV Communications for monitoring and control of wind power plants - Mapping to communication profile (Redline Version)
- IEC 61400-25-5:2017 Communications for monitoring and control of wind power plants - Conformance testing
- IEC 61400-25-6:2016 Communications for monitoring and control of wind power plants - Logical node classes and data classes for condition monitoring
- IEC TS 61400-25-71:2019 Communications for monitoring and control of wind power plants - Configuration description language
- IEC TS 61400-26-1:2019 Availability for wind energy generation systems
- IEC TS 61400-26-4:2024 Reliability for wind energy generation systems
- IEC 61400-27-1:2020 Electrical simulation models - Generic models
- IEC 61400-27-2:2020 Electrical simulation models - Model validation
- IEC TS 61400-28:2025 Through-life management and life extension of wind power assets
- IEC TS 61400-29:2023 Marking and lighting of wind turbines
- IEC TS 61400-30:2023 Safety of wind turbine generators - General principles for design
- IEC TS 61400-31:2023 Siting risk assessment
- IEC 61400-40:2026 Electromagnetic compatibility (EMC) - Requirements and test methods
- IEC 61400-50:2022 Wind measurement - Overview
- IEC 61400-50-1:2022 Wind measurement - Application of meteorological mast, nacelle and spinner mounted instruments
- IEC 61400-50-2:2022 Wind measurement - Application of ground-mounted remote sensing technology
- IEC 61400-50-3:2022 Use of nacelle-mounted lidars for wind measurements
- IEC TS 61400-50-4:2025 Use of floating lidar systems for wind measurements

Reference No 159 : Scottish Borders Council: **REQUEST FOR SCOPING OPINION FOR PROPOSED SECTION 36 APPLICATION FOR LONGCROFT WIND FARM. Our Ref: 23/00445/SCO, Your Ref: ECU00004774, E-Mail: sshearer@scotborder.gov.uk, Date: 29.05.2023**
Acoustics: Scottish Borders Council will look to condition developments to a fixed day time limit of LA90, 10mins 35 dB unless satisfactory justification in line with the criteria set out in ETSU-R97 is provided.

12.3.2.4 **Operational Phase Noise – Wind Turbines**
The noise assessment documented in this chapter is based on guidance in relation to acceptable levels of noise from wind farms as contained in the DoEHLG 2006 Guidelines published by the Department of the Environment, Heritage and Local Government in 2006. The DoEHLG 2006 Guidelines are based on detailed recommendations set out in the Department of Trade and Industry (UK) Energy Technology Support Unit (ETSU) publication 'The Assessment and Rating of Noise from Wind Farms' (1996) (ETSU-R-97). The ETSU document has been used to supplement the guidance contained within the DoEHLG 2006 Guidelines, where appropriate and necessary.

12.3.2.4.1 ***Wind Energy Development Guidelines for Planning Authorities***
"In general, a lower fixed limit of 45dB(A) 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."

This represents the commonly adopted daytime noise criterion curve in relation to wind farm developments. However, an important caveat should be noted as detailed in the following extract.

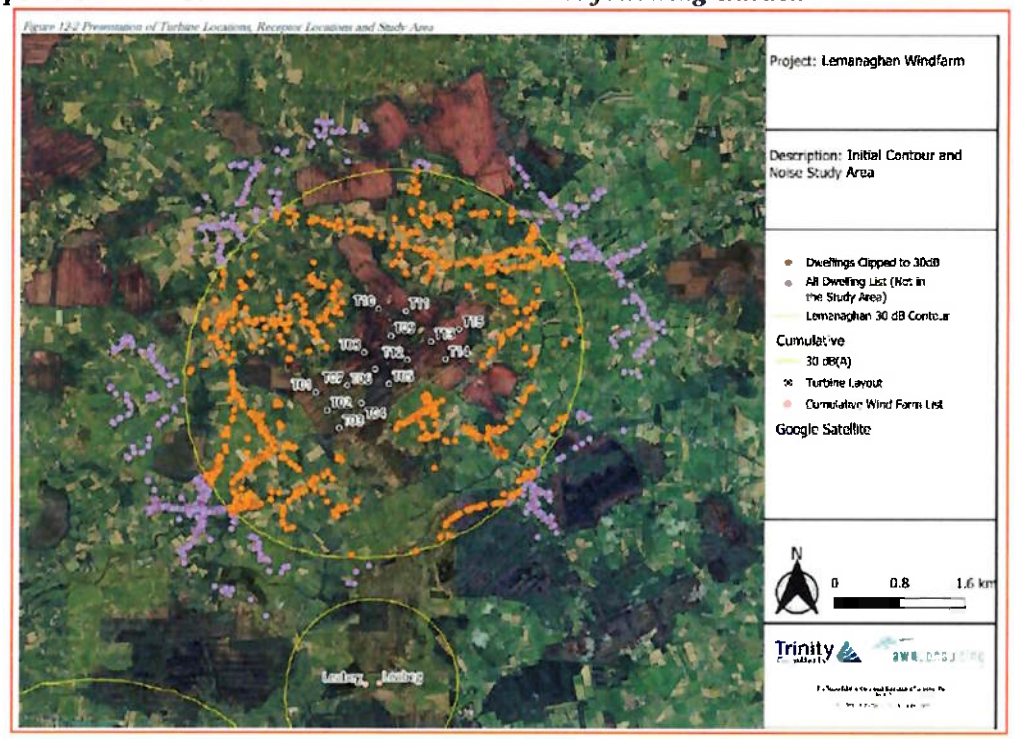


Table 12.13 Derived Background Noise Levels of $L_{A90,10min}$ for Various Wind Speeds - Daytime

Locations	Period	Background Noise Levels dB L_{A90} at standardised 10m height wind speed m/s for 145 m Hub Height							
		3	4	5	6	7	8	9	10
NML1 (H085)	Daytime	26.3	27.3	28.3	29.6	31.2	33.2	35.7	38.9
NML2 (H025)	Daytime	30.7	32.0	33.4	34.7	35.8	36.5	36.7	36.7
NML3 (within the site)	Daytime	27.6	27.9	27.9	27.8	27.9	28.6	30.0	32.5
NML4 (H011)	Daytime	26.1	26.2	26.7	27.9	29.9	32.9	37.1	42.6
NML5 (H111)	Daytime	29.8	30.6	31.4	32.3	33.4	35.2	37.7	41.1
NML6 (H026)	Daytime	29.4	30.3	31.2	32.3	33.7	35.4	37.6	40.2
NML7 (H077)	Daytime	28.1	28.7	29.2	30.0	31.2	33.1	36.0	40.1
NML8 (H003)	Daytime	26.6	27.8	28.5	29.3	30.7	32.9	36.6	42.2

Table 12-14 Derived Background Noise Levels of $L_{A90,10min}$ for Various Wind Speeds – Night-time

Locations	Period	Background Noise Levels dB L_{A90} at standardised 10m height wind speed m/s for 145 m Hub Height							
		3	4	5	6	7	8	9	10
NML1 (H085)	Night-time	16.8	17.8	19.4	21.4	23.5	25.5	27.4	28.7
NML2 (H025)	Night-time	18.3	19.5	21.2	23.3	25.7	28.3	31.2	34.1
NML3 (within the site)	Night-time	18.5	18.9	19.5	20.2	21.0	22.1	23.5	25.1
NML4 (H011)	Night-time	18.6	19.2	20.5	22.5	25.5	29.8	35.6	43.1
NML5 (H111)	Night-time	18.2	19.5	21.2	23.5	26.6	30.5	35.4	41.4
NML6 (H026)	Night-time	16.4	17	18.1	19.9	22.5	26.0	30.7	36.7
NML7 (H077)	Night-time	18.2	18.7	19.8	21.7	24.3	27.9	32.4	38.0
NML8 (H003)	Night-time	19.5	20.2	21.5	23.5	26.3	30.0	34.8	40.8

The average wind speed is given as c8m/s. This transposes into night-time noise levels of 22.1 – 30.5dBa

Table 12-15 Proposed Noise Criteria Curves

Location	Period	Turbine Noise Limits $L_{A90,10min}$ Levels (dB) at Various Standardised 10m Height Wind Speeds)						
		3	4	5	6	7	8	9
NML 1 (H085)	Day	40	40	40	40	45	45	45
	Night	43	43	43	43	43	43	43
NML 2 (H025)	Day	45	45	45	45	45	45	45
	Night	43	43	43	43	43	43	43
NML 3 (within the site)	Day	40	40	40	40	40	40	45
	Night	43	43	43	43	43	43	43
NML 4 (H011)	Day	40	40	40	40	40	45	45
	Night	43	43	43	43	43	43	43
NML 5 (H111)	Day	40	45	45	45	45	45	45
	Night	43	43	43	43	43	43	43
NML 6 (H026)	Day	40	45	45	45	45	45	45
	Night	43	43	43	43	43	43	43
NML 7 (H077)	Day	40	40	40	45	45	45	45
	Night	43	43	43	43	43	43	43
NML 8 (H003)	Day	40	40	40	40	45	45	45
	Night	43	43	43	43	43	43	43

For a wind speed of 8m/s, the applicant proposes a level of 43dBa for night-time noise levels. This is 21dBa above back ground noise levels above.

Table 12.7 Significance in Change of Noise Level

Change in Sound Level (dB)	Subjective Reaction	DMRB Magnitude of Impact	EPA Significance of Effect
0	Inaudible	No impact	Imperceptible
0.1 – 2.9	Barely Perceptible	Negligible	Not significant
3 – 4.9	Perceptible	Minor	Slight, Moderate
5 – 9.9	Up to a doubling of loudness	Moderate	Significant
10+	Doubling of loudness and above	Major	Very significant

For a 10dB increase in noise levels we get a MAJOR Magnititude of Impact & a VERY SIGNIFICANT Significance of Effect. The increase is over 20dB at this location, which is a quadrupling of noise & off the scale for significance change.

12.5.2.1.3 ***Description of Effects***

The likely predicted noise and vibration effects are below the limits and/or thresholds identified. With respect to the EPA's criteria for description of effects (outlined in Section 1.7.2 of Chapter 1), the likely potential effects at the nearest NSL, under a theoretical precautionary scenario, associated with construction of proposed turbines and hardstanding areas are described as follows:

Quality	Significance	Duration
Negative	Not Significant	Short Term

The above effect should be considered in terms that the effect is variable, and that this assessment considers the locations of the greatest potential impact.

The 8m/s is the average annual speed. From the Applicants tables, the increase in noise is Significant & it is not Short Term. The noise levels are not just Negative, they are catastrophic for people trying to sleep.

12.6.2 **Operational Phase**

12.6.2.1 **Wind Turbine Noise**

An assessment of the operational wind turbine noise levels has been undertaken in accordance with best practice guidelines and procedures as outlined in Section 12.3.2.4. The findings of the assessment, presented in Section 12.5.3.1 has confirmed that the predicted operational noise levels associated with the Proposed Project will be within best practice turbine noise criteria at all locations with no significant cumulative impacts or effects.

The findings of the assessment confirmed that the predicted operational noise levels from the Proposed Project will be within the relevant best practice noise criteria for the detailed potential turbine specification. Therefore, no specific mitigation measures are required.

If alternative turbine models are considered for the Proposed Wind Farm, an updated noise assessment will be prepared to confirm that the noise emissions will comply with the noise criteria outlined in Section 12.4.3 and/or the relevant operational criteria associated with the grant of planning for the Proposed Project.

This is absolute nonsense. The predicted operational noise levels will NOT be within best practice turbine noise criteria & no details of increased noise provided due to Wake turbulence or blade detritus.

12.7.2.1 **Wind Turbine Noise**

The predicted noise levels associated with the Proposed Project will be within best practice noise criteria curves recommended in line with DoEHLG 2006 Guidelines it is not considered that a significant effect is associated with the Proposed Project.

While noise levels at low wind speeds will increase due to the Proposed Project and specifically the operation of the turbines, the predicted levels will remain low, albeit new sources of noise will be introduced into the soundscape.

The predicted residual operational turbine noise effects are summarised as follows at the nearest NSLs.

Quality	Significance	Duration
Negative	Not Significant	Long Term

Note the change for Duration from 12.5.2.1.3 above, from Short-Term to Long-Term

12.12 **EIA Classification Summary**

Table 12.26 Impact Assessment Classification Summary

Topic	Pre-Mitigation Effect	Mitigation Section Reference	Residual Effect	Significance
Operational Phase				
Assessment of Wind Turbine Noise	Long-Term, Not Significant, Negative	Section 12.6.2.1 Section 12.6.2.2	Long-Term, Not Significant, Negative	Not Significant

A quadrupling of noise on householders becomes Not Significant for the applicant.

Table 12-1 Example Threshold of Potential Significant Effect at Noise Sensitive Locations

Assessment category and threshold value period (T)	Threshold values, LAeq,T dB		
	Category A Note A	Category B Note B	Category C Note C
Night-time (23:00 to 07:00hrs)	45	50	55
Evenings and weekends Note D	55	60	65
Daytime (07:00 – 19:00hrs)	65	70	75

Chapter 12: Noise and Vibration of the EIAR has been prepared by AWN Consulting to assess the likely significant environmental noise and vibration effects of the Proposed Project. The objective of the noise and vibration assessment is to specify appropriate noise and vibration thresholds and limit values, determine the potential impacts and effects with reference to the 'EPA Guidelines on the Information to be Contained in Environmental Impact Statements' (EPA, 2022), and, if required, specify appropriate mitigation measures to ensure that the impacts on noise-sensitive receptors are within acceptable threshold values and limits.

To inform the noise impact assessment, an environmental noise survey was conducted to establish the existing baseline and background noise levels in the receiving environment. This was achieved through simultaneous wind measurements and noise monitoring over several weeks, capturing noise levels across a representative set of wind speeds and directions. Typical background noise levels for day and night periods at various wind speeds have been measured in accordance with best practice guidance contained in the Institute of Acoustics document 'A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise' (IOA GPG). The results of the background noise survey have been used to derived appropriate noise criteria for the development in line with the guidance contained in the DoEHLG 2006 Guidelines.

When considering a renewable energy development of this nature, the potential noise and vibration effects on the surroundings must be considered for three stages: the short-term construction phase and decommissioning phases, and the long-term operational phase.

There is no published statutory Irish guidance relating to the maximum permissible noise level that may be generated during the construction phase of a project. Local authorities will generally control construction noise and vibration by restricting the hours during which activities can take place and may consider noise limits at their discretion. The assessment of construction, operational, and decommissioning noise and vibration has been conducted in accordance with the following best practice guidance:

- Code of practice for noise and vibration control on construction and open sites, British Standard BS5228;

- Guidelines for the Treatment of Noise and Vibration in National Road Schemes, Transport Infrastructure Ireland (TII);
- Design Manual for Roads and Bridges (DMRB) Sustainability & Environment Appraisal LA 111 Noise and Vibration Revision 2 (National England (now National Highways).
- A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise', Institute of Acoustics (IOA GPG);
- Supplementary Guidance Notes', IOA GPG

Subject to good working practices outlined in the CEMP (Appendix 4-4), the assessment has confirmed that noise and vibration from construction and decommissioning activities are not expected to result in any significant effects at any Noise Sensitive Locations (NSLs).

The applicable guidelines for the assessment of noise for wind energy developments are the DoEHLG 2006 Guidelines. The DoEHLG 2006 Guidelines are broadly in line with the recommendations set out in 'The Assessment and Rating of Noise from Wind Farms', published by the Department of Trade, and Industry (UK) Energy Technology Support Unit 1996 ETSU-R-97. The ETSU-R-97 document has been used to supplement the guidance contained within the DoEHLG 2006 Guidelines, where appropriate and necessary.

Background noise levels for day and night periods have been derived from noise survey data undertaken at seven locations in the receiving environment surrounding the Proposed Project.

Based on the proposed site layout and the details of turbine noise emissions, hub height, and tip height for the range of turbine types considered in the assessment, turbine noise levels have been predicted at NSLs across a range of operational wind speeds for the Vestas V150 at 145 m Hub Height. While the noise profiles of the Vestas V150 wind turbine have been used for the purposes of this assessment, the exact make and model of the turbine installed on the site will be dictated by a competitive procurement process but will adhere to the specifications and parameters (i.e. Tip Height, Hub Height and Rotor Diameter).

The findings of the assessment, presented in the EIAR has confirmed that the predicted operational noise levels associated with the Proposed Wind Farm will be within best practice turbine noise criteria, inclusive of the DoEHLG 2006 Guidelines, at all locations with no significant cumulative impacts or effects.

Operational noise from the proposed onsite 220kV substation has been assessed and found to be within the proposed criteria based on review of the most appropriate guidelines and standards. It is considered that operational noise from fixed plant associated with the Proposed Project will not result in any significant noise and vibration effects at NSLs.

The Applicant will fully investigate any complaints about unusual or excessive wind turbine noise, including "swishing" sounds (amplitude modulation) or tonal noises, by reviewing conditions at the time and carrying out noise monitoring agreed with local authorities. If excessive amplitude modulation is confirmed, an independent acoustic consultant will assess it using recognised industry methods to reduce it through technical adjustments, operational changes, or, in rare cases, turbine curtailment. Overall, this approach follows best practice to minimise noise impacts as far as reasonably possible.

A commitment has been provided that prior to the commissioning of the Proposed Wind Farm; the Developer will submit a Noise Compliance Monitoring Programme to the planning authority for written agreement. The Noise Compliance Monitoring Programme will include a detailed methodology for the noise measurements, procedures for recording results and locations at which noise is to be monitored. To date there is no clear industry consensus on how AM should be regulated or managed through the planning stage. In the absence of clear policy in Ireland to control AM from wind turbines, AWN have provided a Draft Noise Complaint Management Protocol for addressing AM or tonality presented (Appendix 12-6). A final version of this protocol will be contained within the Noise Compliance Monitoring Programme to be agreed the relevant Local Authority and/or Authorities in the event that a complaint relating to excessive AM is reported.

Reference Number 160 : Three-dimensional effects of the wake on wind turbine sound propagation using parabolic equation. Hemant Bommidala, Jules Colas, Ariane Emmanuelli, Didier Dragna, Codor Khodr,

Benjamin Cotte, Richard J.A.M. Stevens PII: S0022-460X(25)00110-5 DOI: https://doi.org/10.1016/j.jsv.2025.119036 Reference: YJSVI 119036. Journal of Sound and Vibration.

The influence of three-dimensional (3D) wind turbine wake effects on sound propagation is investigated. To study this, numerical simulations are conducted using a 3D parabolic equation model at low frequencies, with comparisons made to a two-dimensional (2D) approach that neglects transverse horizontal propagation. Three atmospheric stability conditions are investigated using analytical wind profiles that incorporate the wake effects. The wind turbine noise source is specified using an aeroacoustic extended source model. 3D effects due to the wake are shown to be significant, especially for the stable atmosphere. Indeed, horizontal refraction induces focusing that a 2D approach fails at predicting. As the wind turbine blades are rotating, the focal zones are moving accordingly, yielding large variations of the sound levels. Downstream the turbine, amplitude modulation can locally reach values as high as 16.5 dB over long distances. In addition, higher average SPL are predicted by 3D simulations compared to 2D ones, with deviations up to 4.5 dB. For neutral and unstable conditions differences in 2D and 3D sound propagation approaches are smaller, as velocity gradients in the wind turbine wake are smaller.

13 Cultural Heritage

An assessment of the potential effects of the Proposed Project on the Cultural Heritage resource was carried out by Tobar Archaeological Services. Cultural heritage includes archaeology, architectural heritage and any other tangible assets. The assessment was based on desktop research, field surveys, GIS-based mapping, Zone of Theoretical Visibility (ZTV) and was also assisted by representative photomontages and photowire images. A detailed examination of the available baseline data was undertaken in addition to a comprehensive site inspection. The latter comprised a walk-over survey of the Proposed Project site, any proposed infrastructure therein and proposed ecological enhancement areas.

Where potential effects have been identified, such as to potential sub-surface archaeology, appropriate mitigation measures have been recommended in order to minimise any such effects. Proposed mitigation includes pre-development testing where peat depths allow, archaeological monitoring of construction-phase ground works and floating of proposed roads. Direct effects to recorded monuments have been predominantly avoided by design. Where the Proposed Project layout interacts with the recorded monument OF007-350----gravel/stone trackway at 2 no. locations with proposed new road infrastructure, the proposed new road and the associated cable will be floated over the monument. A construction methodology for the proposed road construction has been devised to allow for a horizontal buffer over the recorded monument, see Appendix 4-3: Peat and Spoil Management Plan.

Potential indirect effects on the setting of any United Nations Educational, Scientific and Cultural Organisation (UNESCO) World Heritage Sites and those on a Tentative List within 25km, National Monuments within 15km, recorded monuments within 5km and Record of Protected Structures and National Inventory of Archaeological Heritage structures within 5km were included in order to assess potential effects on setting in the wider landscape. The ZTV was utilised to assess the level of theoretical visibility of the proposed turbines from cultural heritage assets within the 5km and 15km study areas. Potential effects on setting are based on the precautionary scenario in that natural screening, boundaries, buildings and vegetation are not taken into account in the ZTV model and, in reality, the potential effect is likely to be less.

Two UNESCO WH Tentative List sites are located within 25km of the nearest proposed turbine (T3 and T15) and comprise the Hill of Uisneach, and Birr Castle and Demesne. The ZTV demonstrates no theoretical visibility of the proposed turbines from Birr Castle and Demesne. While the ZTV demonstrates theoretical visibility of the proposed turbines from the Hill of Uisneach given the distance of the Proposed Wind Farm (c. 24km) to the Core and Buffer Area as defined in the Westmeath County Development Plan, the immediate setting of the Hill of Uisneach or its associated monuments will not be affected by the introduction of the proposed turbines as the visual change as a result of the Proposed Wind Farm is considered small in scale, leading to a low magnitude of change.

The Monastic Complex at Lemanaghan was visited as part of this assessment. As part of the Landscape and Visual assessment (Chapter 14) two photomontages (VP 13 and 14) were also created from the monastic complex illustrating visibility of the proposed turbines from both the church and graveyard (OF015-004003- and OF015-004004-) and from St Mella's Cell (OF015-004006-). Photowires and other visualisations were also produced from the Monastic Complex and are presented in Appendix 13-5. The appendix provides a detailed overview of the Monastic Complex, its potential connectivity with other monuments such as toghers and roadways including the Slí Mhór, and the visitor experience at the complex, and should be read in conjunction with both Chapter 13: Cultural Heritage and Chapter 14: Landscape and Visual. Any physical connection that may once have existed between toghers in Lemanaghan Bog to the north (within the Proposed Project site), in Derrynagun Bog to the east-northeast (OF015-084----) (outside the Proposed Project site) and Lemanaghan Monastic Complex is no longer present. Such connectivity, if it once existed, pertains to the time period in which the Monastic Complex was still functioning as a place of worship and pilgrimage. The landscape around the Monastic Complex and within Lemanaghan Bog has been significantly altered since this time.

Using the distance to the nearest turbine and the number of turbines visible from the Lemanaghan Monastic Complex, a Moderate, Negative, Long-Term effect, which is Not Significant to the wider setting of monastic complex is identified. It should be noted, however, that the immediate setting of the complex will not be affected. Furthermore, the presence of existing vegetative screening both around the monastic site and along the intervening public road will reduce potential visual effects including during the winter months as demonstrated by VP14 in Volume 2: Photomontage Booklet.

An assessment of potential cumulative effects was also undertaken taking into consideration other planning applications, the historical industrial peat extraction at Lemanaghan Bog, and identified cumulative wind farm projects within 25km. No significant cumulative effects have been identified and no cumulative effects to the immediate setting of cultural heritage assets will occur.

No significant direct or indirect effects to the recorded cultural heritage resource as a result of the Proposed Project have been identified. Where potential direct effects to sub-surface archaeology have been identified, appropriate mitigation measures are proposed in order to ameliorate these potential effects.

14 Landscape and Visual

Chapter 14: Landscape and Visual assesses the likely significant landscape and visual impacts arising as a result of the Proposed Project. Although all elements of the Proposed Project are assessed, the Chapter focuses upon the proposed turbines, as they are deemed to be the primary essential aspects of the proposal under assessment from a landscape and visual perspective. The Chapter also assesses the proposed 220kV onsite substation and steel masts that form part of the Proposed Grid Connection. The Chapter describes the baseline landscape and assesses the direct effects on the landscape of the Proposed Wind Farm, as well as effects on landscape character and the impact on sensitive landscape receptors (Areas of High Amenity) and Landscape Character Areas (LCAs). Visibility of the proposed turbines was assessed from receptors within a study area extending 25km from the proposed turbines (i.e., LVIA Study Area); and visual effects were determined from information gathered during multiple site visits as well as other tools such as ZTV mapping, photomontages and photowires.

The Proposed Project site is located within the flat lowland landscape of County Offaly, characterised by an extensive network of open peatlands that are typical of the Irish midland landscape. The character of these peatlands forming the Proposed Project site, is now strongly influenced by the industrial peat extraction practices historically conducted at the site, which now resembles a cutover peatland landscape, with limited scenic or aesthetic qualities pertaining to this landscape. The proposed turbines are located within an area designated with Moderate Sensitivity in the Offaly County Development Plan (OCDP). Cutaway bogs, which comprise the majority of this landscape type and where majority of the turbines are located in area noted in the OCDP as appropriate for "sensitively designed and located developments including renewable energy (wind farms)." The Proposed Project site is not located within any protected landscapes within any local landscape policy, and no sensitive landscape designations (Areas of High Amenity) fall within the Proposed Project site itself.

On-site visibility appraisals, ZTV mapping, a Route Screening Analysis and photomontage viewpoint locations determined that visibility of the proposed turbines will be very limited from locations beyond 5 km from the Proposed Project site. Siting of the proposed turbines at low base elevation in an extensively flat landscape with highly vegetated working fields surrounding the Proposed Project site largely restricts visual exposure in the wider landscape. Visibility of the proposed turbines beyond the immediate landscape setting of the Proposed Project site is limited to localised areas of high elevation where open views across the flat and highly vegetated landscape are available from elevated vantage points, which is in general not a common occurrence in the LVIA Study Area. In terms of location, spatial extent, spacing and layout, the siting and design of the Proposed Project adheres to the guidance for the siting of wind farms in Flat Peatland Landscapes as set out in the DoEHLG 2006 Guidelines and the Draft DoHPLG 2019 Guidelines. Residual effects upon the landscape of the proposed turbines are deemed to be 'Long-term', 'Negative' and 'Slight'. On balance, these effects are not considered significant.

Photomontages were used to assess the visual effects arising as a result of the Proposed Project from 20 no. viewpoint locations. The assessment concluded that no 'Profound' or 'Very Significant' effects occurred at any of the 20 photomontage viewpoints. A residual 'Significant' effect occurred at 1 no. viewpoint location (VP11) as the turbines are in relatively close proximity (<1km) to residential receptors. However, in all instances, the Proposed Project exceeds the recommended 500m set back distance in the DoEHLG 2006 Guidelines and also is in line with the 4 times tip height set-back distance (in this case 880m) set out for residential visual amenity prescribed by the Draft DoHPLG 2019 Guidelines. Residual 'Moderate' effects occurred at 8 of the 20 No. viewpoints. All other viewpoints were assessed as resulting in 'Slight' residual effects (8), 'Not Significant' (2), or Imperceptible (1). Cumulative visual effects have greatest potential to arise with other existing, permitted, and proposed developments. However, given the setting of the Proposed Project and limited visibility with the extensive flat landscape, cumulative effects are limited to elevated vantage points within the study area.

The Lemanaghan Monastic Site is the closest sensitive receptor to the Proposed Project (apart from residential receptors); however, as discussed throughout Chapter 14: Landscape and Visual, Chapter 13: Cultural Heritage, and the accompanying appendices, the Proposed Project will not alter the physical fabric or key features of the monuments, and any change will be limited to the wider landscape setting, where the proposed turbines will be seen beyond the immediate visual context of the Monastic Site. Furthermore, the Proposed Project is set back beyond the buffer specifically created to mitigate impacts on the Lemanaghan Monastic Site as set out in local planning policy through the 2021 amended Wind Energy Zoning (as per the Offaly County Council Chief Executive's Report)7, with

the exception of turbine T05, which is located on the boundary of an area designated 'not Deemed Suitable for Wind Energy Developments'.

In conclusion, the LVIA determined that the Proposed Project is located within a landscape that can effectively accommodate a wind energy development of this scale. Only one 'Significant' residual effect occurs at one viewpoint location (VP11) as the turbines are in relatively close proximity (<1km) to this location. The assessments have determined that the landscape of the Proposed Project site is capable of effectively accommodating the Proposed Project.

7 https://www.offaly.ie/app/uploads/Council/Council_Services_A-Z/Planning_Building/Chief-Executive-REport-Material-Amendment-Stage-2021.pdf

Reference Number 161 : 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.

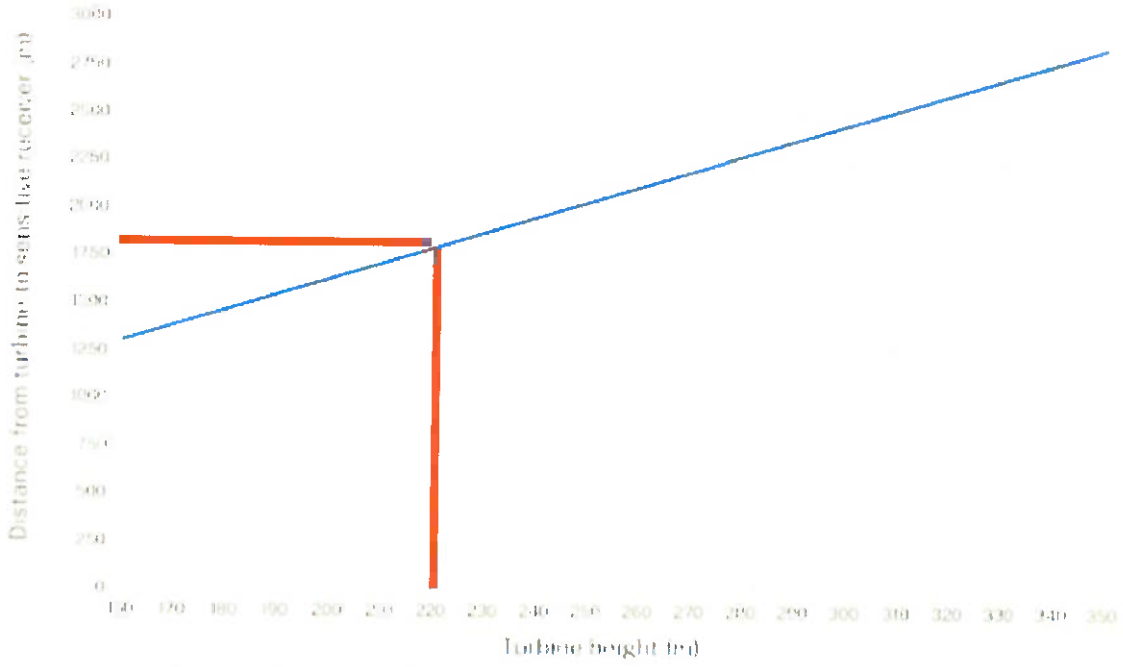


Figure 2. Setback from sensitive receivers

Response from MLavelle: For a 220m turbine height, the setback distance should be 1.75km

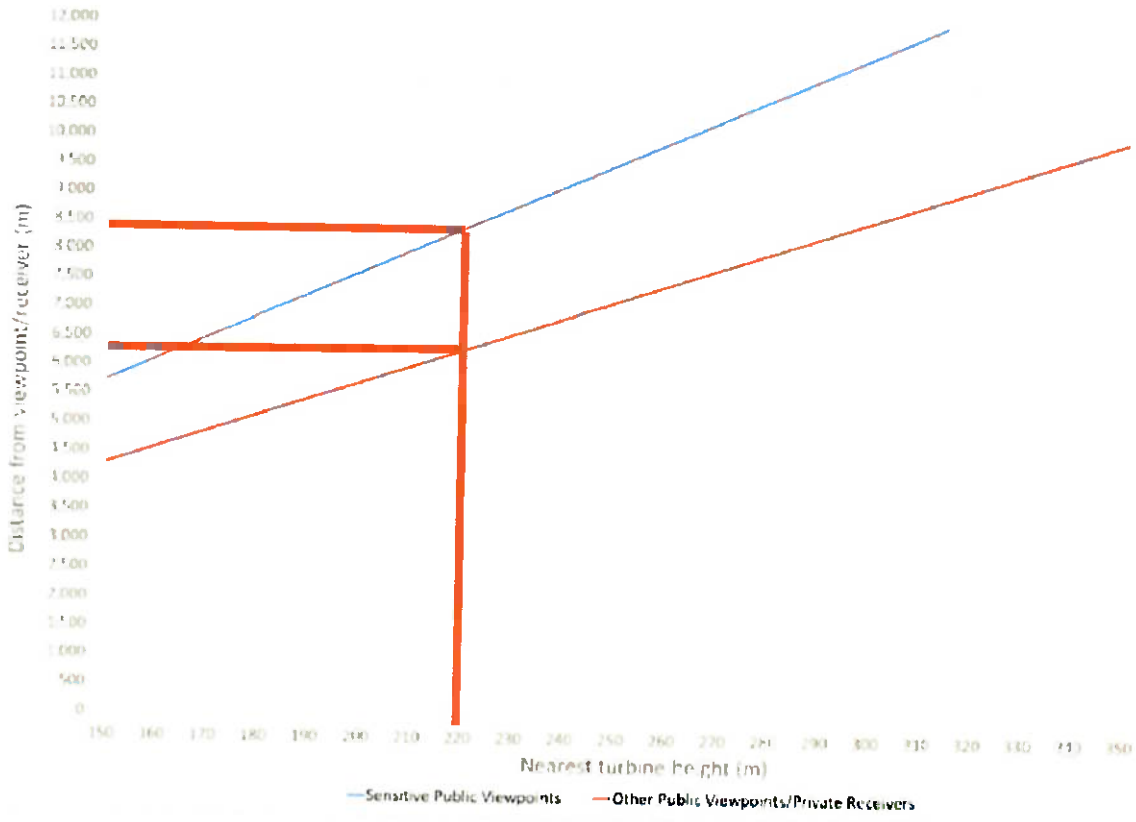


Figure 7. Extent of the scoping study area

Response from MLavelle: For a sensitive public viewpoint & 220m turbine height, the setback distance should be 8.5km. For other viewpoints, the setback should be 6.25km.

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.

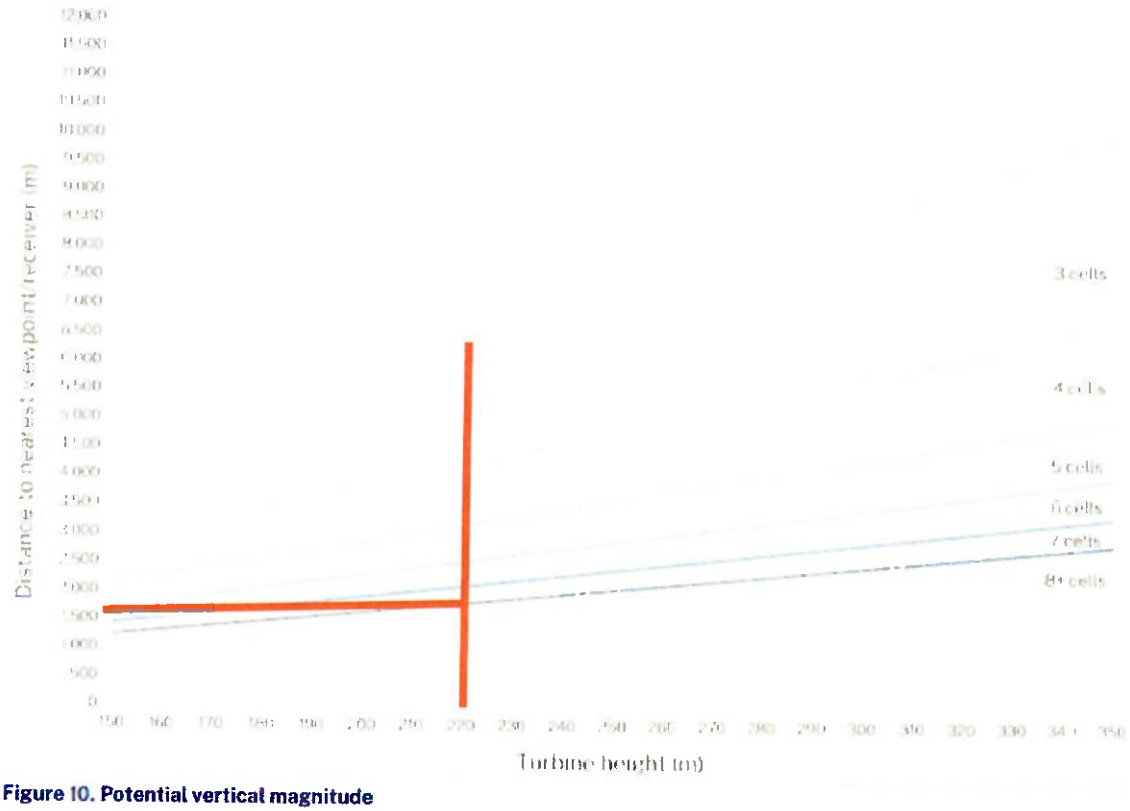


Figure 10. Potential vertical magnitude

Response from MLavelle: For a windfarm with more than 8 turbines, the setback should be 1.6km.

Reference Number 162: Collapse mechanism and risk management of wind turbine tower in strong wind. Jui-Sheng Chou, Yu-Chen Ou,Kuan-Yu Lin. Journal of Wind Engineering & Industrial Aerodynamics 193 (2019) 103962

In this study, the 1479 cases from 2007 to 2017, are considered.

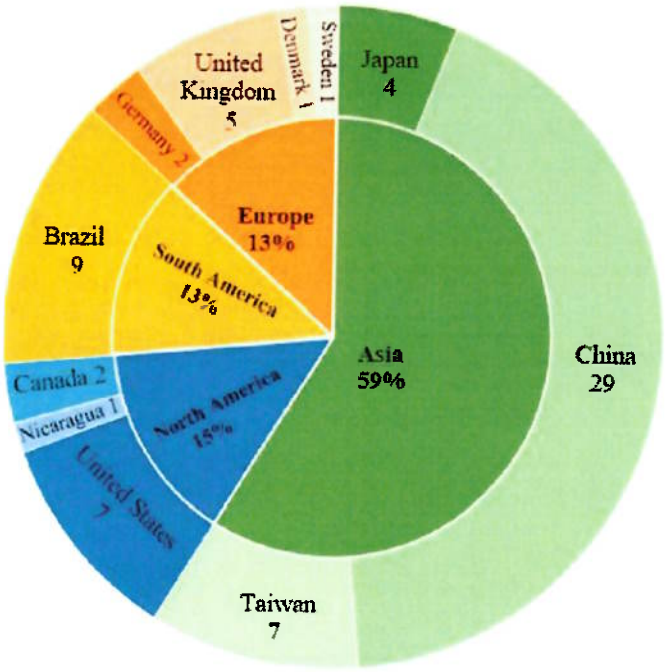


Fig. 3. Wind turbine collapse cases distribution across countries.

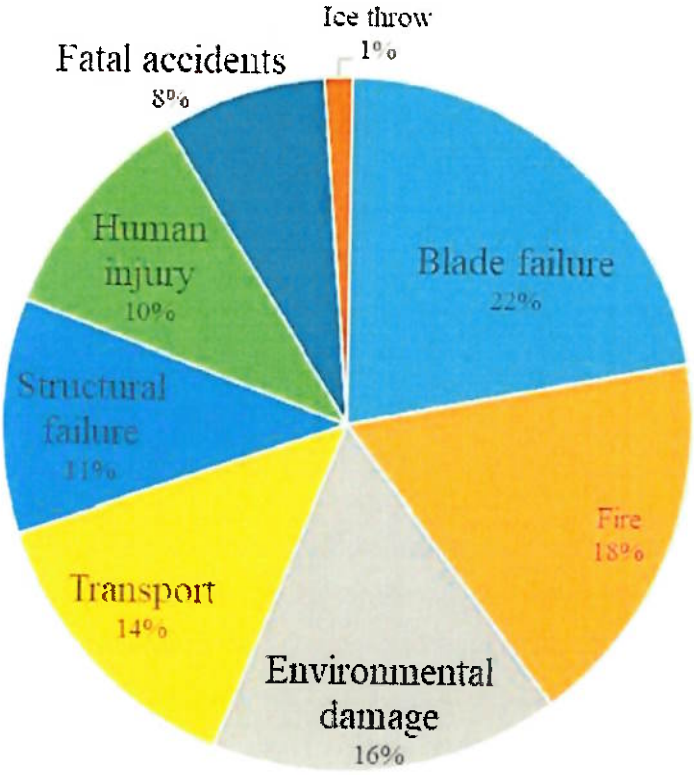


Fig. 1. Wind turbine disasters in recent years (excluding those associated with miscellaneous cases).

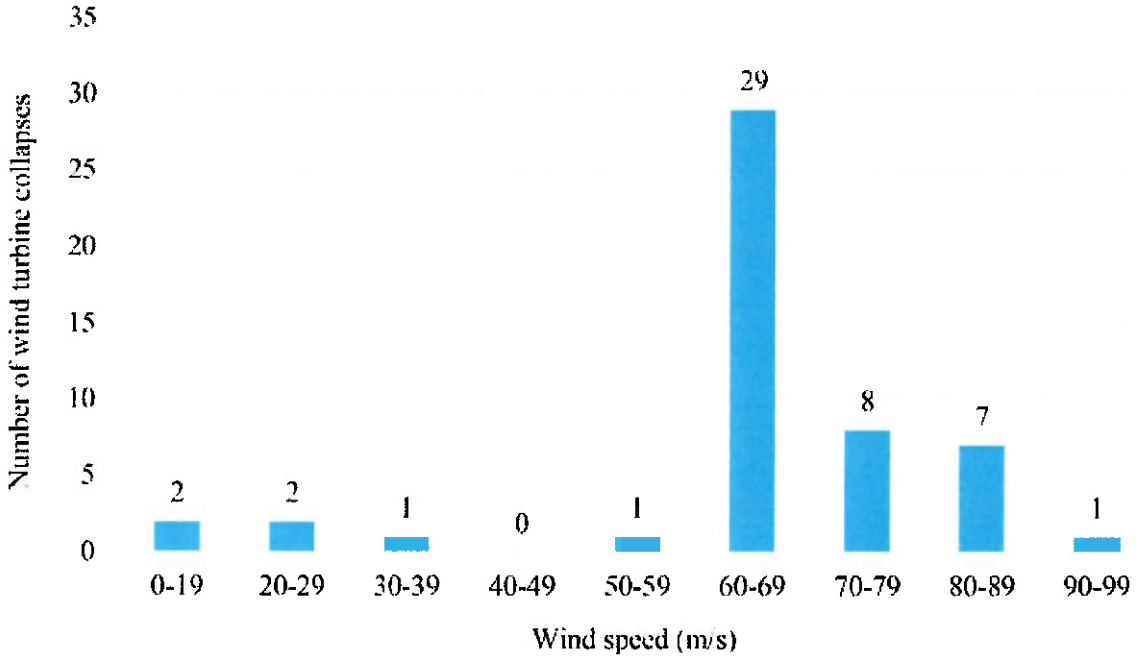


Fig. 4. Statistics on highest wind speed recorded when wind turbine collapses.

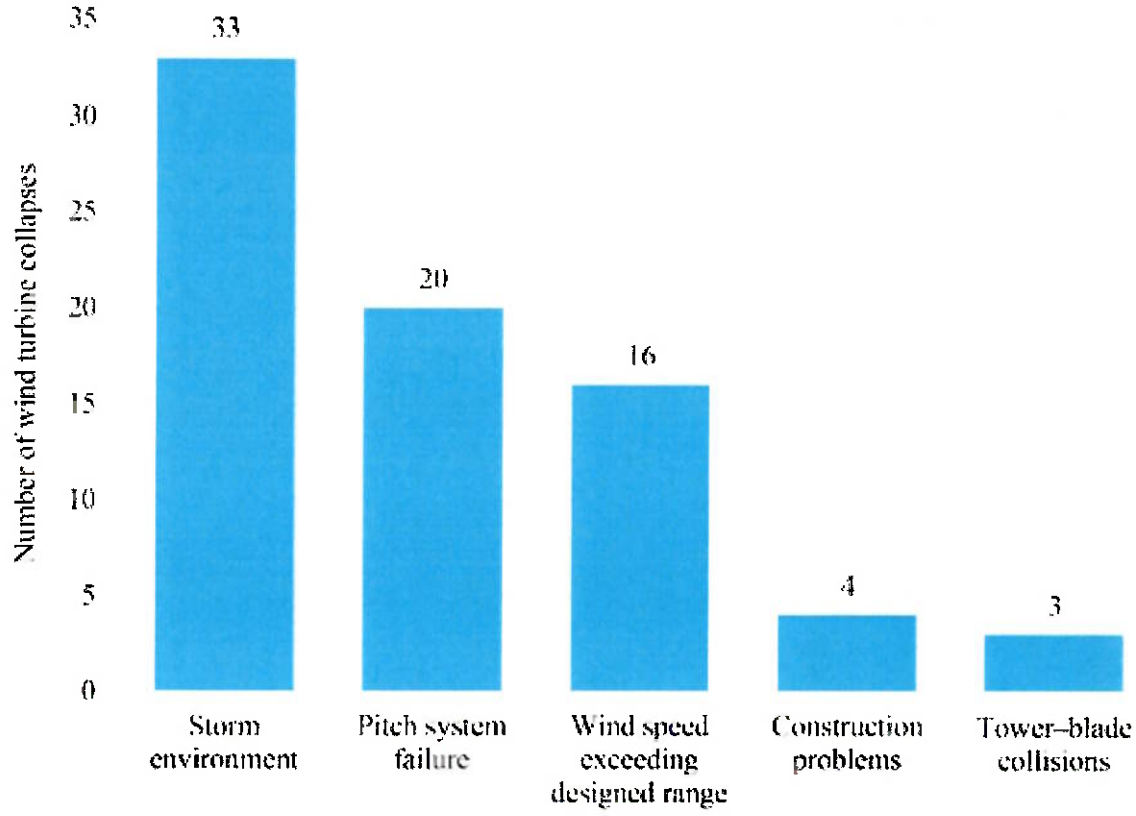


Fig. 7. Statistics on causes of wind turbine collapse.

Reference No. 163 : Barnwell Manor Wind Energy Limited Appellant - And – Respondents.
(1) East Northamptonshire District Council
(2) English Heritage
(3) National Trust

(4) The Secretary Of State For Communities And Local Government
Case No: C1/2013/0843 Neutral Citation Number: [2014] Ewca Civ 137 In The Court Of Appeal (Civil Division)
On Appeal From The High Court Of Justice Queen's Bench Division Administrative Court The Hon. Mrs Justice Lang Co/4231/2012

"Likewise in my view, paragraph 196, which says that "[where] a development proposal will lead to less than substantial harm to the significance of a designated heritage asset, ***this harm should be weighed against the public benefits of the proposal*** *...", falls within the reach of paragraph 11d)i. This policy must be read together with the policy in paragraph 194 that* ***"[any] harm to, or loss of, the significance of a designated heritage asset (from its alteration or destruction, or from development within its setting), should require clear and convincing justification"****. Like paragraphs 172 and 173, it allows for an appropriate balancing exercise to be undertaken. It is inherent in the policy* ***that if the harm to the heritage asset is not outweighed there may be a "clear reason" for refusing planning permission****. Here again, the policy does not prescribe the outcome of the balancing exercise in a particular case. That is for the decision-maker to resolve by applying the policy appropriately, in accordance with the relevant principles."*

15.1 Traffic and Transport

An assessment of the traffic effects on the local highway network was undertaken for the Proposed Project by Alan Lipscombe Traffic and Transport Consultants. The assessment considers the likely significant effects on the transport delivery routes to the site resulting from the additional traffic movements that will be generated by the Proposed Project during the construction, operational and decommissioning phases.

An assessment of the geometry of the delivery route was also undertaken in order to ensure that the abnormally sized vehicles required to deliver the turbine plant to the site are accommodated.

The construction phase is estimated to take approximately 24 to 30 months, and the works can be broken down into three main overlapping phases, 1) civil engineering works: 18 months, 2) electrical works: 18 months, and 3) turbine erection and commissioning: 9 months. The traffic and transport assessment contained in Chapter 15 has utilised a 24-month programme under a precautionary scenario, i.e., assuming the greatest potential volume of traffic over the shortest potential construction phase.

Traffic Route & Study Area

The Proposed Project is entirely located within County Offaly.

The Turbine Delivery Route (TDR) for the abnormally sized loads transporting the large turbine components commences at Galway Port in Galway City. Turbine infrastructure being imported to Galway Port will be delivered to site via north from the Galway Port through Galway City via the Lough Atalia Road, the R339 Wellpark Road, northwest onto the R336 Tuam Road, before turning west onto the N6 National Road for approximately 3.7km where the N6 joins the M6. The transport vehicles will merge onto the M6 and head east towards to the Proposed Wind Farm. It is proposed that the large wind turbine plant will be delivered via the M6 before turning south onto the N52 at Junction 5 (Tullamore/Kilbeggan). The route follows the N52 south, bypassing Tullamore to the east and passing through the settlements of Blue Ball, Kilcormac and Five Alley. Deliveries will turn right onto the N62 (at the junction known as Kennedy's Cross) and will proceed northwards towards Ferbane for approximately 22km to Site Entrance 1 on the N62. The abnormal loads will be delivered in convoys of 3 vehicles over 40 separate nights, with each convoy accompanied by a Garda escort.

The total length of the turbine delivery route from the exit off the M6 is approximately 68km.

Due to the nature of the Proposed Project, all proposed works will be local to the Proposed Project site and as such, the construction phase will utilise 4 no. site entrance locations. Of the 4 no. site entrance locations, 3 no. are existing site entrances that will be upgraded, and 1 no. is a proposed new entrance on the northern side of the L7002 local road. An existing agricultural site entrance off the L7001 local road network will also be upgraded to facilitate construction phase access to the Proposed Grid Connection infrastructure located under the existing Shannonbridge-Maynooth 220kV OHL. Use of existing road (which will be upgraded) and temporary construction track will be established from the existing entrance off the L7001 local road to the Proposed Grid Connection infrastructure located under the existing OHL. Following the construction of this infrastructure, this temporary track will be covered with a layer of topsoil and reseeded and the existing road and entrance will continue to facilitate agricultural activities.

The operational phase will utilise 4 no. site entrance locations to facilitate maintenance and monitoring activity and amenity access. Of the 4 no. locations, 3 no. are the same as the identified construction phase entrances and 1 no. is a new site entrance that will facilitate amenity access only.

The proposed access to the development on local roads is along legacy narrow roadways with limited passing facilities. The granting of this industrial facility will negate the level of safety for the local residents. The additional development is likely to lead to an over intensification of traffic on a local road without footpaths. The proposed development is premature pending major road improvement works to allow lorries to pass each other. The proposed development may also need for third party cooperation to improve the road as the existing carriageway has an average width of less than 5 metres. The overuse of the substandard local road by commercial lorries has both the potential to endanger pedestrian safety & cyclists, due to the absence of a footpath, by reason of traffic hazard and create obstruction at times when two trucks are attempting to pass. The proposed development located on such narrow Local roads is likely to constitute a risk to pedestrian safety.

The proposed development is located on Local Roads, that are substandard in terms of width and alignment. The scale of traffic generated by the proposed development over the Local roads both at construction and operational stage would render the road unsuitable to carry the increased loads arising from the development, would endanger public safety by reason of traffic hazard and obstruction of road users, Children, Pedestrians & Cyclists, would be premature having regard to the deficiency in the road network serving the rural area within which the site is located, would set an undesirable precedent for similar development of this scale and nature elsewhere & would seriously injure the residential amenities of the area and would therefore be contrary to the proper planning and sustainable development of the area.
The Development would lead to an over intensification of traffic on substandard out of capacity Local Roads. It is, therefore, recommended that the development be refused due to the hazard and obstruction concerns outlined above.
The proposed development of a windfarm facility is not serviced by a suitable transportation network.
The road network is not ideally suitable for the scale of construction traffic required to develop the Windfarm Facility.
The development is totally dependent on the transport of construction materials, labour and raw materials by substandard roads.
The road network is primarily a network of "legacy roads". These roads do not have a road structure as envisaged in the design standards. Rather the network depends on the periodic replacement of a thin road surface course or courses without the necessary road capping layer and sub-base being present beneath (directly on the subgrade). This renders the road liable to significant damage from HGV traffic (especially over-weight vehicles) caused by the transfer of wheel loads to the subgrade at stress levels above that which the subgrade can support.

Vehicle types and network geometry

The types of vehicles that will be required to negotiate the local network will be up to 80 metres long and will carry a blade 76 metres in length.

An assessment of the geometric requirements of the delivery vehicles was undertaken on the delivery route (Appendix 4-7). Locations where it was established that the existing road geometry will not accommodate all of the vehicles associated with the Proposed Project have been assessed, with the extent of remedial works identified. In addition to the assessment presented, it is recommended that a dry run is undertaken by the transport company to check vertical and horizontal clearance on the transport route prior to construction.

No vertical profiles or photographs were provided for the Sight Distance Triangles or Forward Sight Distances.

Appendix 4-7: Lemanaghan Wind Farm Abnormal Indivisible Load Route Survey January 2026 10110431

Response from MLavelle: The provision of Sweptpath maps without townland boundaries, townland names or north point to indicate locations is unacceptable. These maps indicate areas of over-run & over-sail across private property without consent from the landowners. It would also seem that the applicant proposes to use the private set-down areas at the front of existing houses without consent.

Additionally, it doesn't indicate river or canal bridge crossings with structural assessments to carry weights of Blades (80tonne), Towers, Nacelles (400tonne) or Cranes (750tonne).

David Naughton

From: NFO <information@tii.ie>
Sent: Monday 17 May 2021 17:20
To: David Naughton
Subject: RE: 200804 - EIAR Scoping Document for proposed Lemanaghan Wind Farm

Dear Mr. Naughton,

I refer to your email of 6 May 2021 regarding the above EIAR Scoping exercise.

TII will endeavour to consider and respond to planning applications referred to it given its status and duties as a statutory consultee under the Planning Acts. The approach to be adopted by TII in making such submissions or comments will seek to uphold official policy and guidelines as outlined in the Section 28 Ministerial Guidelines 'Spatial Planning and National Roads Guidelines for Planning Authorities' (DoECLG, 2012). Regard should also be had to other relevant guidance available at www.TII.ie.

The issuing of this correspondence is provided as best practice guidance only and does not prejudice TII's statutory right to make any observations, requests for further information, objections or appeals following the examination of any valid planning application referred.

National Strategic Outcome 2 of the National Planning Framework includes the objective to maintain the strategic capacity and safety of the national road network. It is also an investment priority of the National Development Plan, 2018 – 2027, to ensure that the extensive transport networks which have been greatly enhanced over the last two decades, are maintained to a high level to ensure quality levels of service, accessibility and connectivity to transport users.

In relation to your EIAR Scoping referral, TII notes the proposed site adjoins the N62, national road, at a location on the network that is subject to a general 100kph speed limit. In such circumstances, the developer/applicant should be aware that official policy concerning access to national roads seeks to avoid the creation of additional access points from new development or the generation of increased traffic from existing accesses (i.e. non-public road access) to national roads, to which speed limits greater than 50kph apply. Therefore, there are policy and road safety considerations that would need to be resolved in any subsequent application, including in relation to any future associated amenity uses, and available alternative arrangements to the local and regional road network should be utilised.

With respect to EIAR scoping issues, the recommendations indicated below provide only general guidance for the preparation of an EIAR, which may affect the national road network.

The developer/scheme promoter should have regard, *inter alia*, to the following:

- TII notes that the subject site adjoins the national, regional and local road network. Access to the road network shall be developed in accordance with official policy and road safety considerations, as outlined above. Consultations should be had with the relevant Local Authority/National Roads Design Office with regard to locations of existing and future national road schemes.

- TII would be specifically concerned as to potential significant impacts the development would have on the national road network (and junctions with national roads) in the proximity of the proposed development.

- The developer should assess visual impacts from existing national roads.

- The developer should have regard to any EIAR/EIS and all conditions and/or modifications imposed by An Bord Pleanála regarding road schemes in the area. The developer should in particular have regard to any potential cumulative impacts.

- The developer, in preparing EIAR, should have regard to TII Publications (formerly DMRB and the Manual of Contract Documents for Road Works).

- The developer, in preparing EIAR, should have regard to TII's Environmental Assessment and Construction Guidelines, including the *Guidelines for the Treatment of Air Quality During the Planning and Construction of National Road Schemes* (National Roads Authority, 2006).

- The EIAR/EIS should consider the Environmental Noise Regulations 2006 (SI 140 of 2006) and, in particular, how the development will affect future action plans by the relevant competent authority. The developer may need to consider the incorporation of noise barriers to reduce noise impacts (see *Guidelines for the Treatment of Noise and Vibration in National Road Schemes* (1st Rev., National Roads Authority, 2004)).

- It would be important that, where appropriate, subject to meeting the appropriate thresholds and criteria and having regard to best practice, a Traffic and Transport Assessment (TTA) be carried out in accordance with relevant guidelines, noting traffic volumes attending the site and traffic routes to/from the site with reference to impacts on the national road network and junctions of lower category roads with national roads. In relation to national roads, TII's TTA Guidelines (2014) should be referred to in relation to proposed development with potential impacts on the national road network. The scheme promoter is also advised to have regard to Section 2.2 of the NRA/TII TTA Guidelines which addresses requirements for sub-threshold TTA. Any improvements required to facilitate development should be identified. It will be the responsibility of the developer to pay for the costs of any improvements to national roads to facilitate the private development proposed as TII will not be responsible for such costs,

- The designers are asked to consult TII Publications to determine whether a Road Safety Audit is required.

- In the interests of maintaining the safety and standard of the national road network, the EIAR should identify the methods/techniques proposed for any works traversing/in proximity to the national road network.

- TII recommends that that applicant/developer should clearly identify haul routes proposed and fully assess the network to be traversed. Where abnormal 'weight' loads are proposed, separate structure approvals/permits and other licences may be required in connection with the proposed haul route and all structures on the haul route through all the relevant County Council administrative areas should be checked by the applicant/developer to confirm their capacity to accommodate any abnormal 'weight' load proposed.

  The national road network is managed by a combination of PPP Concessions, Motorway Maintenance and Renewal Contracts (MMaRC) and local road authorities in association with TII.

  The applicant/developer should also consult with all PPP Companies, MMaRC Contractors and road authorities over which the haul route traverses to ascertain any operational requirements such as delivery timetabling, etc. and to ensure that the strategic function of the national road network is safeguarded.

  Additionally, any damage caused to the pavement on the existing national road arising from any temporary works due to the turning movement of abnormal 'length' loads (e.g. tearing of the surface course, etc.) shall be rectified in accordance with TII Pavement Standards and details in this regard shall be agreed with the Road Authority prior to the commencement of any development on site.

  Designers should consult TII Publications to determine whether a Road Safety Audit is required for any of the temporary works proposed. Any recommendations should be incorporated into designs.

- Grid connection and cable routing proposals should be developed to safeguard proposed road schemes as TII will not be responsible for costs associated with future relocation of cable routing where proposals are catered for in an area of a proposed national road scheme. In that regard, consideration should be given to routing options, use of existing crossings, depth of cable laying, etc.

  In the context of the existing national road network, in accordance with the National Planning Framework National Strategic Outcome no. 2 'Enhanced Regional Accessibility', there is a requirement to maintain the

strategic capacity and safety of the network. This requirement is further reflected in the National Development Plan, the recent publication of the Draft National Investment Framework for Transport in Ireland and also the existing Statutory Section 28 Spatial Planning and National Roads Guidelines for Planning Authorities.

There is around 99,000km of roads in Ireland, the national road network which caters for strategic inter-urban travel consists of only approx. 5.4% of this. There is a critical requirement to ensure the strategic capacity and safety of this national road network is maintained and significant Government investment already made in the national road network is safeguarded.

The provision of cabling along the national road network represents a number of significant implications for TII and road authorities in the management and maintenance of the strategic national road network and TII is of the opinion that grid connection cable routing should reflect the foregoing provisions of official policy. Therefore, TII advises that grid connection cable routing should seek to utilise the extensive existing local road network, or alternatives, as opposed to the strategic national road network contrary to the provisions of official policy.

Other consents or licences may be required from the road authority for any trenching or cabling proposals crossing the national road. The Authority requests referral of all proposals agreed and licensed between the road authority and the applicant which affect the national road network.

Cable routing should avoid all impacts to existing TII infrastructure such as traffic counters, weather stations, etc. and works required to such infrastructure shall only be undertaken in consultation with and subject to the agreement of TII, any costs attributable shall be borne by the applicant/developer. The developer should also be aware that separate approvals may be required for works traversing the national road network.

Notwithstanding any of the above, the developer should be aware that this list is non-exhaustive, thus site and development specific issues should be addressed in accordance with best practice.

I trust that the above comments are of use in your EIAR preparation.

Yours sincerely,

Alban Mills
Senior Regulatory and Administration Executive

From: David Naughton <dnaughton@mkoire and.ie>
Sent: Wednesday 5 May 2021 11:48
To: Landuse Planning <LandUsePlanning@tii.ie>
Subject: 200804 - EIAR Scoping Document for proposed Lemanaghan Wind Farm

CAUTION: This email originated from outside of TII. Do not click links or open attachments unless you recognise the sender and are sure that the content is safe.

Dear Sir or Madam,

Please find attached a cover letter and Scoping Document for a proposed wind farm development in Lemanaghan and adjacent townlands in Co. Offaly.

As part of the scoping exercise for the proposed development, we would welcome any comments in relation to the proposed project.

If you have any queries, please do not hesitate to contact me.

Kind regards,

David Naughton B.Sc. (Env.)
Environmental Scientist

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Tuam Road, Galway
Ireland, H91 VW84
+353 (0) 91 735611
www.mkoireland.ie

[redacted]

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Edel Mulholland

From: INFO <information@tii.ie>
Sent: Thursday 14 November 2024 17:00
To: Edel Mulholland
Subject: TI24-129235 - EIAR Scoping Document for Proposed Lemanaghan Wind Farm Offaly

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Caution: This is an external email and may be malicious. Please take care when clicking links or opening attachments.

Dear Ms. Mulholland,

Thank you for your correspondence of 23 October 2024 in relation to the above. The position in relation to your enquiry is as follows.

Transport Infrastructure Ireland (TII) wishes to advise you that it is not in a position to engage directly with planning applicants regarding proposed developments. TII will endeavour to consider and respond to planning applications referred to it given its status and duties as a statutory consultee under the planning acts. The approach to be adopted by TII in making such submissions or comments will seek to uphold official national road and light rail policy and guidelines including Spatial Planning and National Roads Guidelines for Planning Authorities (DoECLG, 2012) and TII Publications.

In relation to your EIAR Scoping referral, TII again notes the proposed site adjoins the N62, a national road, at a location on the network that is subject to a general 100km/h speed limit. In such circumstances, the developer/applicant should be aware that official policy concerning access to national roads seeks to avoid the creation of additional access points from new development or the generation of increased traffic from existing accesses (i.e. non-public road access) to national roads, to which speed limits greater than 50km/h apply. Therefore, there are policy and road safety considerations that would need to be resolved in any subsequent application, including in relation to any future associated amenity uses, and available alternative arrangements to the local and regional road network should be utilised.

Regard should also be had to other relevant guidance available at www.TII.ie.

The issuing of this correspondence is provided as best practice guidance only and does not prejudice TII's statutory right to make any observations, requests for further information, objections or appeals following the examination of any valid planning application referred.

Concerning EIAR scoping issues, the recommendations indicated below provide only general guidance for the preparation of an EIAR, which may affect the national roads and/or light rail networks. The project promoter should have regard, inter alia, to the following:

Having regard to the EPA guidelines on the information to be contained in Environmental Impact Assessment Reports, 2022 it is recommended as appropriate that the national road and light rail networks be recognised as strategic transport assets under "material assets".

EIAR assessment and mitigation should have regard to the following:

- **National Roads:** Official policy for development at or near national roads is set out in the DoECLG Spatial Planning and National Roads Guidelines for Planning Authorities (2012) available at https://www.gov.ie/en/collection/85b83-planning-guidelines-standards/

- **TII Publications**: In addition, as part of TII's responsibilities for managing and improving the country's national road and light rail networks, TII sets development guidance and standards for traffic and road assessments and construction that may be necessary by reason of proposed development location, scale or typology to be prepared to accompany applications for developments or works. Technical guidance and standards are contained in TII Publications, available at https://www.tiipublications.ie/.

In addition, the EIAR should have regard to, inter alia, the following:

National Road Network:

- TII would be specifically concerned with the potential significant impacts the development would have on the national road network (and junctions with national roads) in the proximity of the proposed development,

- Consultations should be had with the relevant Local Authority/National Roads Design Office (RDO) with regard to locations of existing and future national road schemes,

- The EIAR should have regard to any prior Environmental Impact Statement or Assessment Report and all conditions and/or modifications imposed by An Bord Pleanála regarding road schemes in the area. The developer should in particular have regard for any potential cumulative impacts,

- The EIAR should have regard to the provisions of Chapter 3 of the DoECLG Spatial Planning and National Roads Guidelines in the assessment.

TII Publications:

- It would be important that, where appropriate, subject to meeting the applicable thresholds and criteria and having regard to best practice, a Traffic and Transport Assessment (TTA) be carried out in accordance with relevant guidelines, noting traffic volumes attending the site and traffic routes to/from the site with reference to impacts on the national road network and junctions of lower category roads with national roads. TII's Traffic and Transport Assessment Guidelines (TII Publication No. PE-PDV-02045) should be referred to in relation to the proposed development with potential impacts on the national road network. The scheme promoter is also advised to have regard to Section 2.2 of the Guidelines which addresses requirements for sub-threshold TTA,

- The designers and assessors are asked to consult TII Publications to determine whether a Road Safety Audit is required.

TII environmental assessment guidance:

- The EIAR should have regard to TII's Environmental Assessment and Construction Guidelines, including the Good Practice Guidance for the Treatment of Noise during the Planning of National Road Schemes (March 2014),

- The EIAR should consider the European Communities (Environmental Noise) Regulations 2018 (S.I. No. 549 of 2018)) and, in particular, how the development will affect future action plans by the relevant competent authority. The developer may need to consider the incorporation of noise barriers to reduce noise impacts (see

Good Practice Guidance for the Treatment of Noise during the Planning of National Road Schemes (March 2014)].

Haul routes utilising the national road network:

- Elements of the national road network are operated and managed by a combination of Public-Private Partnerships (PPP) concessions, Motorway Maintenance and Renewal Contractors (MMaRC) and local road authorities in association with TII. In relation to haul route identification, the applicant/developer should clearly identify haul routes proposed and fully assess the network to be traversed to ascertain any operational requirements, including delivery timetabling, etc. to ensure that the strategic function of the national road network is safeguarded.

- Separate structure approvals/permits and other licences and works-specific deeds of indemnity may be required in connection with the proposed haul route, including where temporary modification to the road network may be required. Consultation with relevant local authorities, PPP and MMaRC may also be required.

- All structures on the haul route should be checked by the applicant/developer to confirm their capacity to accommodate any abnormal load proposed, including abnormal weight load. Additionally, any damage caused to the pavement on the existing national road arising from any temporary works due to the turning movement of abnormal loads (e.g. tearing of the surface course, etc.) shall be rectified in accordance with TII Pavement Standards and details in this regard shall be agreed with the Road Authority prior to the commencement of any development on site.

National Road Crossings:

- In the interests of maintaining the safety and standard of the national road network, the EIAR should identify the methods/techniques proposed for any works traversing/in proximity to the national road network,

- The preferred method of necessary national road network crossings is horizontal directional drilling (HDD). It is appropriate for the designers to contact thirdpartyworks@tii.ie in order to coordinate and process approvals for this type of crossing that may include requirements for Section 53 consent and specific indemnities for the works.

Potential cable routing

Any grid connection and cable routing proposals should be developed to safeguard existing national roads and/or proposed road schemes as TII will not be responsible for costs associated with future relocation of cable routing where proposals are catered for in an area of a proposed national road scheme. In that regard, consideration should be given to routing options, use of existing crossings, depth of cable laying, etc.

In the context of the existing national roads network, in accordance with the National Planning Framework National Strategic Outcome no. 2 'Enhanced Regional Accessibility', there is a requirement to maintain the strategic capacity and safety of the network. This requirement is further reflected in the National Development Plan, the National Investment Framework for Transport in Ireland and also the existing Statutory Section 28 Spatial Planning and National Roads Guidelines for Planning Authorities. There are around 99,000km of roads in Ireland, the national road network which caters for strategic inter-urban travel consists of only approximately 5.4% of this. There is a critical requirement to ensure the strategic capacity and safety of this national road network is maintained and significant Government investment already made in the national road network is safeguarded.

The provision of cabling along the national road network represents a number of significant implications for TII and road authorities in the management and maintenance of the strategic national road network

and TII is of the opinion that grid connection cable routing should reflect the foregoing provisions of official policy.

TII has identified a number of significant implications for TII and road authorities in the management and maintenance of the strategic national road network resulting from the laying of high voltage electricity cabling in the national road reservation, including:

- Impacts on embankments, bridges, drainage, and road furniture infrastructure leading to future maintenance liabilities,
- Impediments to future maintenance and operations activities, such as safety barrier repair and French drain renewal,
- Impediments to future routine network improvements such as pavement overlay and strengthening, installation of new verge-side signs and other road furniture,
- Impediment to future online upgrades of national roads because of the implications to road authority/TII in having to incur the additional costs of moving underground cables in order to accommodate the road improvements.

Proposals to lay cable in the national road reservation, including the construction of associated joint bays, have the potential to impact road authorities and TII in undertaking future maintenance and improvement requirements. There may also be additional cost implications to national road improvements and maintenance resulting from the presence of high-voltage cabling within the national road reservation.

Section 12.4.1.1 'Accelerate Renewable Electricity Generation' of the Climate Action Plan 2024 (CAP24) outlines the objective of reaching 80% of electricity demand from renewable sources by 2030 through a range of measures, including: "All relevant public bodies will carry out their functions in a manner which supports the achievement of the renewable electricity targets, including, but not limited to, the use of road and rail infrastructure to provide a route for grid infrastructure where this is the optimal solution". Consistent with CAP24, for all renewable energy developments requiring grid connection to the national grid, TII recommends that a full assessment of all route alternatives for grid connection takes place, including alternatives to public roads, where appropriate to demonstrate clearly that the 'optimal solution' in accordance with CAP 24 requirements is proposed in the subject application. In TII's experience, grid connection accommodated on national roads has the potential, inter alia, to result in technical road safety issues such as differential settlement due to backfilling trenches and can impact on ability and cost of general maintenance, upgrades and safety works to existing national roads.

Other consents or licences may be required from the road authority for any trenching or cabling proposals crossing the national road. TII requests referral of all proposals agreed and licensed between the road authority and the applicant which affect the national road network.

Cable routing should avoid all impacts to existing TII infrastructure such as traffic counters, weather stations, etc. and works required to such infrastructure shall only be undertaken in consultation with and subject to the agreement of TII, any costs attributable shall be borne by the applicant/developer. The developer should also be aware that separate approvals may be required for works traversing the national road network.

Notwithstanding, any of the above, the developer should be aware that this list is non-exhaustive, thus site and development-specific issues should be addressed in accordance with best practice.

I trust that the above comments are of use in your EIAR preparation.

Yours sincerely,

Rachel Begley
Regulatory & Administration Executive
Transport Infrastructure Ireland

www.tii.ie info@tii.ie +353 (0)1 646 3600

In accordance with TII's Right to Disconnect policy, if you are receiving this email outside of normal working hours, I do not expect a response or action outside of your own working hours unless it is clearly noted as requiring urgent attention.

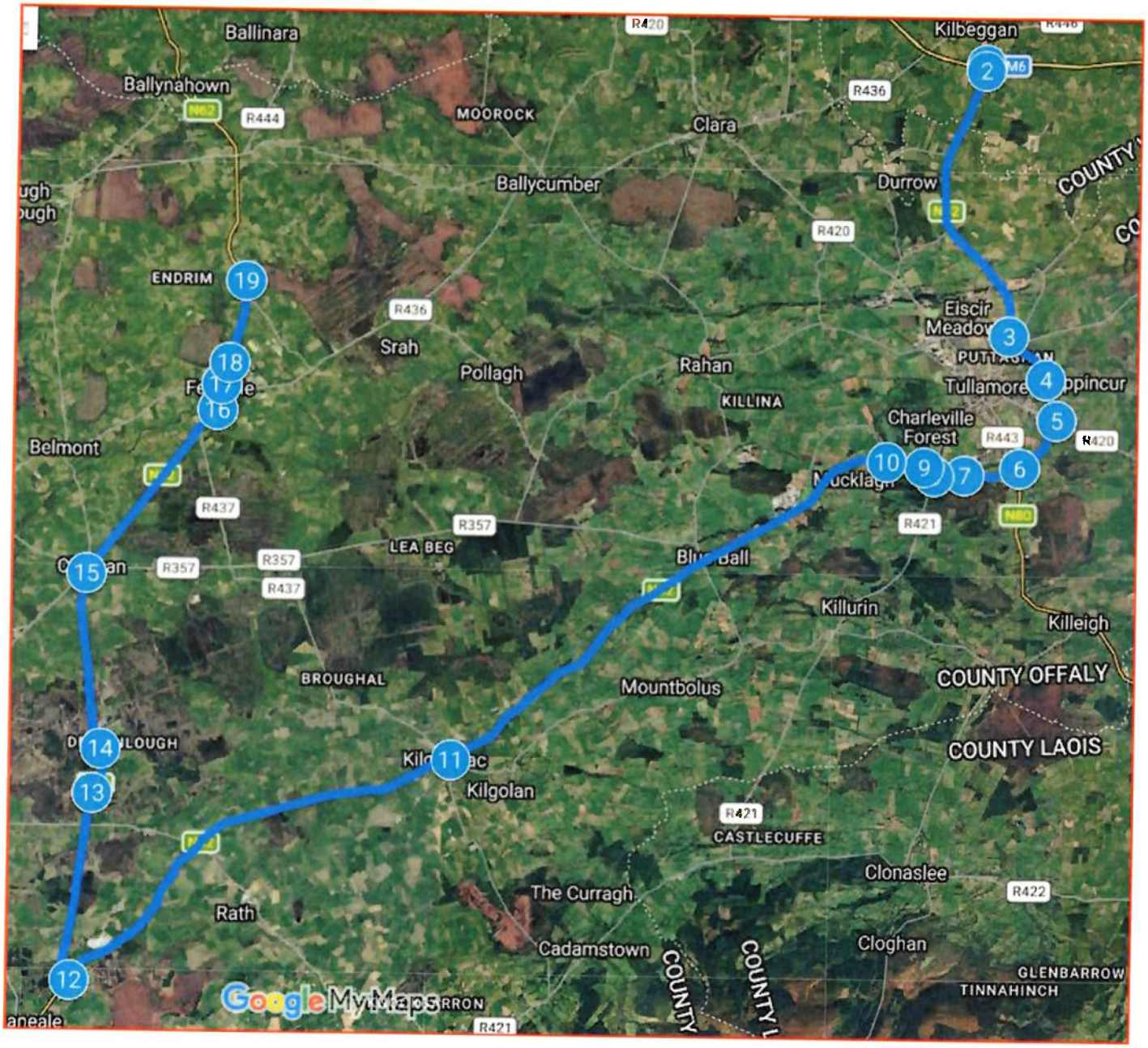
De réir pholasaí BIÉ An Ceart gan a bheith Ceangailte, má tá an ríomhphost seo á fháil agat lasmuigh de na gnáthuaireanta oibre, nílim ag súil le freagra ná le gníomh uait lasmuigh de do ghnáthuaireanta oibre féin mura bhfuil sé ráite go soiléir go bhfuil gá gníomhú go práinneach.

TII processes personal data provided to it in accordance with its Data Protection Notice available at https://www.tii.ie/about/about-tii/Data-Protection/

Próiseálann BIÉ sonraí pearsanta a sholáthraítear dó i gcomhréir lena Fhógra ar Chosaint Sonraí atá ar fáil ag https://www.tii.ie/about/about-tii/Data-Protection/?set-lang=ga

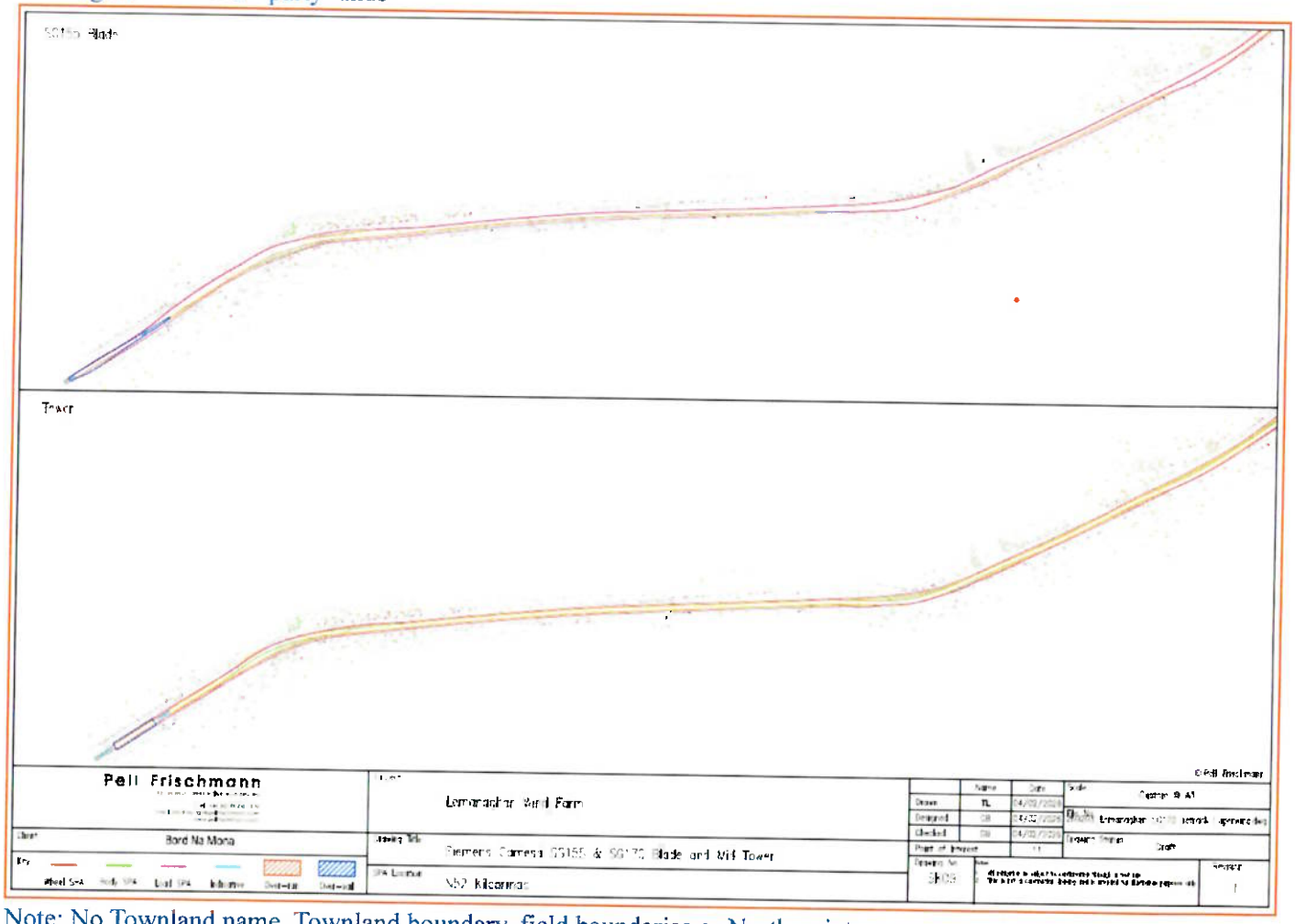
TII E-mail system: This email and any files transmitted with it are confidential and intended solely for the use of the individual or entity to whom they are addressed. If you have received this email in error then please notify postmaster@tii.ie and delete the original including attachments.

Córas r-phoist BIE: Tá an ríomhphost seo agus aon chomhaid a tharchuirtear leis faoi rún agus beartaithe lena n-úsáid ag an duine aonair nó ag an eintiteas a bhfuil siad dírithe chuige/chuici amháin. Más rud é go bhfuair tú an ríomhphost seo trí bhotún, cuir sin in iúil do postmaster@tii.ie, le do thoil, agus scrios an ríomhphost bunaidh agus aon cheangaltáin.

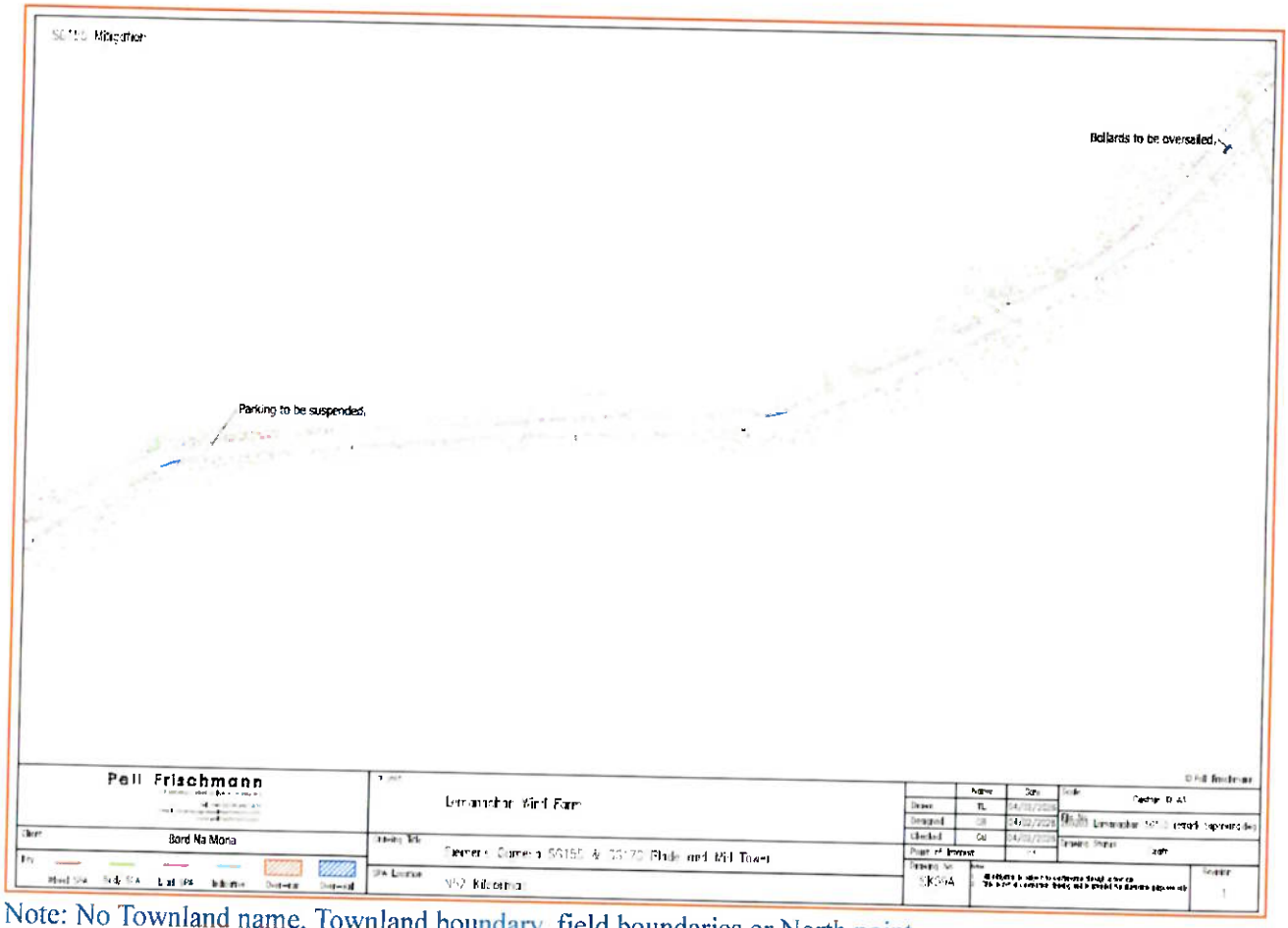

Ballinara
Ballynahown
N62
R444
MOOROCK
R420
Kilbeggan
M6
R436
Clara
Ballycumber
Durrow
N52
COUNTY
ENDRIM
19
R436
Srah
Pollagh
Rahan
Eiscir
Meadow
3
PUTTAGHAN
18
17
16
KILLINA
Tullamore
4
5
Charleville
Forest
R443
R420
Belmont
10
9
7
6
R437
R357
LEA BEG
R421
N80
15
R357
R357
R437
Killurin
Killeigh
BROUGHAL
Mountbolus
COUNTY OFFALY
14
11
COUNTY LAOIS
13
Kilgolan
R421
CASTLECUFFE
Clonaslee
R422
The Curragh
Rath
12
Cadamstown
Cloghan
COUNTY
GLENBARROW
TINNAHINCH
Google My Maps
R421

POI	Key Constraint	Details
12	**N52 / N62 Junction**  	Loads will turn right onto the N62 using a bypass track constructed for an other project. <u>SG155</u> The swept path assessment indicates that loads will oversail the verge of the bypass track where two trees should be removed. Loads will oversail both verges of the N62 on exit from the junction and through the following right bend. <u>SG170</u> Loads will require mitigation in the same areas as the SG155 with larger areas required. An addition three trees should be removed along with fencing. A small area of additional load bearing surfacing is required. Through the following right bend, loads will oversail the wooden fence where potential **third party land** is required to the east of the road. Bord na Móna have indicated that they have control of the land required for these manoeuvres. Swept path assessments SK10a, SK10c, SK11a and SK11c are included in Appendix A.

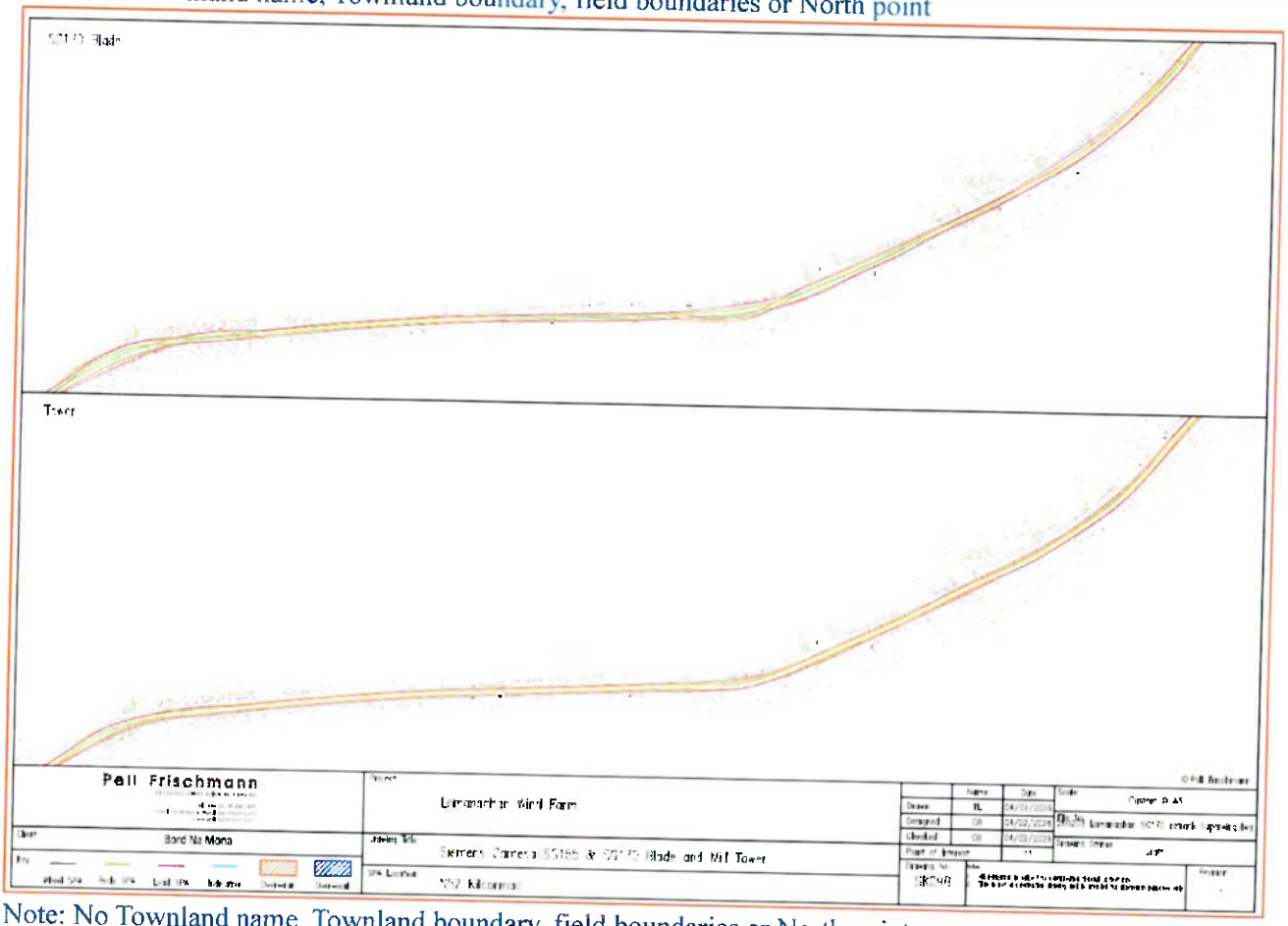
Note agreement for 3rd party lands



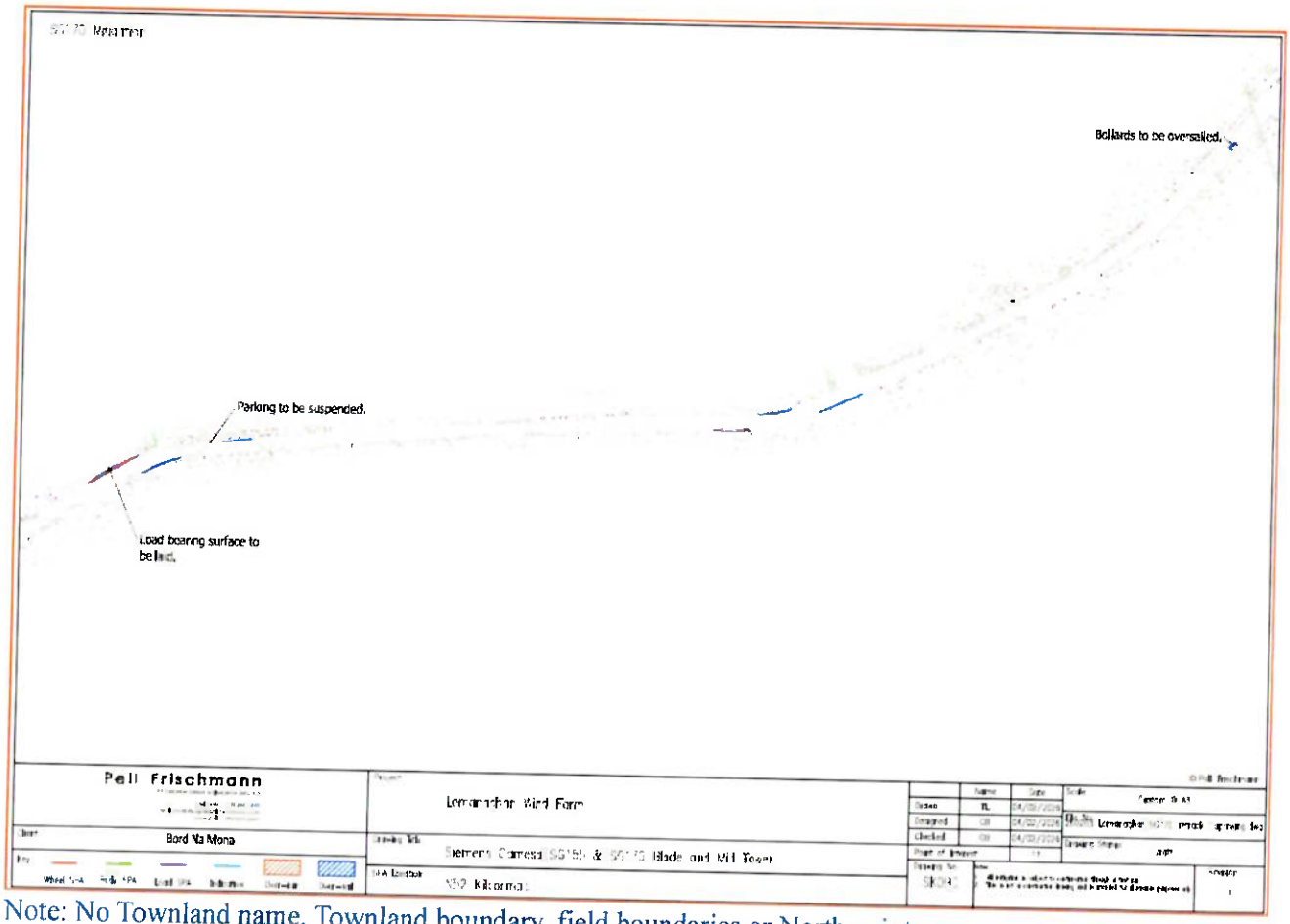
Note: No Townland name, Townland boundary, field boundaries or North point.



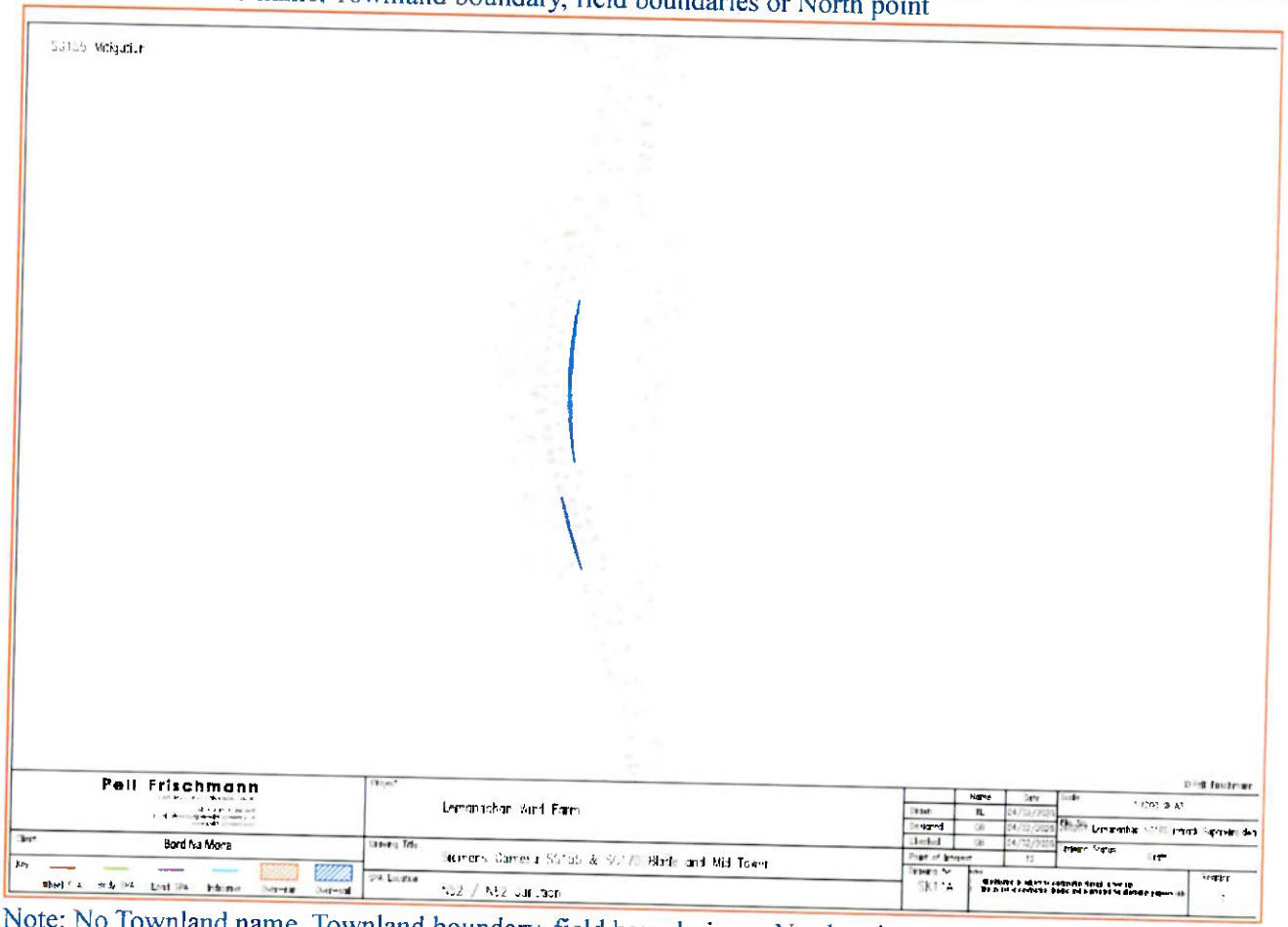
Note: No Townland name, Townland boundary, field boundaries or North point



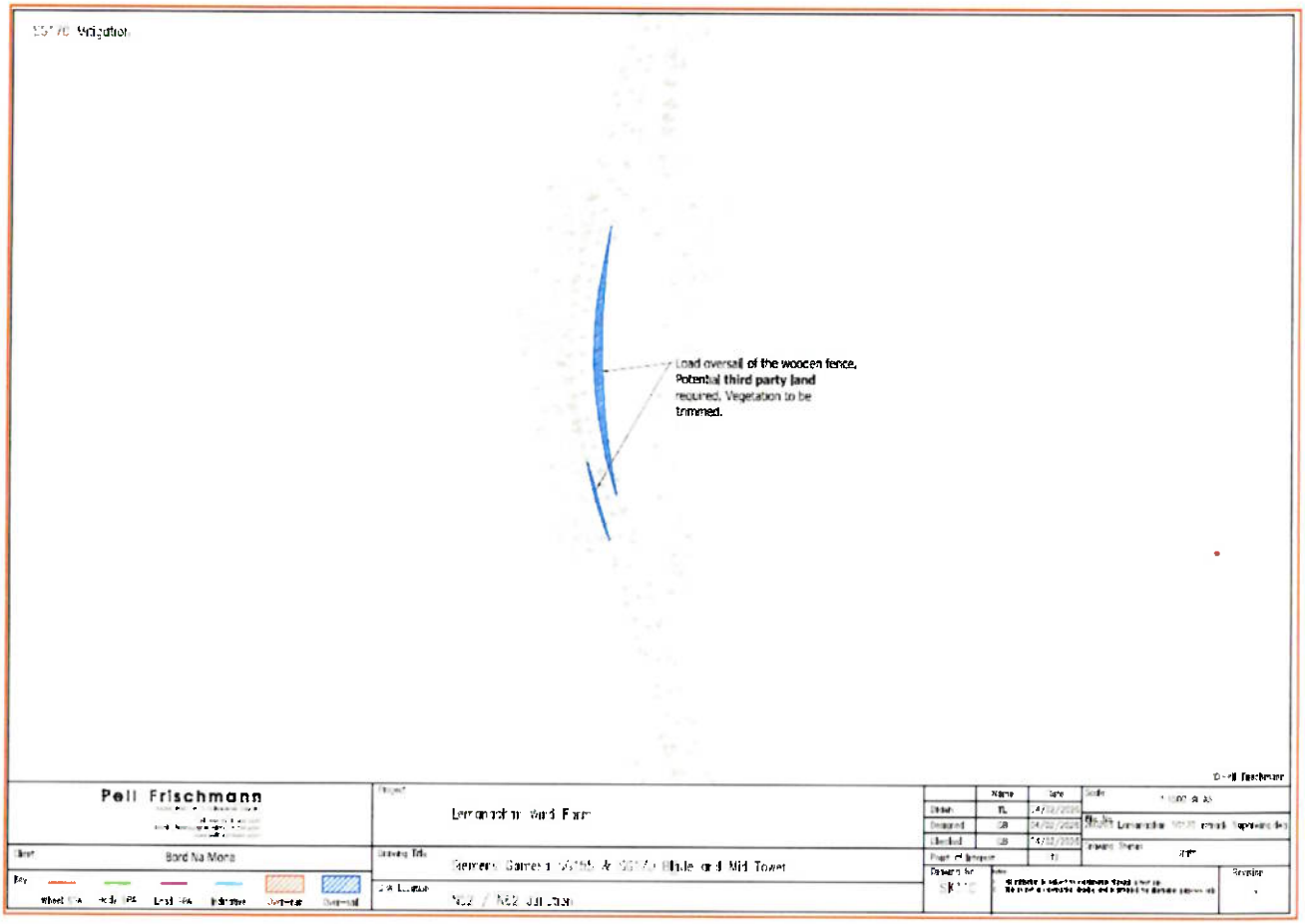
Note: No Townland name, Townland boundary, field boundaries or North point



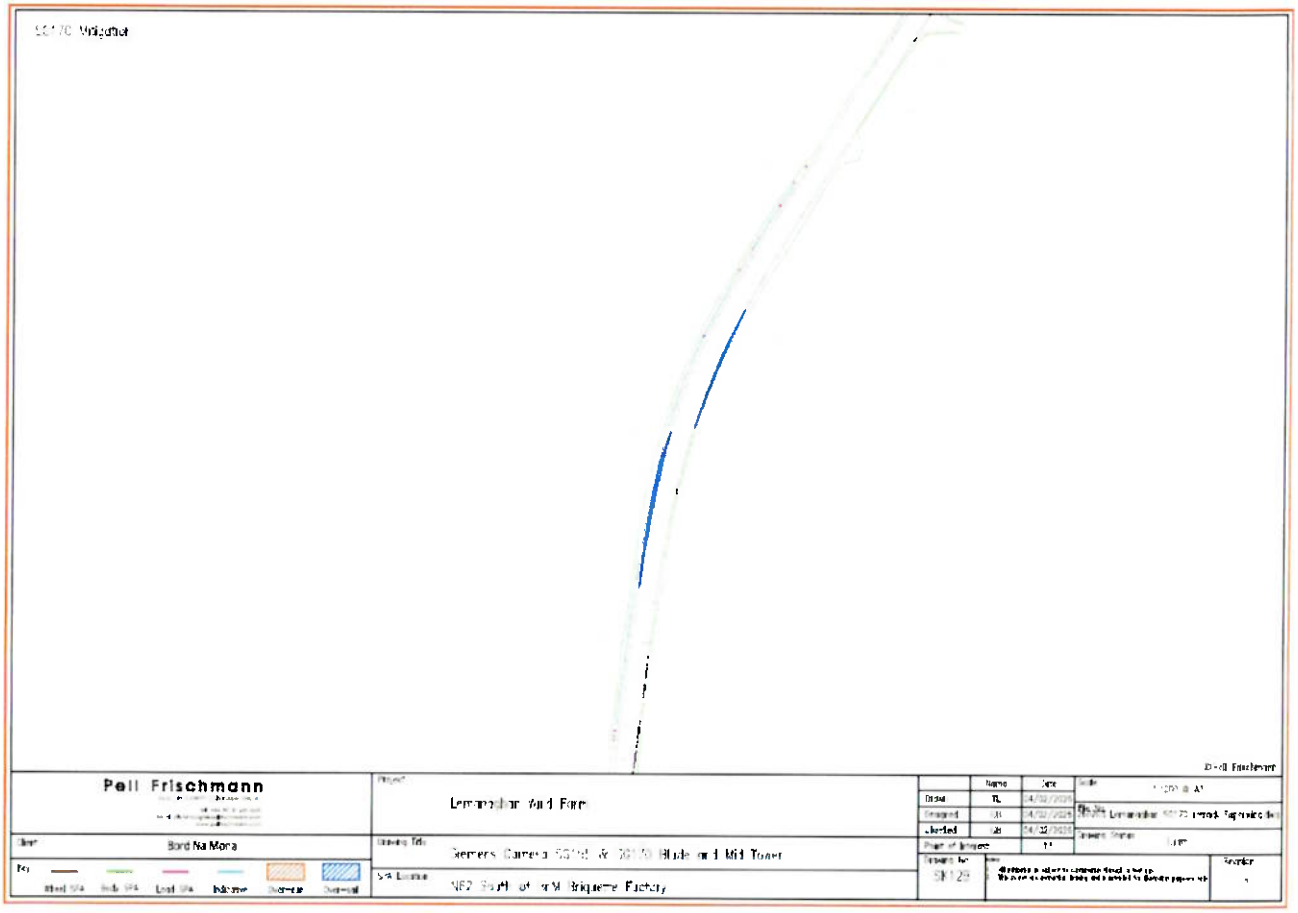
Note: No Townland name, Townland boundary, field boundaries or North point



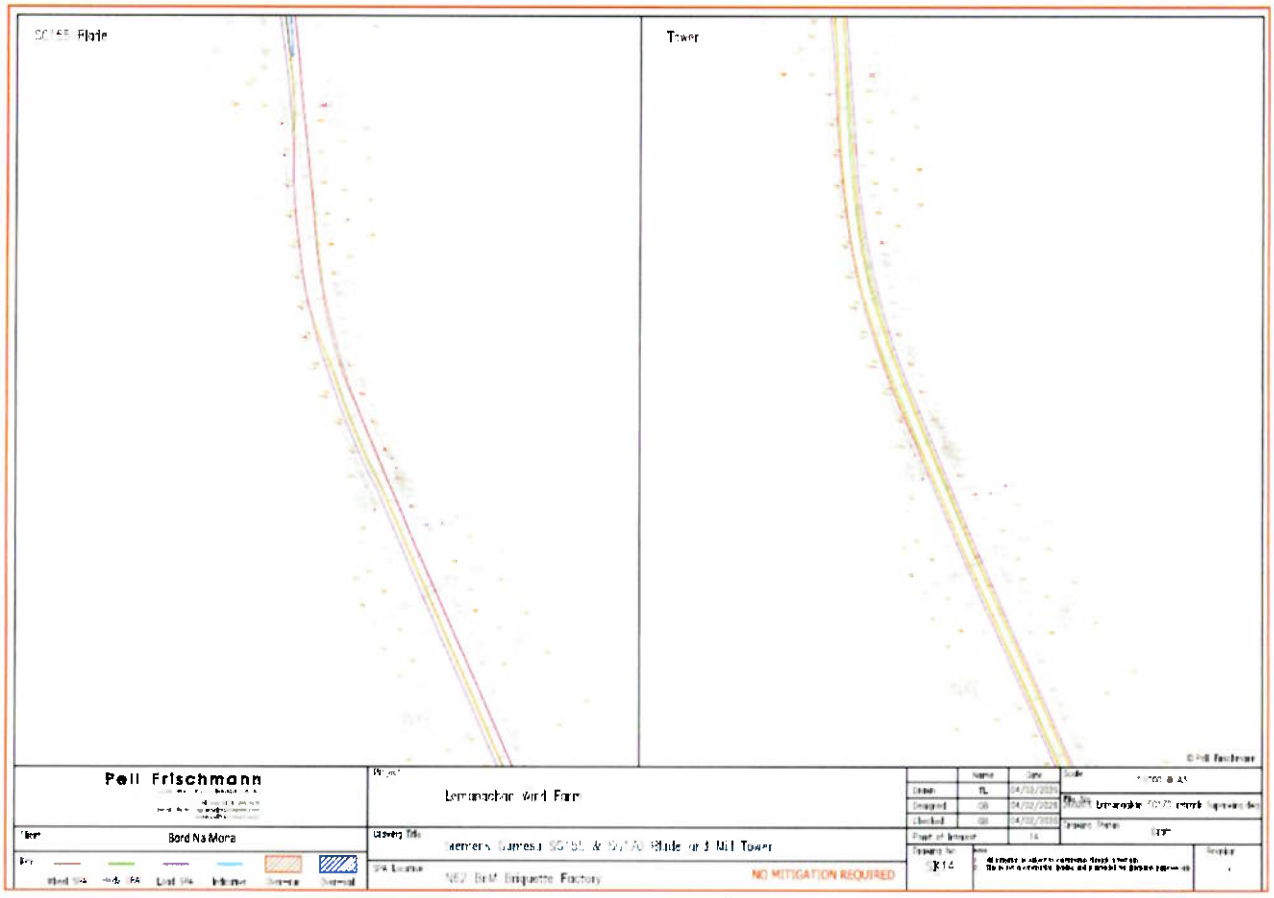
Note: No Townland name, Townland boundary, field boundaries or North point



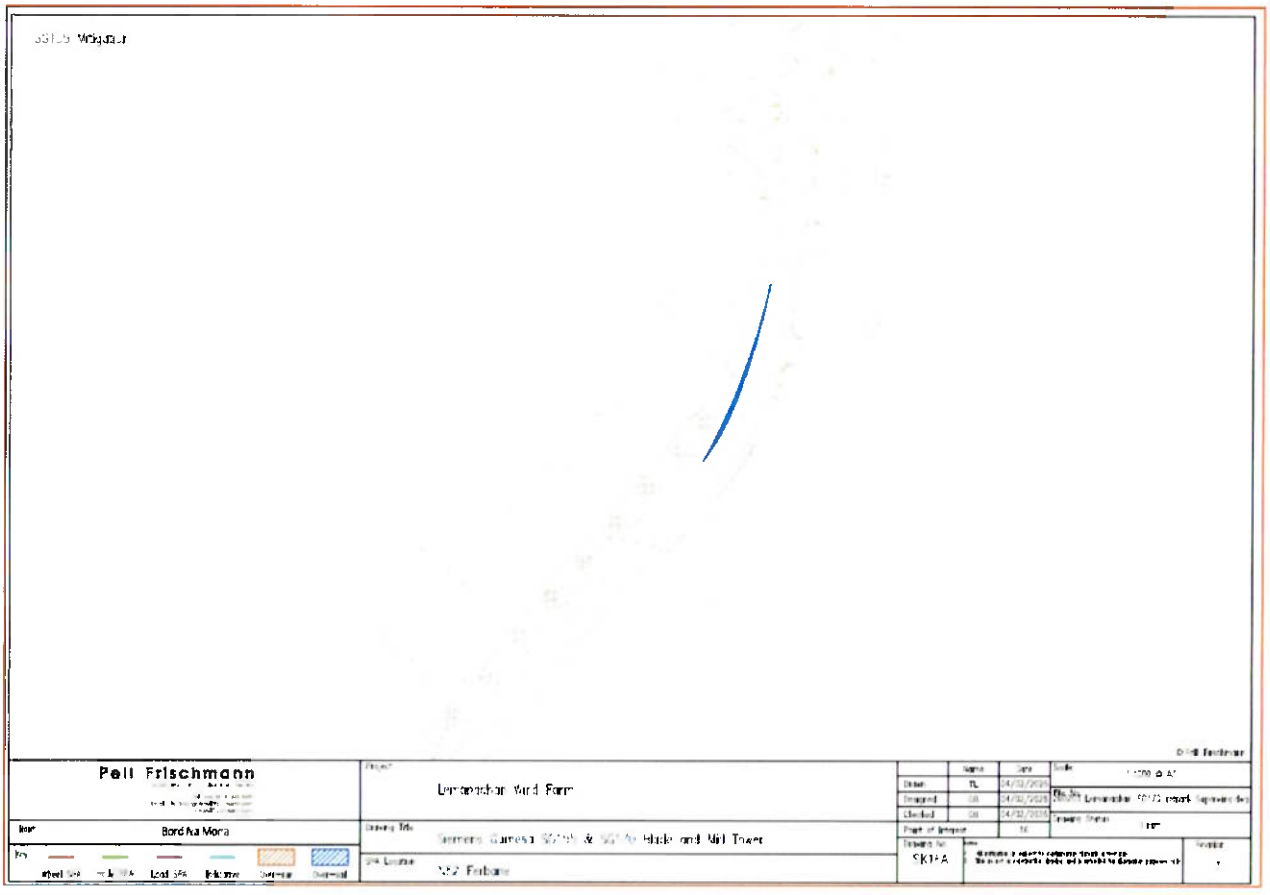
Note: No Townland name, Townland boundary, field boundaries or North point



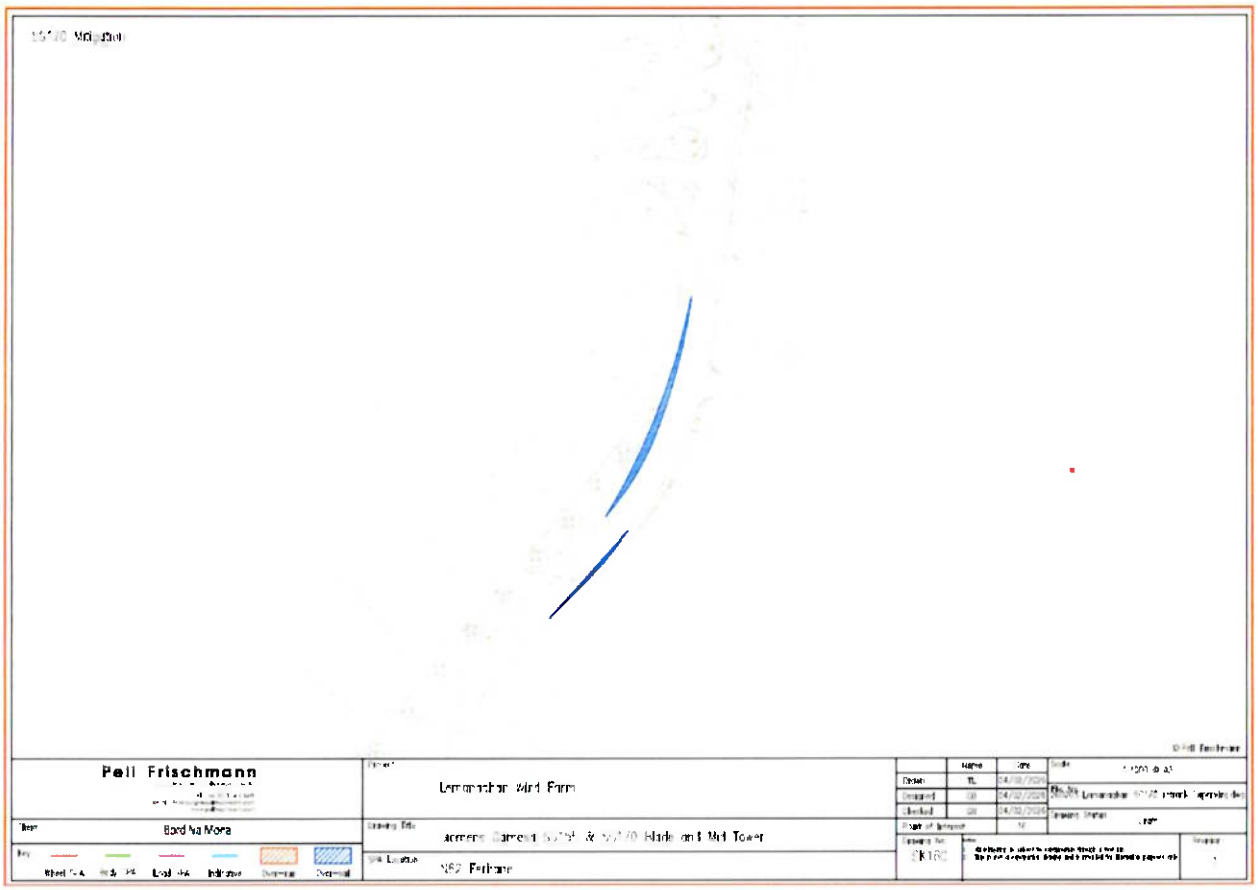
Note: No Townland name, Townland boundary, field boundaries or North point



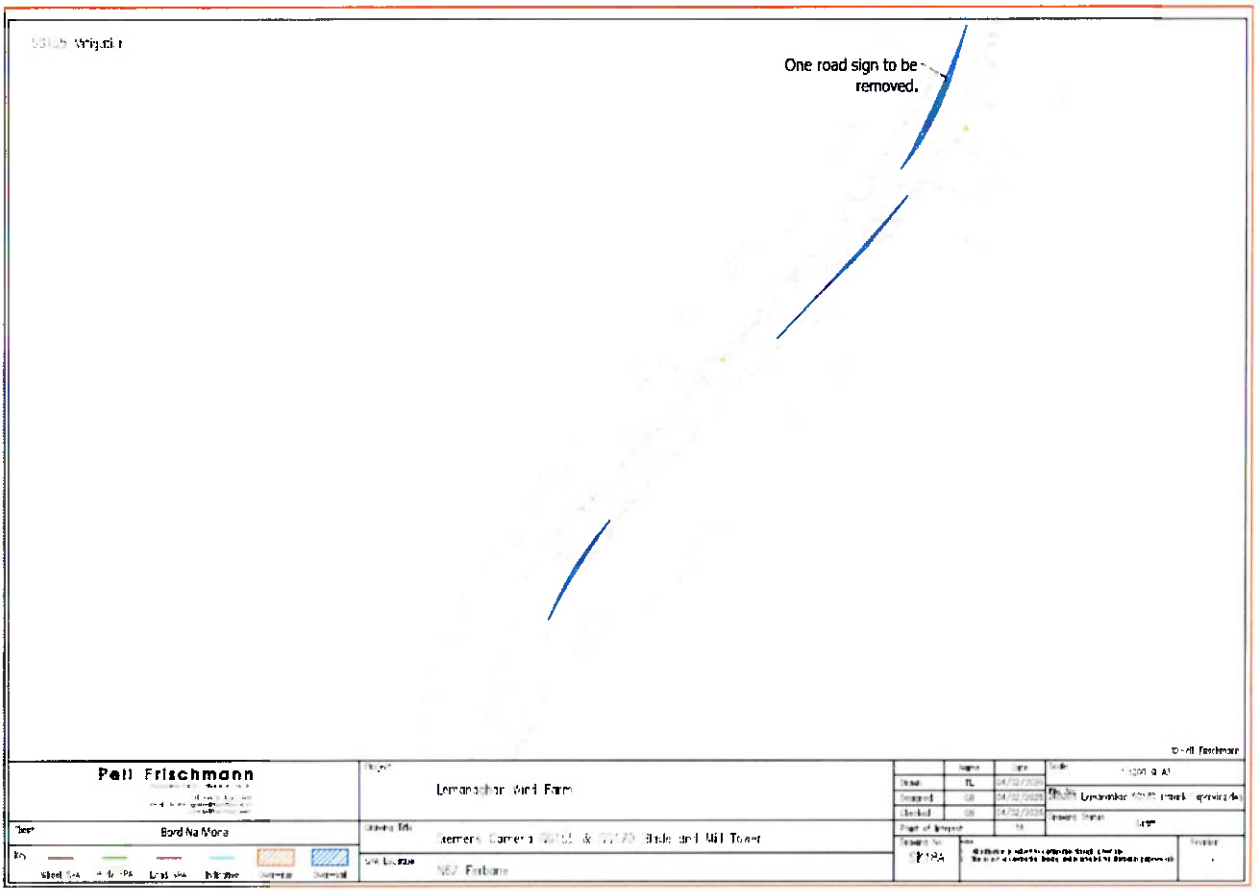
Note: No Townland name, Townland boundary, field boundaries or North point



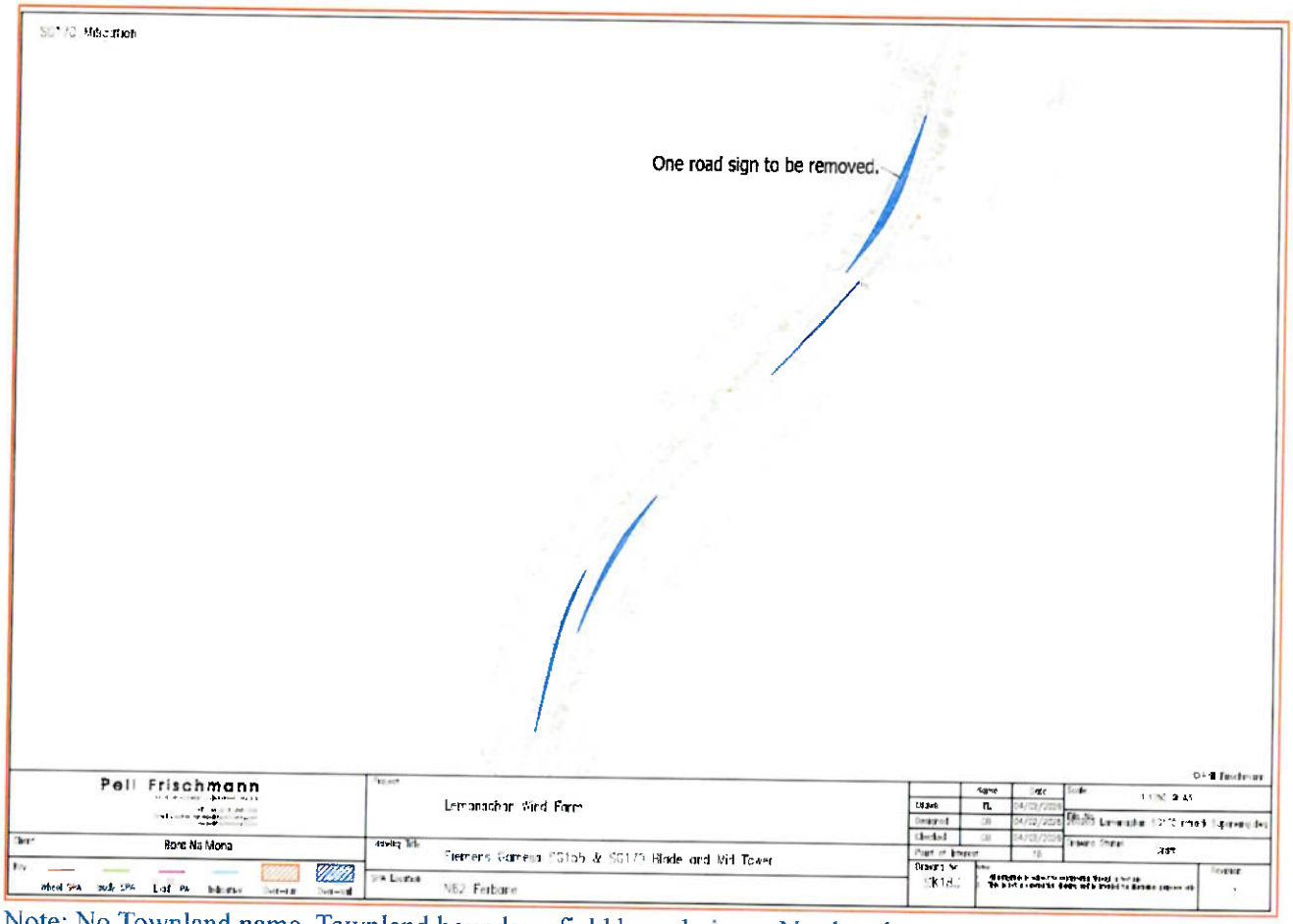
Note: No Townland name, Townland boundary, field boundaries or North point



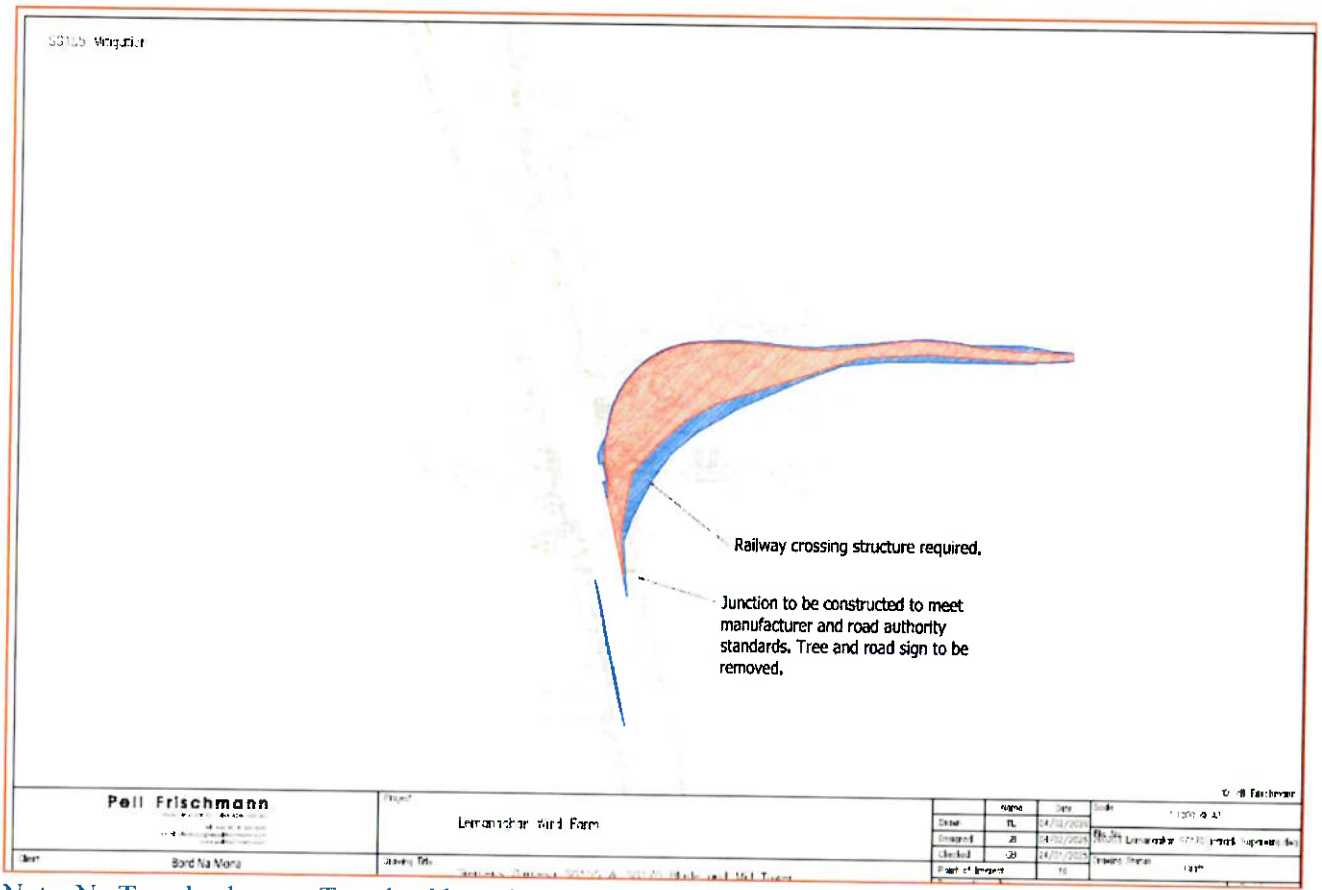
Note: No Townland name, Townland boundary, field boundaries or North point



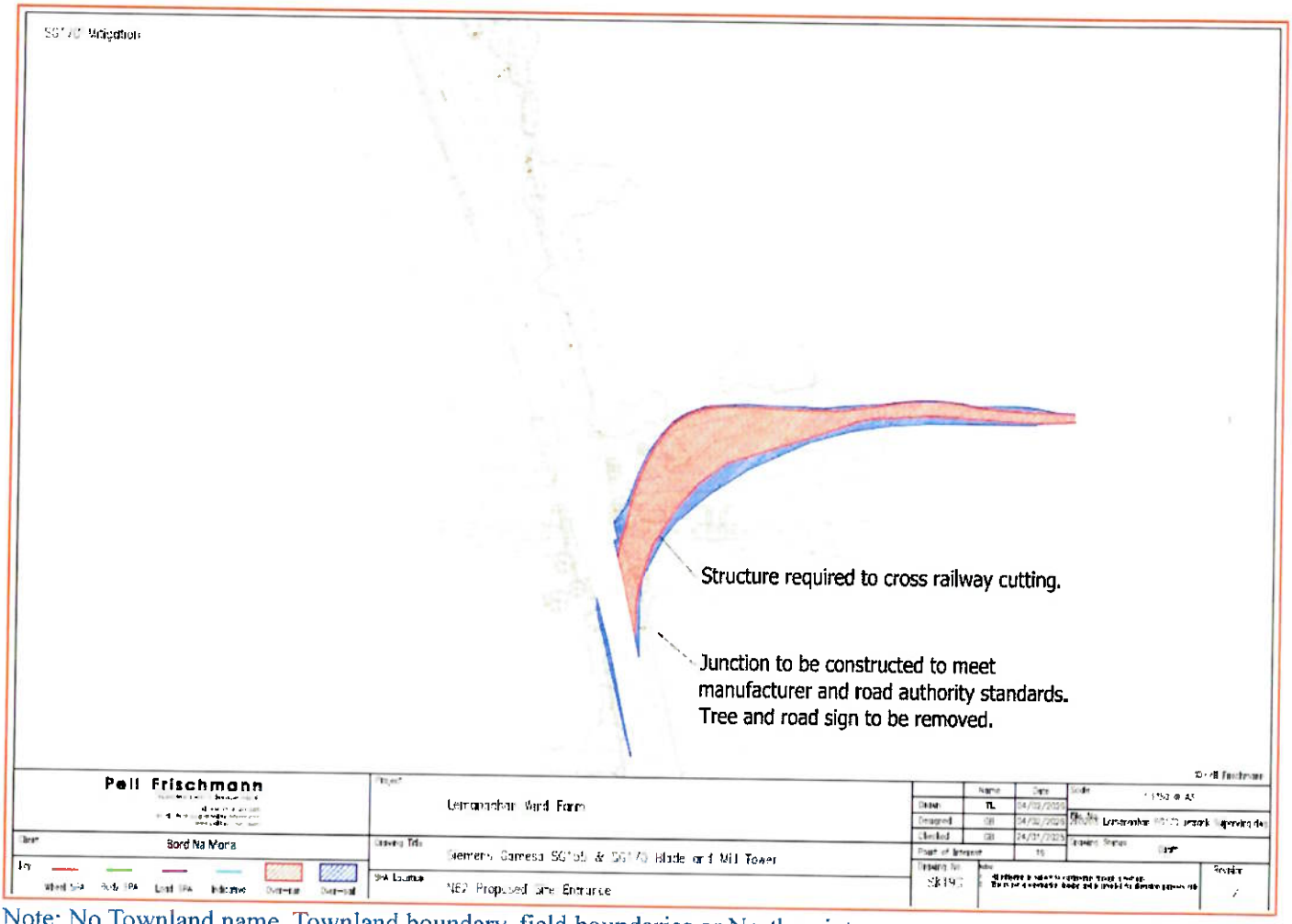
Note: No Townland name, Townland boundary, field boundaries or North point



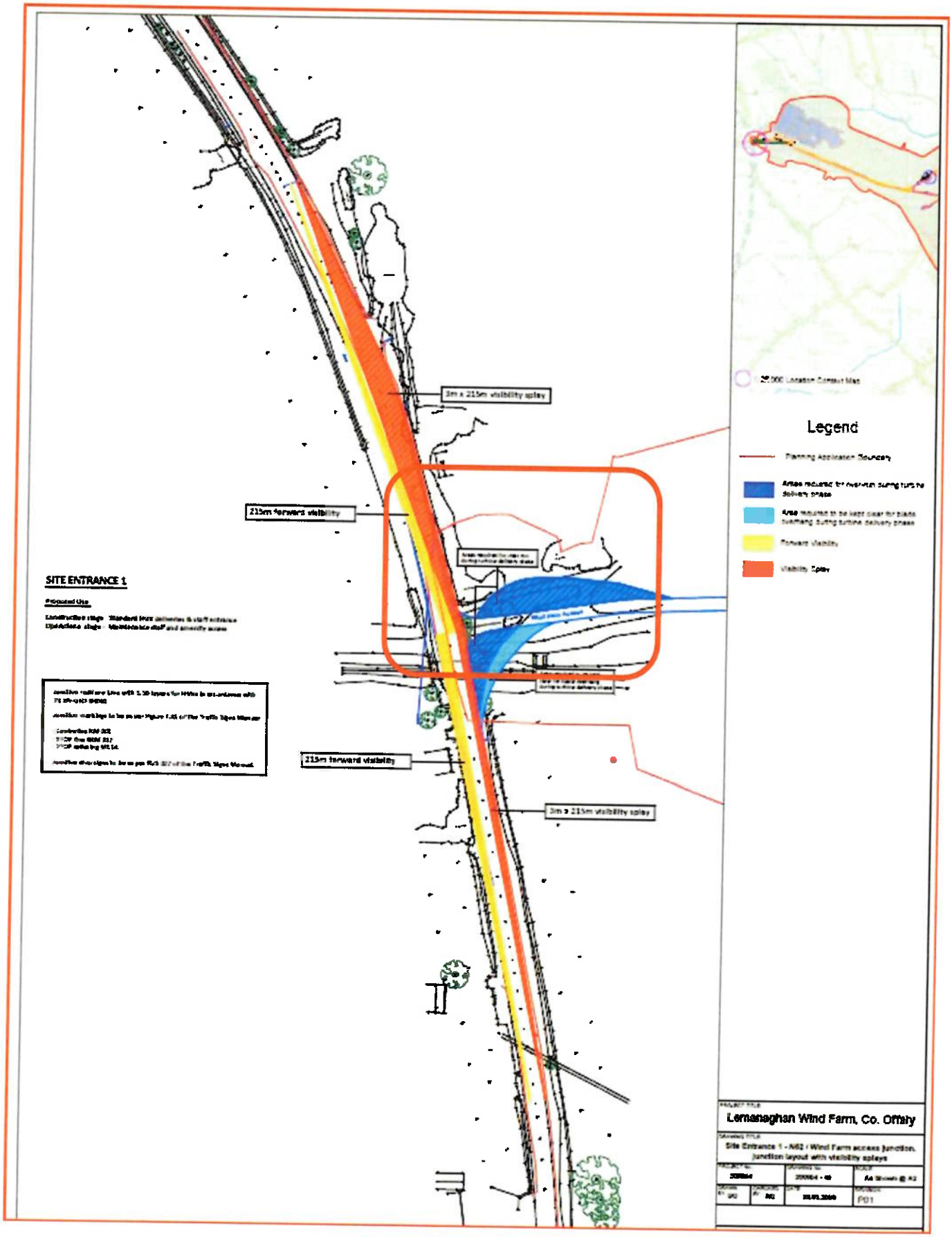
Note: No Townland name, Townland boundary, field boundaries or North point



Note: No Townland name, Townland boundary, field boundaries or North point

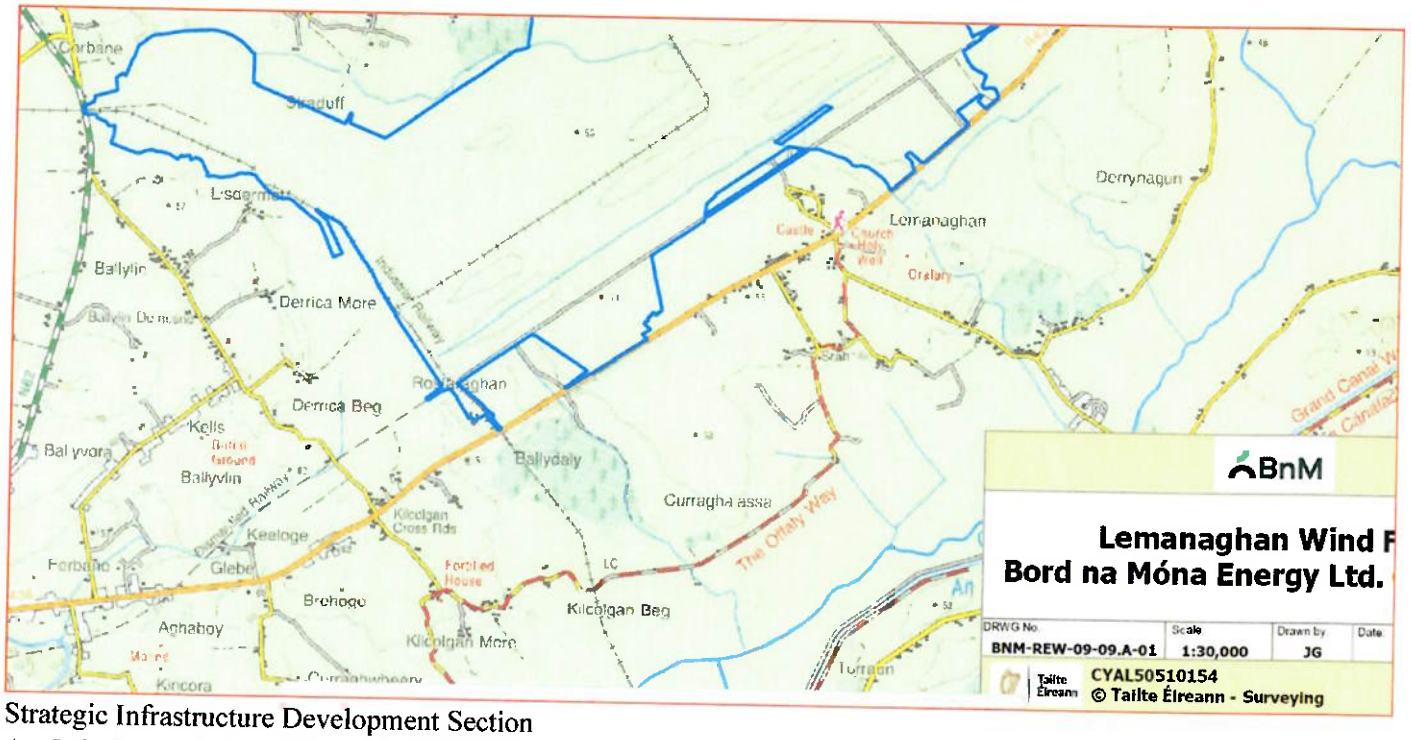


Note: No Townland name, Townland boundary, field boundaries or North point



The landownership at this entrance is not identified as being under the ownership or control of the applicant.

Addendum 2 – Response to Q7 of SID Application Form. Landowner Letters of Consent
Docusign Envelope ID: 1434879B-7470-4F1F-A525-DD97D710DECC BNM
23rd March 2026



Strategic Infrastructure Development Section
An Coimisiún Pleanála,
64 Marlborough Street,
Rotunda,
Dublin 1,
D01 V902.

Re: Lemanaghan Wind Farm DAC
Planning Application re Wind Farm situated in County Offaly

Dear Sirs,

We hereby give our irrevocable consent to any Planning Application made by or on behalf of Lemanaghan Wind Farm DAC and their project partners in connection with proposed Wind Farm on our property.

We confirm that we are the registered owner or the party entitled to be registered owner of the lands delineated as 'BnM Boundary' in the attached map (Drawing BNM-REW-09-09.A-01) in the townlands of: Tumbeagh, Killaghintober, Castlearmstrong, Leabeg, Kilnagoolny, Lemanaghan, Rosfaraghan, Derrica More, Corbane, Lisdermot, Cor Mor and Cor Beg, Straduff, Cooldorragh, Kilnagarnagh, Cappanalosset, Cornafurrish and Corrabeg and Rashinagh Co. Offaly.

Yours faithfully

_____

Sonya Mallon
Company Secretary
For and on behalf of BNM

17th February 2025

Strategic Infrastructure Development Section,
An Bord Pleanála,
64 Marlborough Street,
Dublin 1.

RE: Lemanaghan Wind Farm DAC
Planning Application re Wind Farm situated at Lemanaghan, County Offaly.

Dear Sir/Madam,

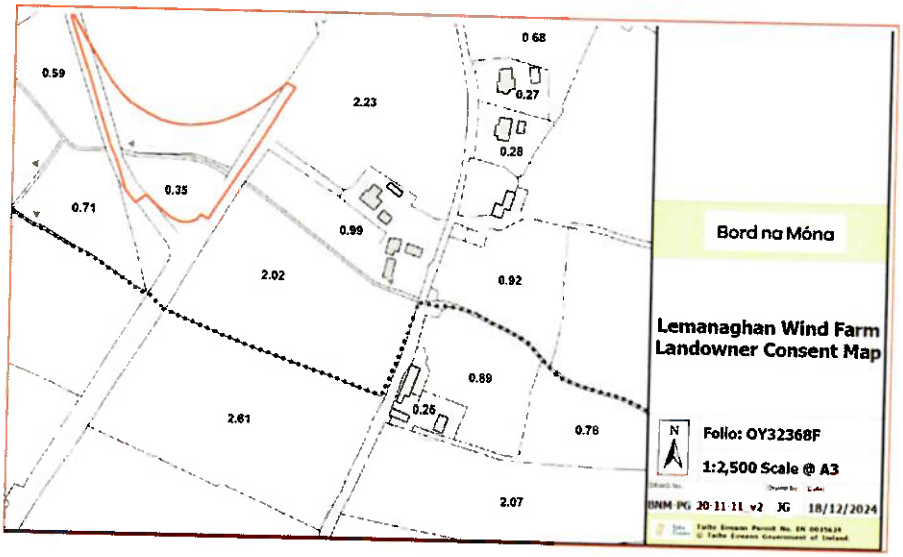
We Bord na Móna Powergen Ltd of Main Street, Newbridge, Co. Kildare hereby confirm that we are the registered freehold owner of the lands outlined in red on the attached map (BNM-PG-20-11-11_v2) comprised in Folio 32368F.

We provide herewith our written consent to Lemanaghan Wind Farm DAC to include our lands

as described above in a planning application pursuant to section 37E of the Planning and Development Act, 2000 (as amended) for a wind farm development and all associated infrastructure at Lemanaghan and other adjacent townlands in the County of Offaly.
Yours sincerely,

_____

John Reilly
Director
Bord na Móna Powergen Limited



John Mollen
Corbane
Ferbane
Co Offaly

Strategic Infrastructure Development Section,
An Coimisiun Pleanála,
64 Marlborough Street,
Dublin 1.

RE: Lemanaghan Wind Farm DAC
Planning Application re Wind Farm situated at Lemanaghan, County Offaly.

Dear Sir / Madam,

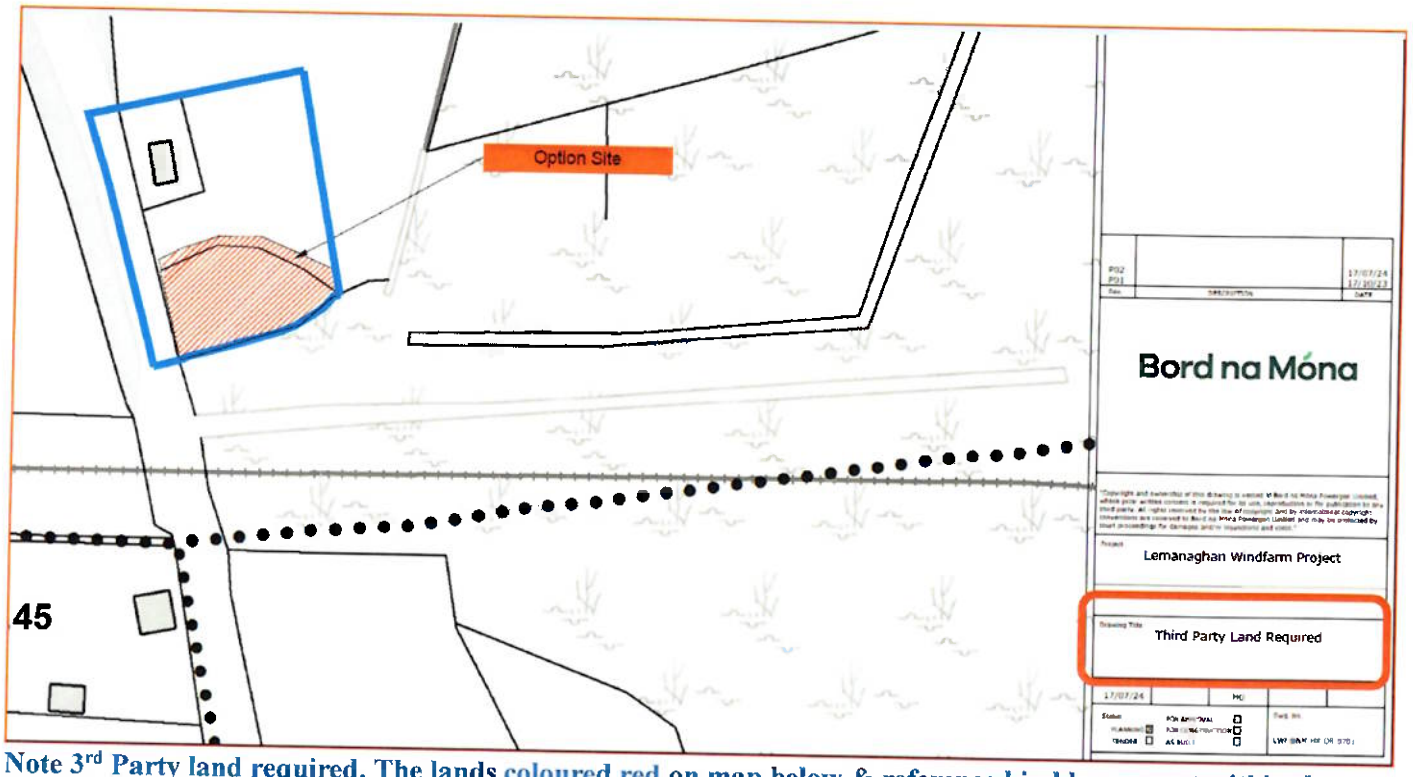
I John Mollen of Corbane, Ferbane, Co. Offaly, hereby confirm that I am the registered freehold owner of the lands shown hatched on the attached map, which is part of folio number OY12540 .

I provide herewith my written consent to Lemanaghan wind Farm DAC to include my lands as described above in a planning application pursuant to section 37E of the Planning and Development Act, 2000 (as amended) for a wind farm development consisting of 15 No. wind turbines, and all associated infrastructure at Lemanaghan and other adjacent townlands in Co Offaly

Yours Sincerely

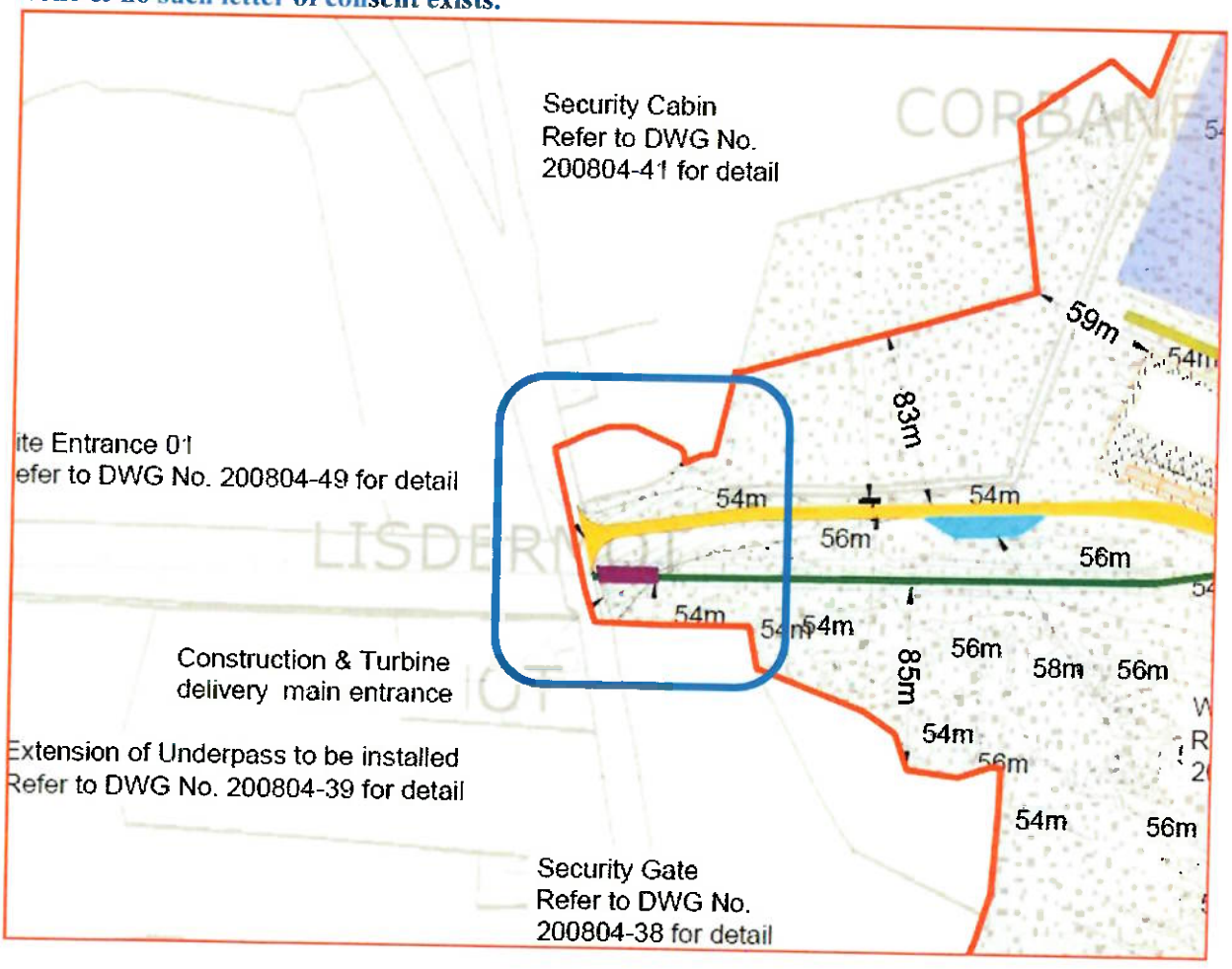
John Mollen

Date: 12-Aug 26

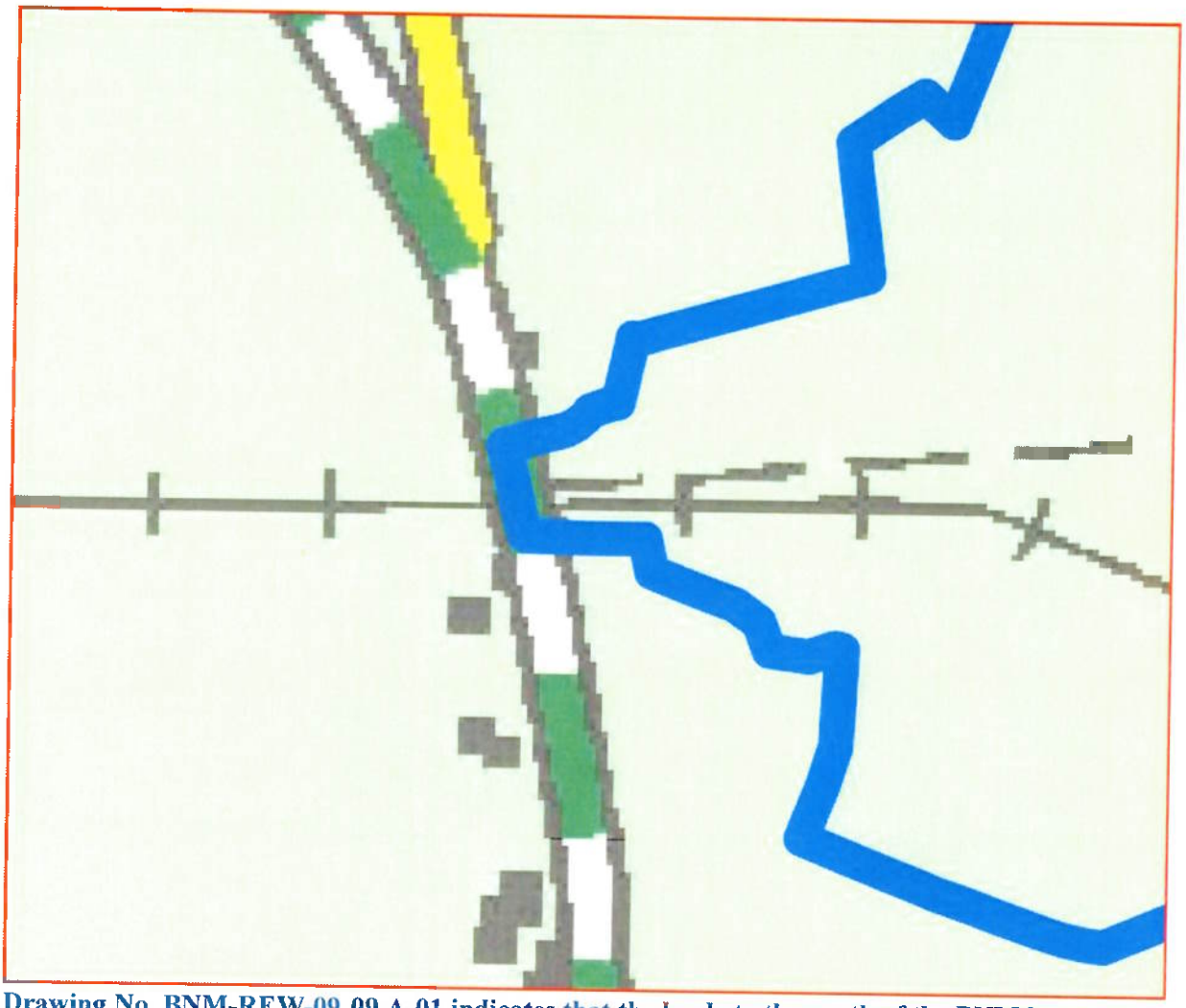


Note 3rd Party land required. The lands coloured red on map below & referenced in blue are not within the ownership or control of the applicant. Note drawing for Site Entrance 1 – N62/Windfarm access junction, junction layout with visibility splays Drawing No. 200804-49.

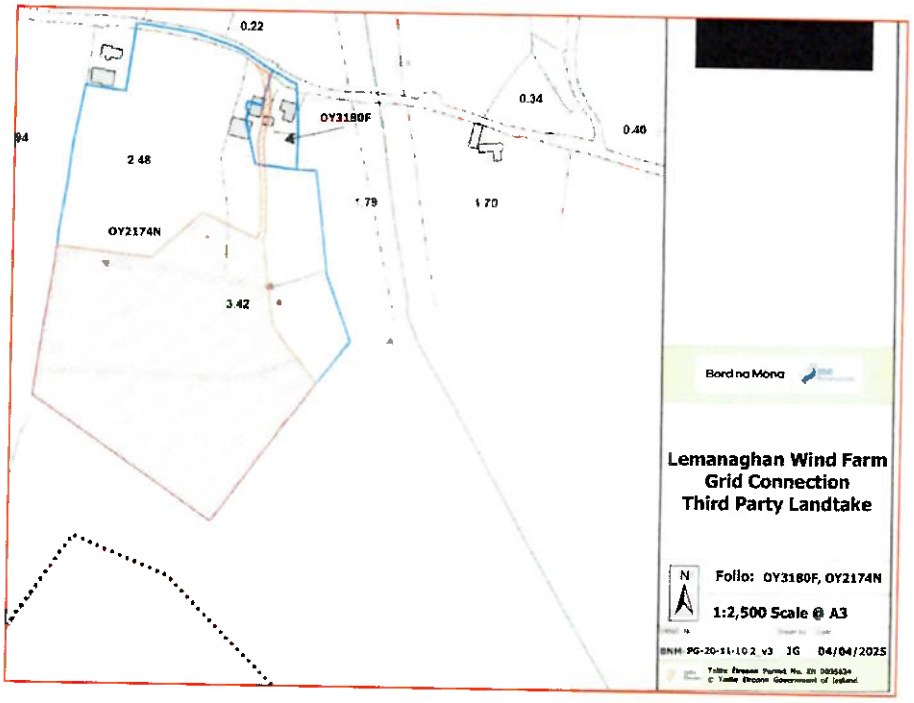
ACP Order 318943-24 states that the applicant must have sufficient legal interest, or can acquire such interest to implement such mitigation measures on lands that have not been identified within the application site boundary, the applicant's landholding or within the applicant's control i.e. through a letter of consent from the appropriate landowner where necessary mitigation measures (access to site) are required. This has not been done & no such letter of consent exists.



Site Layout Plan 01 of 04 : Drawing No. 200804-03.01



Drawing No, BNM-REW-09-09.A-01 indicates that the lands to the north of the BNM boundary coloured blue are not under the control or ownership of the applicant.



Martin Bosco Larkin
Cooldorragh,
Ballinahown,
Co. Offaly

Strategic Infrastructure Development Section,
An Bord Pleanála,
64 Marlborough Street,
Dublin 1

RE: Lemanaghan Wind Farm DAC
Planning Application re Wind Farm situated at Lemanaghan, County Offaly.

Dear Sir / Madam,

I Martin Bosco Larkin of Cooldorragh, Ballinahown, Co. Offaly, hereby confirm that I am the freehold owner of the lands hatched red on the attached map (ref. BNM-PG-20-11-10.2_v2) contained in Folios OY2174N and OY3180F.

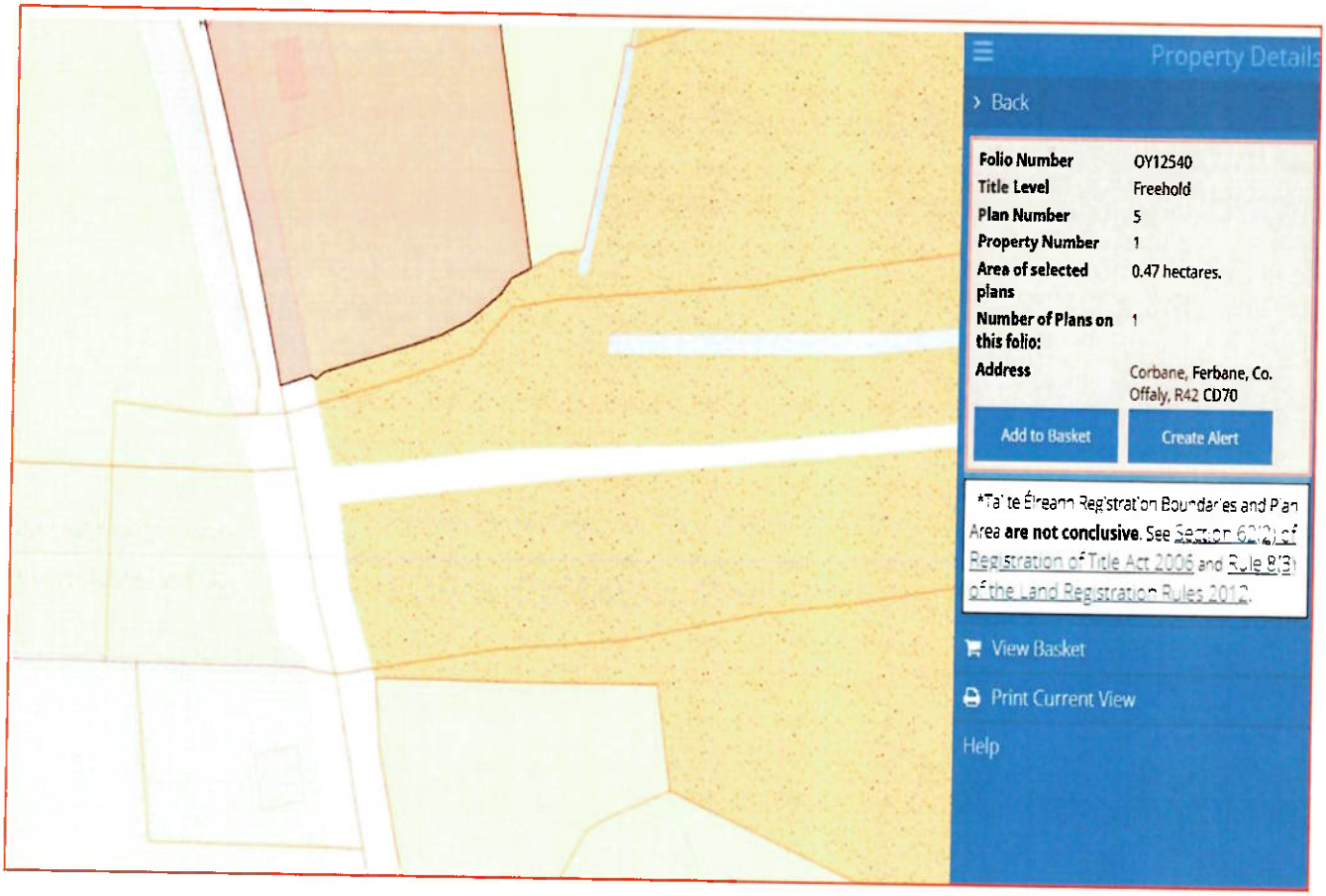
The consent given here to Lemanaghan Wind Farm DAC is to include the lands as described above in a planning application pursuant to section 37E of the Planning and Development Act, 2000 (as amended). This consent relates specifically to the grid connection and all associated infrastructure works required to facilitate connection to the existing 220kV transmission line.

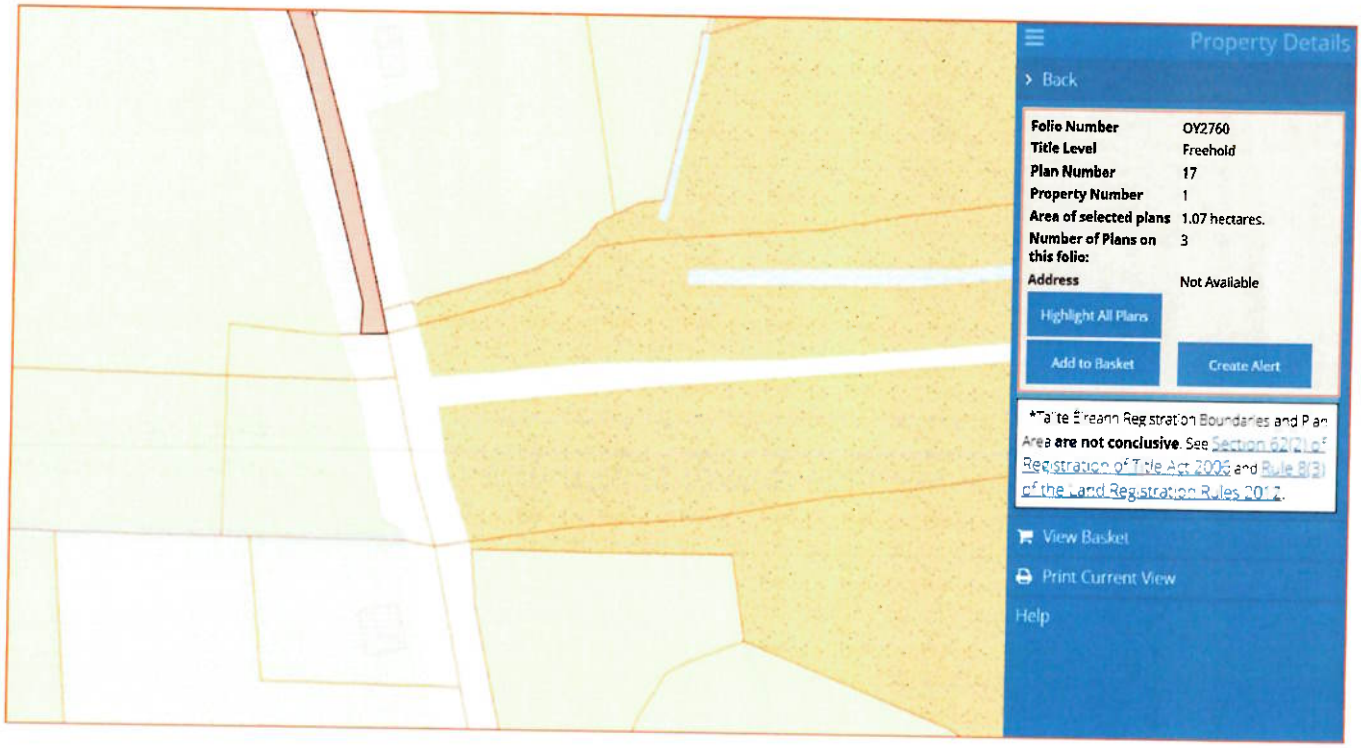
Yours sincerely,

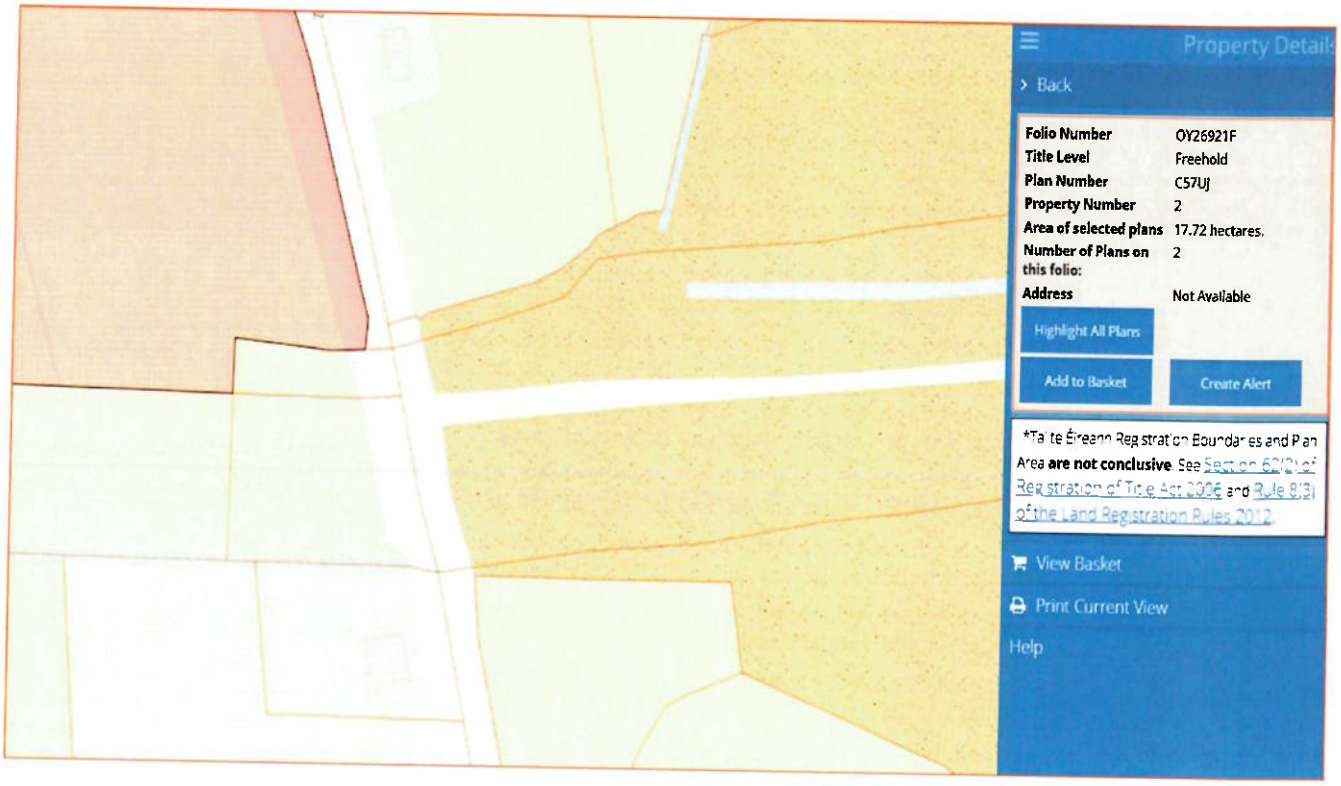
Bosco Larkin

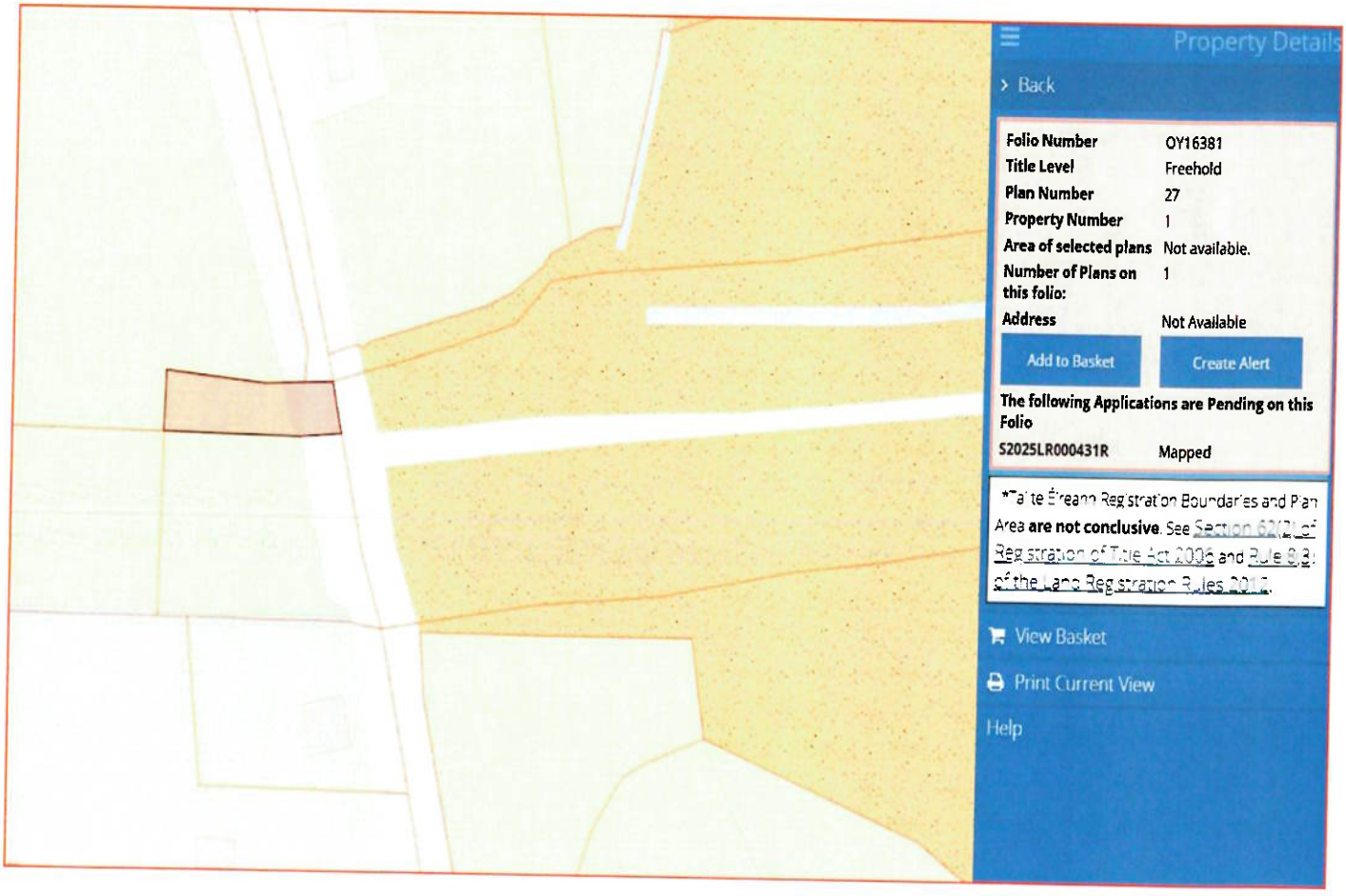
Martin Bosco Larkin
Date: 2nd / 4th /2025

LAND DIRECT LANDOWNERSHIP WITH FOLIOS. Some of these Folios are not included in consent forms.


Property Details
Back
Folio Number OY12540
Title Level Freehold
Plan Number 5
Property Number 1
Area of selected plans 0.47 hectares.
Number of Plans on this folio: 1
Address Corbane, Ferbane, Co. Offaly, R42 CD70
Add to Basket
Create Alert
*Tá te Éireann Registration Boundaries and Plan Area are not conclusive. See Section 62(2) of Registration of Title Act 2006 and Rule 8(3) of the Land Registration Rules 2012.
View Basket
Print Current View
Help

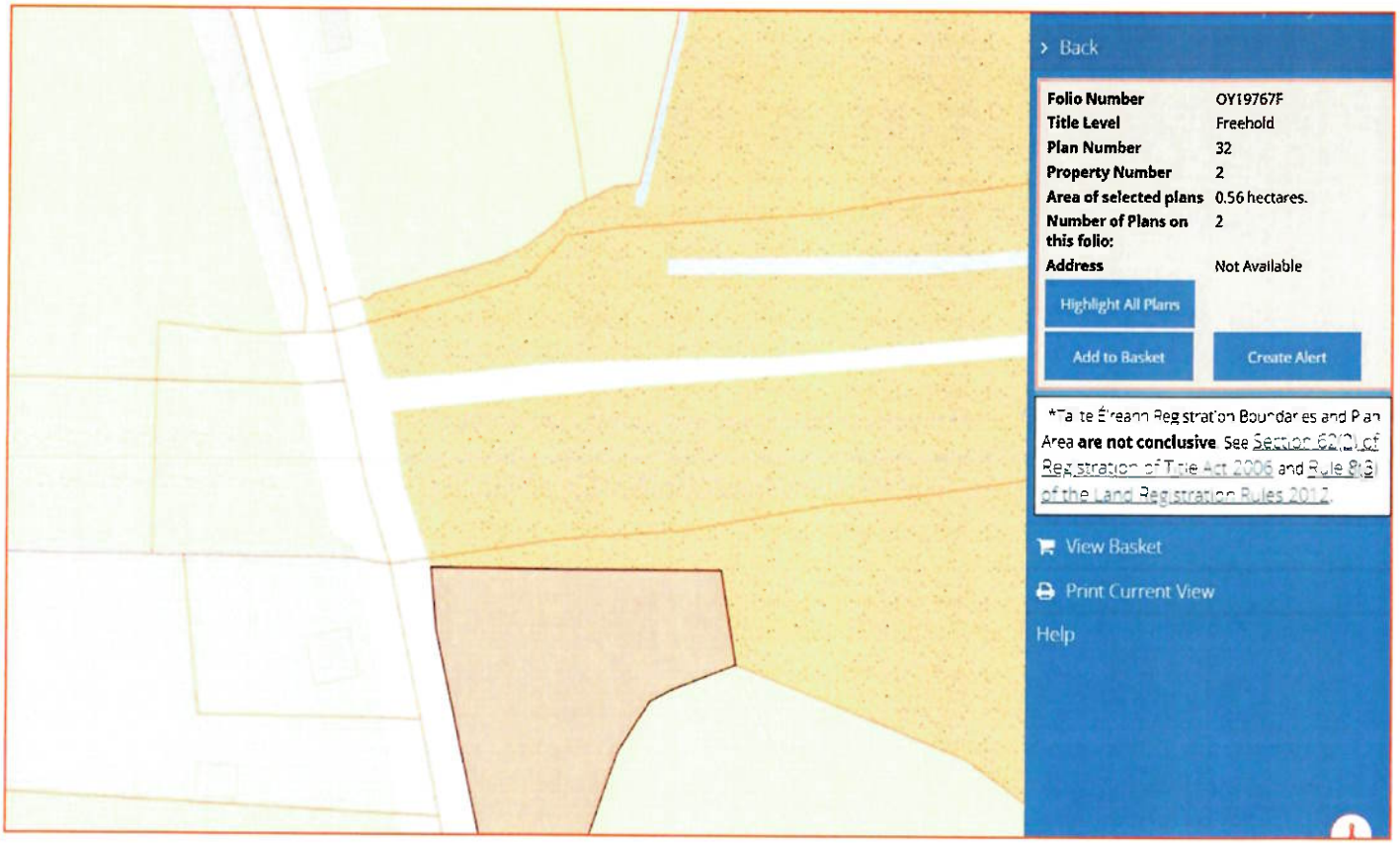

Property Details
Back
Folio Number OY2760
Title Level Freehold
Plan Number 17
Property Number 1
Area of selected plans 1.07 hectares.
Number of Plans on this folio: 3
Address Not Available
Highlight All Plans
Add to Basket
Create Alert
*Tá te Éireann Registration Boundaries and Plan Area are not conclusive. See Section 62(2) of Registration of Title Act 2006 and Rule 8(3) of the Land Registration Rules 2012.
View Basket
Print Current View
Help


Property Details
Back
Folio Number OY26921F
Title Level Freehold
Plan Number C57UJ
Property Number 2
Area of selected plans 17.72 hectares.
Number of Plans on this folio: 2
Address Not Available
Highlight All Plans
Add to Basket
Create Alert
*Tailte Éireann Registration Boundaries and Plan Area are not conclusive. See Section 62(2) of Registration of Title Act 2006 and Rule 8(3) of the Land Registration Rules 2012.
View Basket
Print Current View
Help

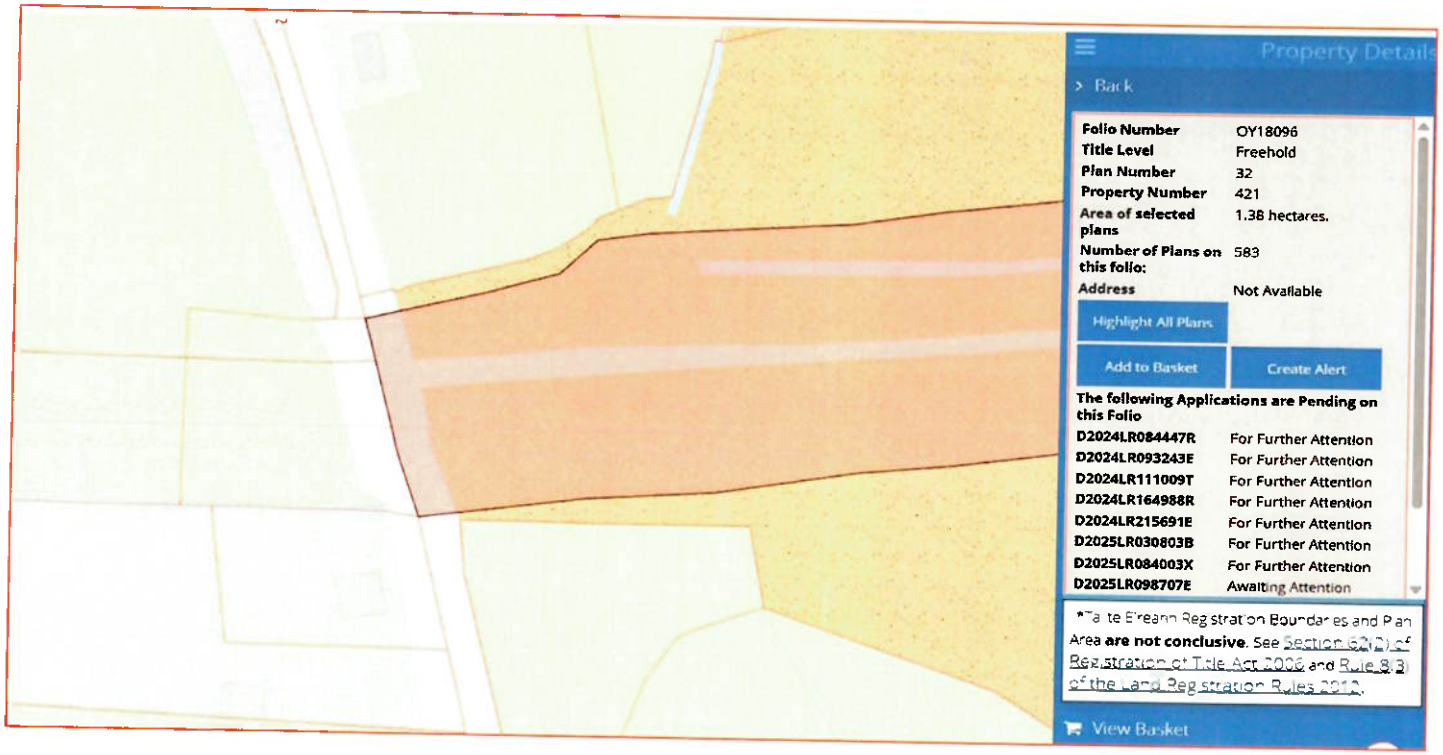

Property Details
Back
Folio Number OY16381
Title Level Freehold
Plan Number 27
Property Number 1
Area of selected plans Not available.
Number of Plans on this folio: 1
Address Not Available
Add to Basket
Create Alert
The following Applications are Pending on this Folio
S2025LR000431R Mapped
*Tailte Éireann Registration Boundaries and Plan Area are not conclusive. See Section 62(2) of Registration of Title Act 2006 and Rule 8(3) of the Land Registration Rules 2012.
View Basket
Print Current View
Help


Property Details
Back
Folio Number OY9892F
Title Level Freehold
Plan Number 42
Property Number 1
Area of selected plans 0.17 hectares.
Number of Plans on this folio: 3
Address Not Available
Highlight All Plans
Add to Basket
Create Alert
*Tailte Éireann Registration Boundaries and Plan Area are not conclusive. See Section 62(2) of Registration of Title Act 2006 and Rule 8(3) of the Land Registration Rules 2012.
View Basket
Print Current View
Help


Property Detail
Back
Folio Number OY12246
Title Level Freehold
Plan Number 1
Property Number 1
Area of selected plans 0.16 hectares.
Number of Plans on this folio: 1
Address Ballylin, Ferbane, Co. Offaly, R42 W326
Add to Basket
Create Alert
*Tailte Éireann Registration Boundaries and Plan Area are not conclusive. See Section 62(2) of Registration of Title Act 2006 and Rule 8(3) of the Land Registration Rules 2012.
View Basket
Print Current View
Help


› Back
Folio Number OY19767F
Title Level Freehold
Plan Number 32
Property Number 2
Area of selected plans 0.56 hectares.
Number of Plans on this folio: 2
Address Not Available
Highlight All Plans
Add to Basket
Create Alert
Tailte Éireann Registration Boundaries and Plan Area are not conclusive. See Section 62(2) of Registration of Title Act 2006 and Rule 8(3) of the Land Registration Rules 2012.
View Basket
Print Current View
Help


Property Details
› Back
Folio Number OY9779F
Title Level Freehold
Plan Number 25
Property Number 7
Area of selected plans 48.66 hectares.
Number of Plans on this folio: 10
Address Not Available
Highlight All Plans
Add to Basket
Create Alert
The following Applications are Pending on this Folio
D2024LR164988R For Further Attention
Tailte Éireann Registration Boundaries and Plan Area are not conclusive. See Section 62(2) of Registration of Title Act 2006 and Rule 8(3) of the Land Registration Rules 2012.
View Basket
Print Current View
Help



Traffic impact on local network

Lemanaghan Wind Farm, Co, Offaly Ch 15 Material Assets - F - 2026.03.19 – 200804.
The traffic counts were obtained from 2 sources. Base year traffic flows were sourced from the Automatic Traffic Count data supplied by TII and utilised at 3 no. locations on the N52 between the M6 in the northeast of the TDR to the junction with the N62 in the southwest. None of these 3 counts are on the N62 or close to the site & irrelevant.

A further 2 no. locations were surveyed with traffic flows counts for the N62 and the R436 obtained via a 24 hour classified turning count undertaken at the junction on Tuesday 26th November 2024 by Traffinomics Ltd. See table 15-3 below. An assessment of the seasonal variation in traffic volumes by month was undertaken using the Automatic Traffic Count site maintained by TII on the N62 between Athlone and Ferbane. Based on this data it was established that traffic volumes during the month of November were higher than the average month, with no seasonal adjustment required for the traffic counts undertaken during this month.
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

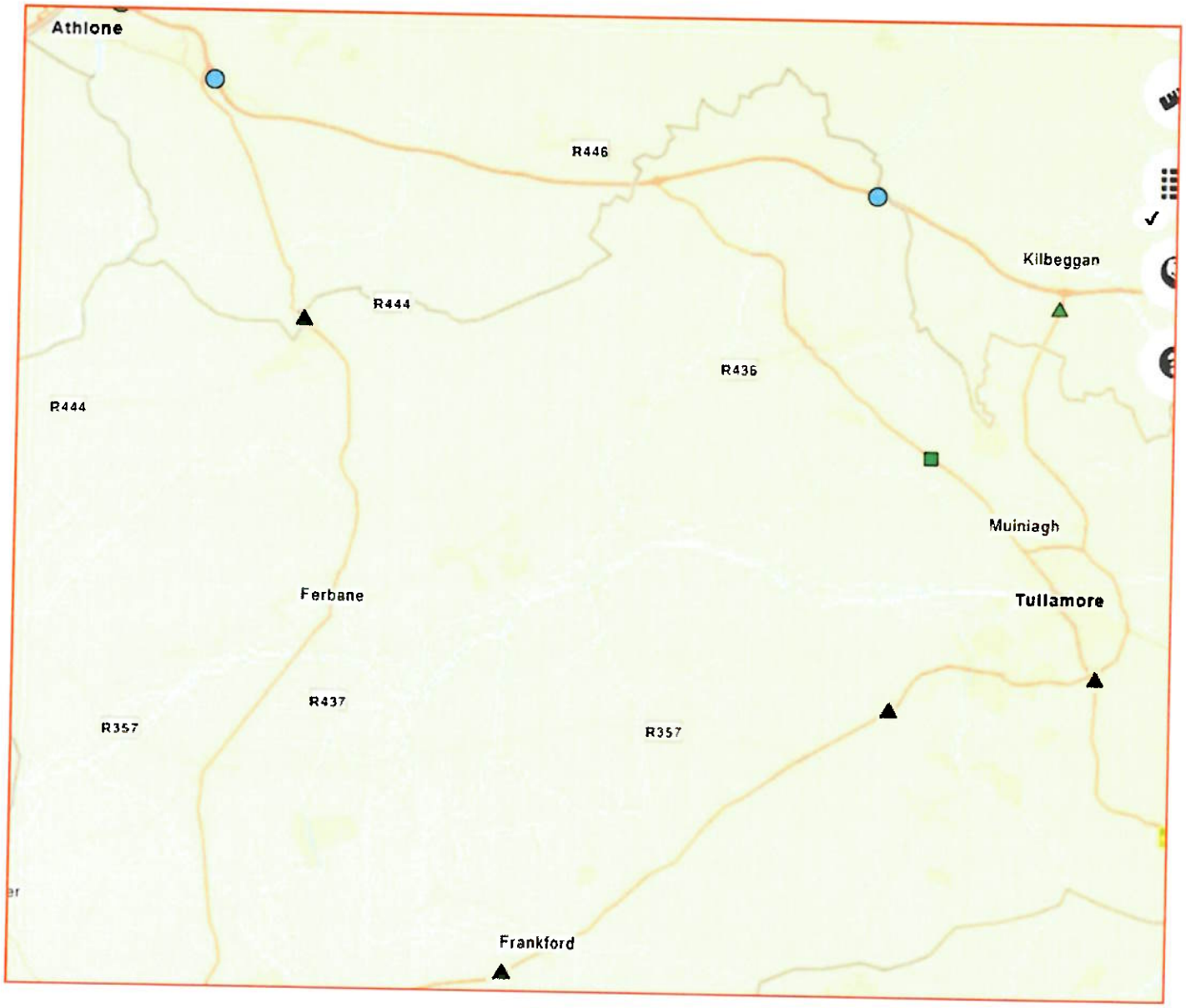
An ATC can be temporarily installed for a specified period or permanently installed as per the network of TII TMUs which allow for the long term monitoring of traffic growth. Either type of ATC can provide useful supplementary information to a turning count or roadside interview data (which are usually undertaken on one day only) as they can indicate whether that survey day was typical or not.

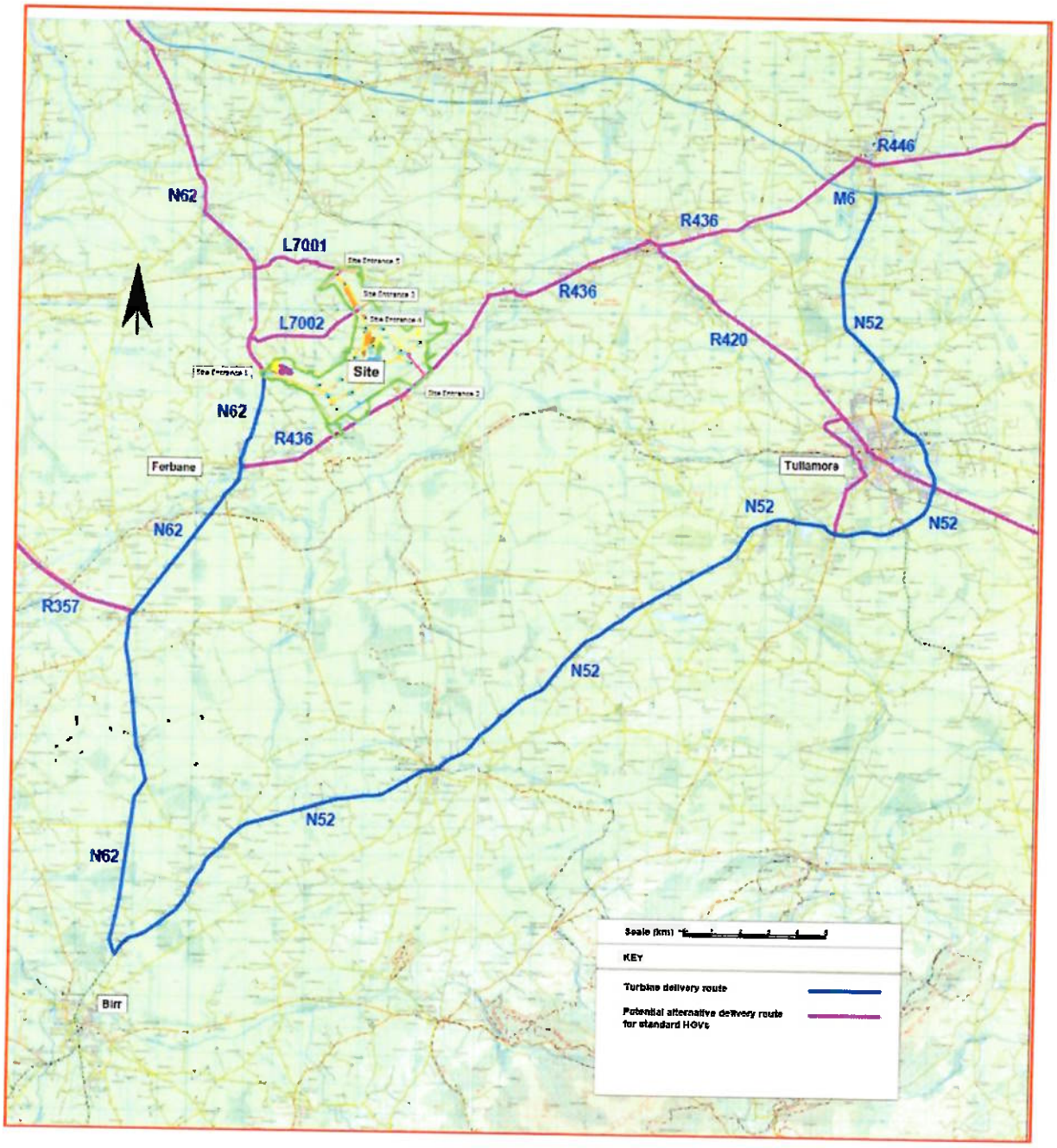
ATCs may also be used to count the number of pedal cyclists but there are known problems with accuracy under this approach. For example, pneumatic tube counters deployed over multiple lanes of carriageway may not generate a big enough pulse to reach the counter. This problem is partly overcome by the 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.

The application identifies 5 site entrances from Figure 15-2:
Site Entrance No. 1: N62
Site Entrance No. 2: R436
Site Entrance No. 3: L7002
Site Entrance No. 4: L7002
Site Entrance No. 5: L7001


Athlone
R446
Kilbeggan
R444
R436
R444
Muiniagh
Ferbane
Tullamore
R437
R357
R357
Frankford



For 15 days when concrete is delivered to the Proposed Wind Farm for the construction of the turbine foundations via the identified construction delivery routes, an additional 454 Passenger Car Units (PCUs) will travel to and from the site. During these days it is forecast that the increase in traffic volumes will range from between +2.5% to +9.2% on the N52 between the M6 and the junction with the N62. For the section of the N62 travelling north from Ferbane toward Site Entrance 1 it is forecast that the construction traffic will result in a 5.0% to 5.1% increase in traffic volumes, and for the R436 heading east from Ferbane towards Site Entrance 2 it is forecast that the additional traffic will result in an 11.1% increase on these 15 days. It is forecast that this will have a temporary, slight, negative effect, which is Not Significant, on existing traffic on the construction haul route and at the access junctions on the N62 and R436.

During the 440 days during which the main element of the construction phase of the Proposed Project will occur, an additional 646 PCUs will travel to and from the site via the identified construction haul routes. On these days it is forecast that the increase in traffic volumes will range from between +3.6% to +13.1% on the N52 between the M6 and the junction with the N62. On the section of the N62 travelling north from Ferbane toward Site Entrance 1 it is forecast that there will be a maximum +7.3% increase in traffic volumes, and for the R436 heading east from Ferbane towards Site Entrance 2 it is forecast that there will be a +15.8% increase on these 440 days. During this period, it is forecast that the additional traffic generated by the Proposed Project will have a temporary, slight, negative effect,

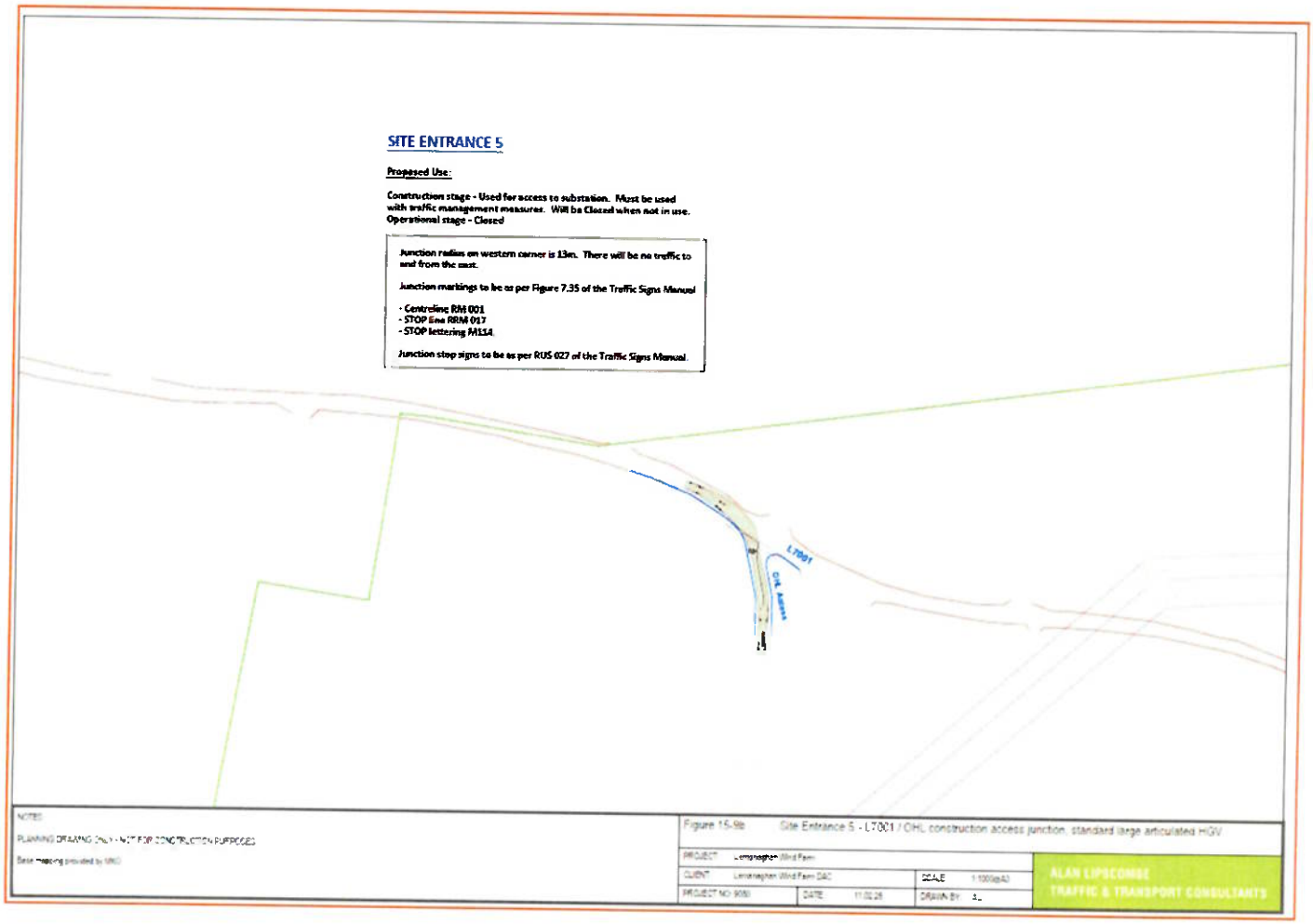
which is Not Significant, on existing traffic on the construction haul route and at the access junctions on the N62 and R436.

On the 40 days during which a convoy of 3 abnormally sized loads accompanied by an escort provided by An Garda Síochána travel to the site and access via Site Entrance 1 on the N62 it is forecast that the increase in traffic volumes will range from between +0.6% to +2.1% on the N52 between the M6 and the junction with the N62. On the section of the N62 travelling north from Ferbane toward Site Entrance 1 it is forecast that there will be a 1.2% increase in traffic volumes. It is forecast that this will have a temporary, slight, negative effect, which is Not Significant, on existing traffic on the delivery route and at the access junction on the N62.

For 15 days when smaller turbine components will be delivered to the site by standard HGVs an additional 64 PCUs will travel to and from the site via the identified construction haul routes. On these days it is forecast that the increase in traffic volumes will range from between +0.4% to +1.3% on the N52 between the M6 and the junction with the N62. On the section of the N62 travelling north from Ferbane toward Site Entrance 1 it is forecast that there will be a 0.7% increase in traffic volumes, and for the R436 heading east from Ferbane towards Site Entrance 2 it is forecast that there will be a 1.6% increase on these 440 days. It is forecast that this will have a temporary, slight, negative effect, which is Not Significant, on existing traffic on the delivery route and at the proposed access junctions.

During the operational phase, the Proposed Wind Farm will be utilised by 1 to 2 site staff and approximately 20 amenity users per day. The effects of the traffic and transport movements during the operational stage will be imperceptible.

APPENDIX 15-2



SITE ENTRANCE 5

Proposed Use:

Construction stage - Used for access to substation. Must be used with traffic management measures. Will be Closed when not in use.
Operational stage - Closed

Junction radius on western corner is 13m. There will be no traffic to and from the east.

Junction markings to be as per Figure 7.35 of the Traffic Signs Manual

- **Centreline RM 001**
- **STOP line RRM 017**
- **STOP lettering M114.**

Junction stop signs to be as per RUS 027 of the Traffic Signs Manual.

Note that the sweptpath takes up the entire L7001 roadway. There are no passing bays. There will be traffic from both East & West.

Lemanaghan Wind Farm, Co. Offaly EIAR Appendices - F - 2026.03.19 - 200804

2.4 Problem: Visibility Splays Obscured in Both Directions

Location: **Site Entrance 5 | Existing Boundary Treatments Either Side of Access**

Drivers attempting to leave the access will have their view blocked in both directions by the existing field boundary. This limited visibility could increase the risk of side-impact collisions at the access.

Figure 2.4 – Visibility Splays Partially Obscured in Both Directions at Site Entrance 5



Recommendation

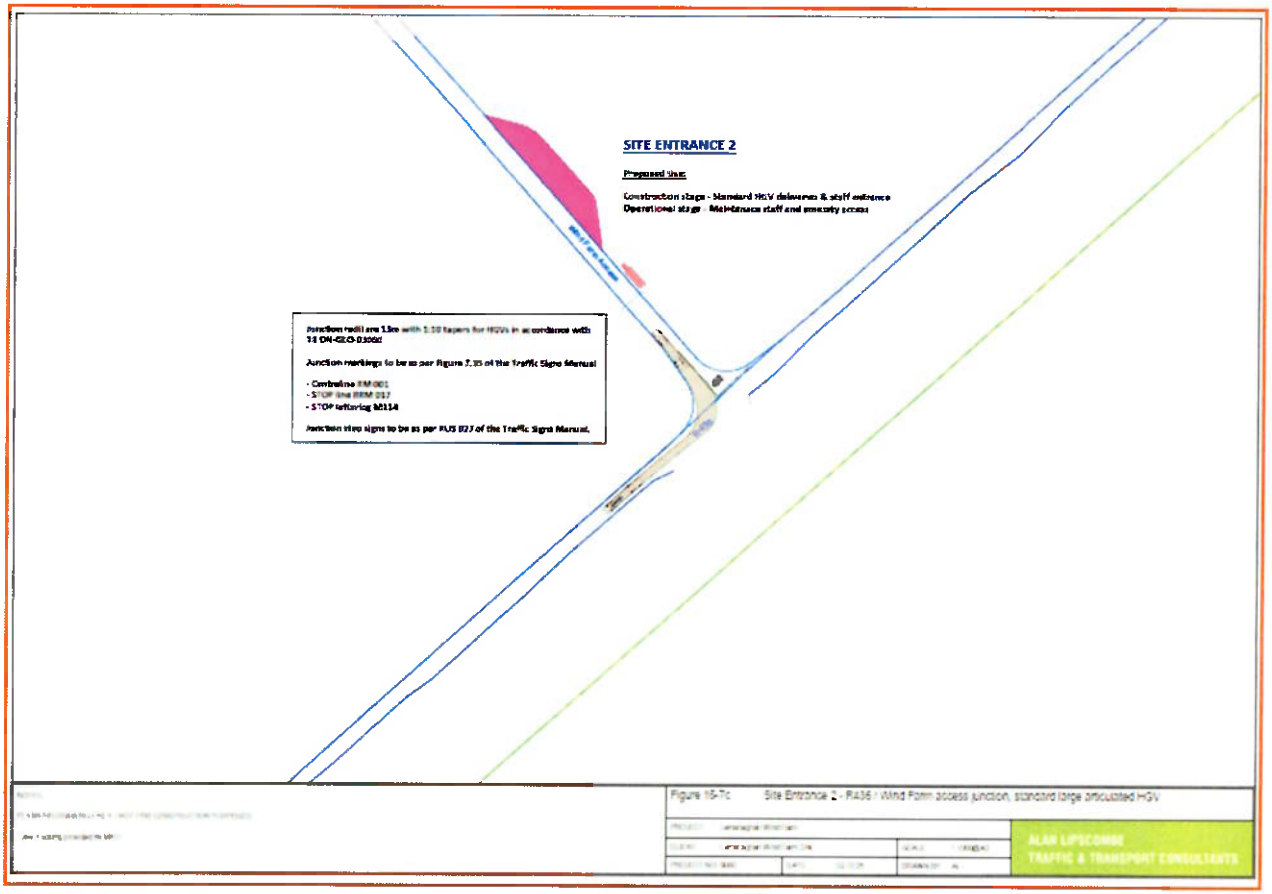
The field boundary should be modified to ensure that an appropriate level of visibility can be provided for drivers exiting the access.

Problem Reference (Section 2)	Designer Response Section			Audit Team Response Section
	Problem Accepted (yes / no)	Recommended Measure Accepted (yes / no)	Alternative Measures or Comments	Alternative Measures Accepted (yes / no)
2.1	Yes	Yes	The relocation of the chevron board will be agreed with TII and Offaly County Council prior to finalising the detailed design of the proposed junction.	Comment noted
2.2	Yes	Yes	The existing field boundary and the existing safety barrier will be modified to ensure that the required visibility splays are available.	Comment noted
2.3	Yes	Yes	The existing level crossing gate is redundant and will be removed.	Comment noted
2.4	Yes	Yes	It is acknowledged that visibility splays at this junction are constrained. For this reason a comprehensive set of traffic management measures (including traffic signs and the presence of Flagmen) will be implemented on the days that it is proposed to use this access for construction traffic, and on the limited number of days access is required for maintenance. This access will return to operate as an agricultural access at all other times.	Comment noted

Note that the Audit Team Response of "Alternative Measures Accepted" are NOT accepted with a YES answer. The "Comment noted" response in column 5 does not comply with the accepted requirement of "YES".

In the case of item reference 2.4, this creates a serious road safety issue.

The absence of adequate widths on the Local Roads without passing bays is not adequate & should have been identified. The failure to identify sweptpath turning movements from exiting traffic is a serious issue.



Sweptpath drawings shown for Junction 2 indicate inadequate width for 2-way traffic.

No sweptpath drawings shown for junction 4.

No sweptpath drawings shown for exiting traffic.

15.2 **Telecommunications and Aviation**

Wind turbines, like all large structures, have the potential to interfere with broadcast signals, by acting as a physical barrier or causing a degree of scattering to microwave links. The most significant effect at a domestic level relates to a possible flicker effect caused by the moving rotor, affecting, for example, radio signals. The most significant potential effect occurs where the wind farm is directly in line with the transmitter radio path.

During the development of any large project that holds the potential to effect telecoms or aviation, the developer is responsible for engaging with all relevant telecom operators and the relevant aviation authorities to ensure that the proposal will not interfere with television or radio signals by acting as a physical barrier. In the event of any potential impact, the developer for each individual project is responsible for ensuring that the necessary mitigatory measures are in place. Therefore, as each project is designed and built to avoid impacts arising, a cumulative impact cannot arise.

Consultation regarding the potential for electromagnetic interference from the Proposed Wind Farm was carried out in 2021 and again in 2025, as identified above, with the relevant national and regional broadcasters, fixed line and mobile telephone operators and other operators, which confirmed that no turbines are proposed within the areas requested to be left clear of turbines. Therefore, no impacts were identified to telecommunications from the Proposed Wind Farm.

A Telecommunications Impact Assessment (Appendix 15-6 and Appendix 15-7) was carried out by Ai Bridges. These appendices detail the field and desktop surveys undertaken to determine if telecommunications network infrastructure, including those highlighted by Iarnród Eireann, would be impacted by the proposed turbines. The Telecommunications Impact Assessment concludes that the proposed turbines will have no impacts on telecommunications.

There are no airports or aerodromes located within or adjacent to the site. The nearest operational aviation facility is Ballyboy Airfield located approx. 14.5 km south of the Proposed Wind Farm. The next closest facility is Birr Aerodrome located approx. 20.5 km southwest of the Proposed Wind Farm. There are no flying clubs in close proximity of the Proposed Project, with the nearest being the Irish Jet Modellers Flying Club, located c. 8.9 km southwest of the proposed turbine T03. Manna Air Delivery, a drone operator, conducts test flights at Bellair Bog, which is located c. 1 km north of the proposed onsite 220kV substation and 2.6km north of the nearest proposed turbine (i.e., T10).

Consultation regarding the potential for electromagnetic interference and impact on aviation Proposed Wind Farm was carried out which confirmed that no proposed turbines are proposed within the areas requested to be left clear of turbines. Therefore, no impacts were identified to telecommunications or aviation from the Proposed Wind Farm.

There are no electromagnetic interference impacts for telecommunications and aviation assets or operations associated with the construction phase of the Proposed Wind Farm or Proposed Grid Connection and therefore no mitigation is required. The potential for electromagnetic interference from proposed turbines may only occur during the operational phase of the Proposed Project. As per the Telecommunications Impact Assessment carried out by Ai Bridges, detailed above, no impacts were identified to telecommunications from the Proposed Project. While no mitigation measures are required, a standard Protocol Document has been prepared by 2RN for the Proposed Project which will be signed by the Developer prior to construction.

Reference Number 164: 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

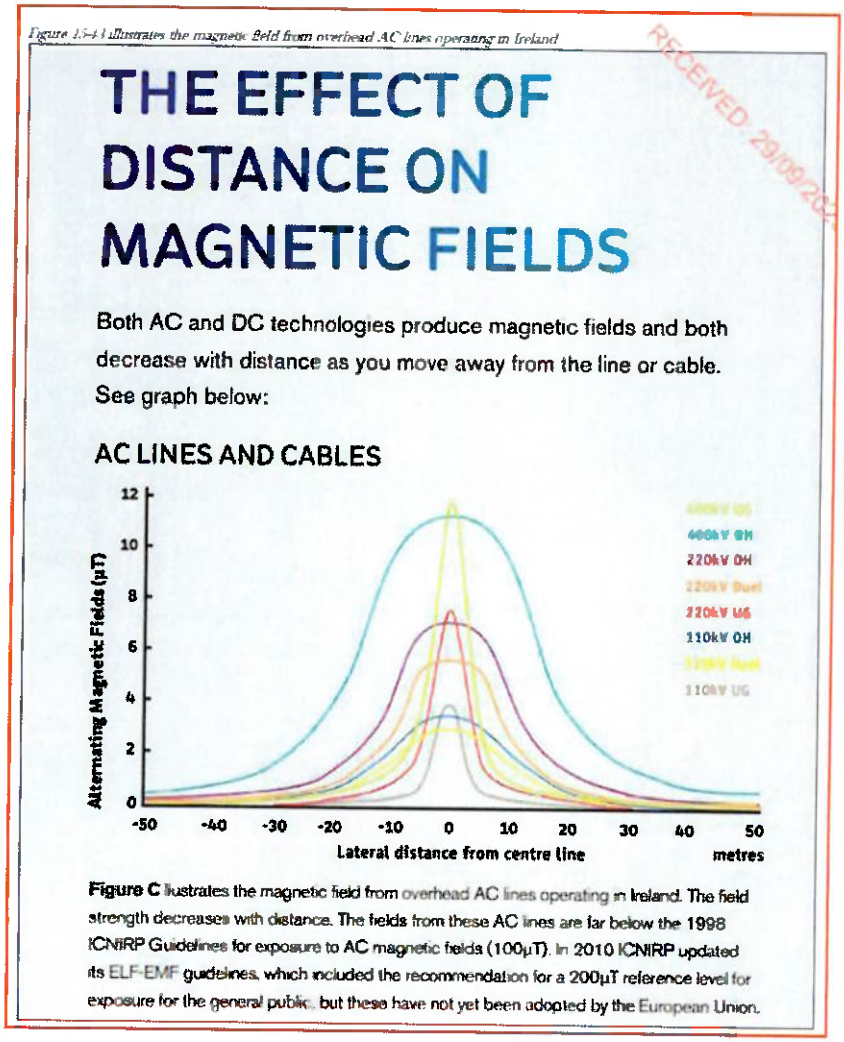
Setback distances from an asset to a residence vary across states. For example, prior to 2011 there were no setback distances for wind turbines in Victoria. The current setback distance is 1km.

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.

15.3 Other Material Assets

This section of the Material Assets chapter considers other utilities or built services in the area such as electricity supply and transmission, water, gas and underground telecommunications. This section also considers waste management during the construction, operational and decommissioning phases of the Proposed Project.

The Proposed Project has been designed to avoid identified services and utilities insofar as possible. Prior to commencement of construction, detailed site investigations will be carried out to confirm design assumptions and undertake additional surveys to identify any new services and utilities and ensure they will not be impacted by the Proposed Project.

The Shannonbridge-Maynooth 220kV Overhead Line (OHL) runs to the north of the site in a northeast-southwest direction and is located within the site, approximately 0.4 km north of the proposed onsite 220kV substation at its closest point. A break in the Shannonbridge-Maynooth 220kV OHL approximately 0.4 km north of the proposed onsite 220kV substation will facilitate the connection of the Proposed Project to the national grid. In advance of works relating to the Proposed Grid Connection break of the existing OHL, comprehensive consultation and coordination will be carried out with EirGrid/ESB to ensure appropriate outage planning, network management, and contingency arrangements are implemented, to minimise any potential impact on local residents, businesses, and critical services. No other electricity infrastructure is present within the Proposed Project site.

A data request was sent to Gas Networks Ireland in February 2023. The data returned demonstrated that there are no gas pipelines within the Proposed Project site. In addition, GNI supply MKO with their latest infrastructure data on a quarterly basis. The latest data share illustrating all GNI infrastructure was provided to MKO in March 2026. The data indicates that there is no GNI infrastructure is located within or adjacent to the site with the nearest infrastructure being approximately 8.6 km to the east of the Proposed Project.

There are no EPA-licensed or local authority-authorised waste facilities or activities located within the Proposed Project site; please note, Lemanaghan Bog is subject to IPC License due to historical peat extraction activities. This interaction, and associated future plans of Lemanaghan Bog, have been assessed throughout the EIAR. The closest, authorised municipal waste facility is located approximately 9km northwest of the Proposed Project site, near Athlone, Co. Westmeath. A Resource Waste Management Plan (RWMP) has been prepared and forms part of the Construction and Environmental Management Plan (CEMP) in Appendix 4-4 of the EIAR.

With the implementation of best practice measures and all mitigation and monitoring measures set out in Chapter 15, the effects on utilities and waste management listed above will be short-term, negative and slight, which is not significant, for the construction phase and decommissioning phases.

There will be no operational phase impacts or associated effects on built services or waste management associated with the Proposed Project. The Proposed Project will have an estimated installed capacity of 90MW which has potential to produce 275,940MWh of electricity. This would be sufficient to supply approximately 65,700 Irish households with electricity per year during its operational phase. The Proposed Project will therefore have a positive, moderate, long-term effect on built services.

Reference Number 165 :
2024/1991 REGULATION (EU) 2024/1991 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 24 June 2024 on nature restoration and amending Regulation (EU) 2022/869

CHAPTER II
RESTORATION TARGETS AND OBLIGATIONS
Article 4
Restoration of terrestrial, coastal and freshwater ecosystems

1. Member States shall put in place the restoration measures that are necessary to improve to good condition areas of habitat types listed in Annex I which are not in good condition.

Such restoration measures shall be put in place:

(a) by 2030 on at least 30 % of the total area of all habitat types listed in Annex I that is not in good condition, as quantified in the national restoration plan referred to in Article 15;

(b) by 2040 on at least 60 % and by 2050, on at least 90 % of the area of each group of habitat types listed in Annex I that is not in good condition, as quantified in the national restoration plan referred to in Article 15.

7. Member States shall put in place restoration measures for the terrestrial, coastal and freshwater habitats of the species listed in Annexes II, IV and V to Directive 92/43/EEC and of the terrestrial, coastal and freshwater habitats of wild birds falling within the scope of Directive 2009/147/EC that are, in addition to the restoration measures referred to in paragraphs 1 and 4 of this Article, necessary to improve the quality and quantity of those habitats, including by re-establishing them, and to enhance connectivity, until sufficient quality and quantity of those habitats is achieved.

8. The determination of the most suitable areas for restoration measures in accordance with paragraphs 1, 4 and 7 of this Article shall be based on the best available knowledge and the latest scientific evidence of the condition of the habitat types listed in Annex I to this Regulation, measured by the structure and functions which are necessary for their long-term maintenance, including their typical species, as referred to in Article 1, point (e), of Directive 92/43/EEC, and of the quality and quantity of the habitats of the species referred to in paragraph 7 of this Article, making use of information reported under Article 17 of Directive 92/43/EEC and Article 12 of Directive 2009/147/EC, and where appropriate taking into account the diversity of situations in various regions as referred to in Article 14(16), point (c), of this Regulation.

9. Member States shall ensure, by 2030 at the latest, that the condition of habitat types is known for at least 90 % of the area distributed over all habitat types listed in Annex I and that by 2040, the condition of all areas of habitat types listed in Annex I is known.

10. The restoration measures referred to in paragraphs 1 and 4 shall consider the need for improved connectivity between the habitat types listed in Annex I and take into account the ecological requirements of the species referred to in paragraph 7 that occur in those habitat types.

11. Member States shall put in place measures which shall aim to ensure that the areas that are subject to restoration measures in accordance with paragraphs 1, 4 and 7 show a continuous improvement in the condition of the habitat types listed in Annex I until good condition is reached, and a continuous improvement of the quality of the habitats of the species referred to in paragraph 7, until the sufficient quality of those habitats is reached.

12.Without prejudice to Directive 92/43/EEC, Member States shall, by the date of publication of their national restoration plans in accordance with Article 17(6) of this Regulation, endeavour to put in place necessary measures with the aim of preventing significant deterioration of areas where the habitat types listed in Annex I to this Regulation occur and which are in good condition or are necessary to meet the restoration targets set out in paragraph 17 of this Article.

13.With regard to paragraphs 11 and 12 of this Article, outside Natura 2000 sites, Member States may, in the absence of alternatives, apply the non-deterioration requirements set out in those paragraphs at the level of each biogeographical region of their territory for each habitat type and each habitat of species, provided that the Member State concerned notifies its intention to apply this paragraph to the Commission by 19 February 2025 and fulfils the obligations set out in Article 15(3), point (g), Article 20(1) point (j), Article 21(1) and Article 21(2), point (b).

Article 11

Restoration of agricultural ecosystems

4.Member States shall put in place measures which shall aim to restore organic soils in agricultural use constituting drained peatlands. Those measures shall be in place on at least:

(a) 30 % of such areas by 2030, of which at least a quarter shall be rewetted;

(b) 40 % of such areas by 2040, of which at least a third shall be rewetted;

(c) 50 % of such areas by 2050, of which at least a third shall be rewetted.

Member States may put in place restoration measures, including rewetting, in areas of peat extraction sites and count those areas as contributing to meeting the respective targets referred to in the first subparagraph, points (a), (b) and (c).

In addition, Member States may put in place restoration measures to rewet organic soils that constitute drained peatlands under land uses other than agricultural use and peat extraction and count those rewetted areas as contributing, up to a maximum of 40 %, to meeting the targets referred to in the first subparagraph, points (a), (b) and (c).
Restoration measures that consist in rewetting peatland, including the water levels to be achieved, shall contribute to reducing greenhouse gas net emissions and increasing biodiversity, while taking national and local circumstances into account.

Where duly justified, the extent of the rewetting of peatland under agricultural use may be reduced to less than required under the first subparagraph, points (a), (b) and (c), of this paragraph by a Member State if such rewetting is likely to have significant negative impacts on infrastructure, buildings, climate adaptation or other public interests and if such rewetting cannot take place on land other than agricultural land. Any such reduction shall be determined in accordance with Article 14(8).

The obligation for Member States to meet the rewetting targets set out in the first subparagraph, points (a), (b) and (c), does not imply an obligation for farmers and private landowners to rewet their land, for whom rewetting on agricultural land remains voluntary, without prejudice to obligations stemming from national law.

Member States shall, as appropriate, incentivise rewetting to make it an attractive option for farmers and private landowners and foster access to training and advice to farmers and other stakeholders on the benefits of rewetting peatland and on the options of subsequent land management and related opportunities.

ANNEX I

TERRESTRIAL, COASTAL AND FRESHWATER ECOSYSTEMS – HABITAT TYPES AND GROUPS OF HABITAT TYPES REFERRED TO IN ARTICLE 4(1) AND (4)

The list below includes all terrestrial, coastal and freshwater habitat types listed in Annex I to Directive 92/43/EEC referred to in Article 4(1) and (4), as well as six groups of those habitat types, namely 1) wetlands (coastal and inland), 2) grasslands and other pastoral habitats, 3) river, lake, alluvial and riparian habitats, 4) forests, 5) steppe, heath and scrub habitats and 6) rocky and dune habitats.

1. GROUP 1: Wetlands (coastal & inland)

Mires, bogs and fens	
Habitat type code as referred to in Annex I to Directive 92/43/EEC	Habitat type name as referred to in Annex I to Directive 92/43/EEC
7110	Active raised bogs
7120	Degraded raised bogs still capable of natural regeneration
7130	Blanket bogs
7140	Transition mires and quaking bogs
7150	Depressions on peat substrates of the *Rhynchosporion*
7160	Fennoscandian mineral-rich springs and springfens
7210	Calcareous fens with *Cladium mariscus* and species of the *Caricion davallianae*
7220	Petrifying springs with tufa formation (*Cratoneurion*)
7230	Alkaline fens
7240	Alpine pioneer formations of the *Caricion bicoloris-atrofuscae*
7310	Aapa mires
7320	Palsa mires
Rivers and lakes	
3110	Oligotrophic waters containing very few minerals of sandy plains (*Littorelletalia uniflorae*)
3120	Oligotrophic waters containing very few minerals generally on sandy soils of the West Mediterranean, with *Isoetes* spp.
3130	Oligotrophic to mesotrophic standing waters with vegetation of the *Littorelletea uniflorae* and/or of the *Isoëto-Nanojuncetea*
3140	Hard oligo-mesotrophic waters with benthic vegetation of *Chara* spp.
3150	Natural eutrophic lakes with *Magnopotamion* or *Hydrocharition* — type vegetation
3160	Natural dystrophic lakes and ponds
3170	Mediterranean temporary ponds
3180	Turloughs

ANNEX V

COMMON FARMLAND BIRD INDEX AT NATIONAL LEVEL

Description

The common farmland bird index summarises population trends of common and widespread birds of farmland and is intended as a proxy to assess the biodiversity status of agricultural ecosystems in Europe. The national common farmland bird index is a composite, multispecies index that measures the rate of change in the relative abundance of farmland bird species across selected survey sites at national level. That index is based on specially selected species that are dependent on farmland habitats for feeding or nesting, or both. National common farmland bird indices are

based on species sets that are relevant to each Member State. The national common farmland bird index is calculated with reference to a base year when the index value is typically set at 100. Trend values express the overall population change in the population size of the constituent farmland birds over a period of years.

List of species used for the common farmland bird index in the Member States

Ireland
Carduelis carduelis - Goldfinch
Columba oenas – Stock Dove
Columba palumbus – Common Wood Pigeon
Corvus cornix – Hooded Crow
Corvus frugilegus - Rook
Corvus monedula - Jackdaw
Emberiza citronella - Yellowhammer
Falco tinnunculus - Kestrel
Fringilla coelebs - Chaffinch
Hirundo rustica –Barn swallow
Chloris chloris - Greenfinch
Linaria cannabina - Linnet
Motacilla alba – White Wagtail
Passer domesticus – House sparrow
Phasianus colchicus – Ring-necked Pheasant
Pica pica - Magpie
Saxicola torquatus - Stonechat
Sturnus vulgaris - Starling

ANNEX VII
LIST OF EXAMPLES OF RESTORATION MEASURES REFERRED TO IN ARTICLE 14(16)

(1) Restore wetlands, by rewetting drained peatlands, removing peatland drainage structures or de-poldering and discontinuing peat excavation

(12) Assist migration of provenances and species where it may be needed due to climate change.

(22) Improve connectivity across habitats to enable the development of populations of species, and to allow for sufficient individual or genetic exchange as well as for species' migration and adaptation to climate change.

Reference number 166 : Client: European Commission, DG Environment. Impact assessment study to support the development of legally binding EU nature restoration targets
Undertaken as part of Contract 07.0202/2019/SER/806106/ENV.D.2. *Supporting the Evaluation of the EU Biodiversity Strategy to 2020 and Followup* .Rotterdam, 06 June 2023.

Figure 2-1 Share of terrestrial surface area by broad ecosystem type in the EU and UK

Note: 1) Marine ecosystem are not included and represent the most extensive ecosystem type in the EU (5.8 million km²); 2) The percentages only add to 98.5% and the remaining 1.5% include some important smaller ecosystems relevant to this Impact Assessment, in particular coastal wetlands

Source: EU Ecosystem Assessment Summary for policy makers[25]. Original source: Corine Land Cover, European Environment Agency, 2018.

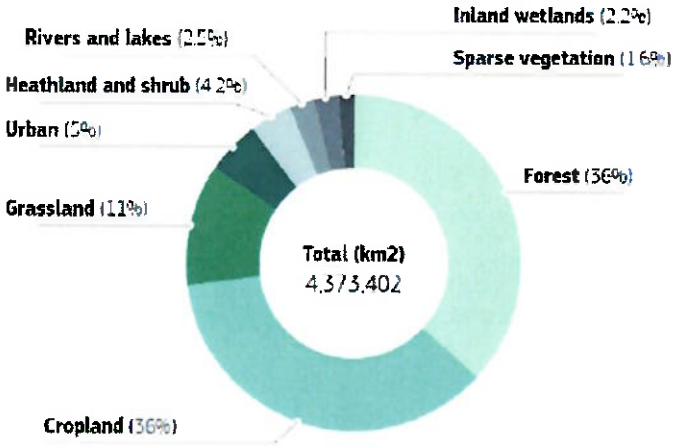
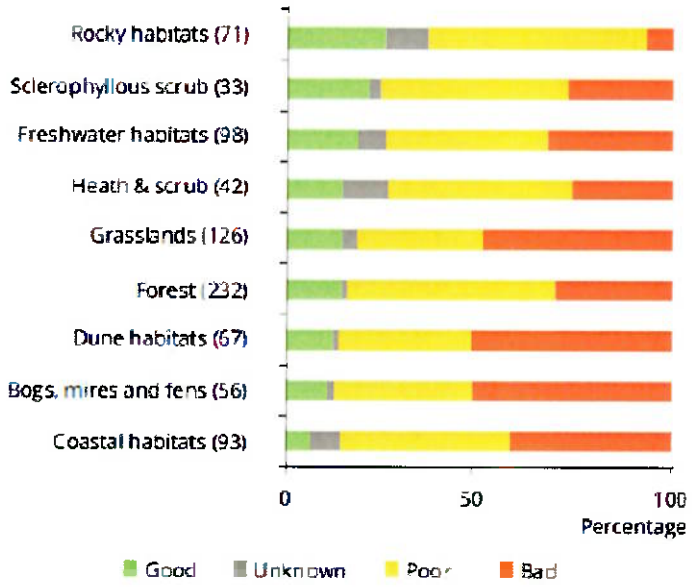


Figure 2-2 Conservation status per habitat group at the EU level

Source: Taken from EEA (2020) State of nature in the EU, Results from reporting under the nature directives 2013-2018. EEA Report No.10/2020.



	• Synergies with related EU initiatives, e.g. LULUCF, Farm to Fork strategy.	
	General *Corresponding to the general objective of the Biodiversity Strategy for 2030.*	Specific Corresponding to the proposal for legally binding restoration targets
Policy and Legal Context	• European Green Deal • EU Biodiversity Strategy • Existing legislation to protect and restore biodiversity and ecosystems such as the Bird and Habitats Directive, Water Framework Directive and the Marine Strategy Framework Directive • Related EU initiatives, e.g. Farm to Fork, revision of the LULUCF Regulation • Strong public interest in nature restoration.	
Problem	General problem: Biodiversity loss and ecosystem degradation	Specific problem: Largely insufficient ecosystem restoration in the EU. Need for more ambitious nature restoration to reverse biodiversity loss, as nature protection alone is insufficient.
Drivers	Main direct drivers of biodiversity loss and ecosystem degradation: • Changes in land and sea use; • Over-exploitation of natural resources; • Climate change; • Pollution; • Invasive alien species.	Specific policy and legislative drivers of insufficient ecosystem restoration in the EU: • Voluntary approaches have been ineffective • Gaps in existing legislation • Lack of comprehensive approach • Funding challenges • Political commitment and ownership by Member States
Objectives	General objective Reverse biodiversity loss so that: • Europe's biodiversity is on the path to recovery by 2030; • All of the EU's ecosystems are restored and resilient by 2050; • Implement the Biodiversity Strategy for 2030).	Specific objectives: To restore degraded ecosystems across the EU, in particular those that have the most potential to remove and store carbon and prevent and reduce the impact of natural disasters. Operational objectives: • Introduce time-bound, measurable, legally binding targets to enable restoration of ecosystems across the board and in a way that addresses the main ecosystem types. • Establish a governance and implementation structure to enable this restoration and ensure that restored ecosystems do not deteriorate. • Set out requirements for effective monitoring, planning, financing and capacity.
Policy Options	Option 1: Baseline scenario Option 2: Overarching legally binding target for ecosystem restoration Option 3: Legally binding targets for specific ecosystems, habitats or (groups of) species Option 4: Hybrid of legally-binding ecosystem-specific targets with an overarching objective	

Figure 4-1 Projected restoration effort (extent) based on Eftec et al and remaining gap to 15-40-100% HD Annex I targets

Note: This figure assumes that Eftec et all only identified 25% of actual restoration action in the then EU28, and the total effort towards the targets reflects the best-estimate total area of degraded Annex I habitats in the EU27 based on the last conservation status reporting under the EU Habitats Directive (Art 17 reporting)[50].

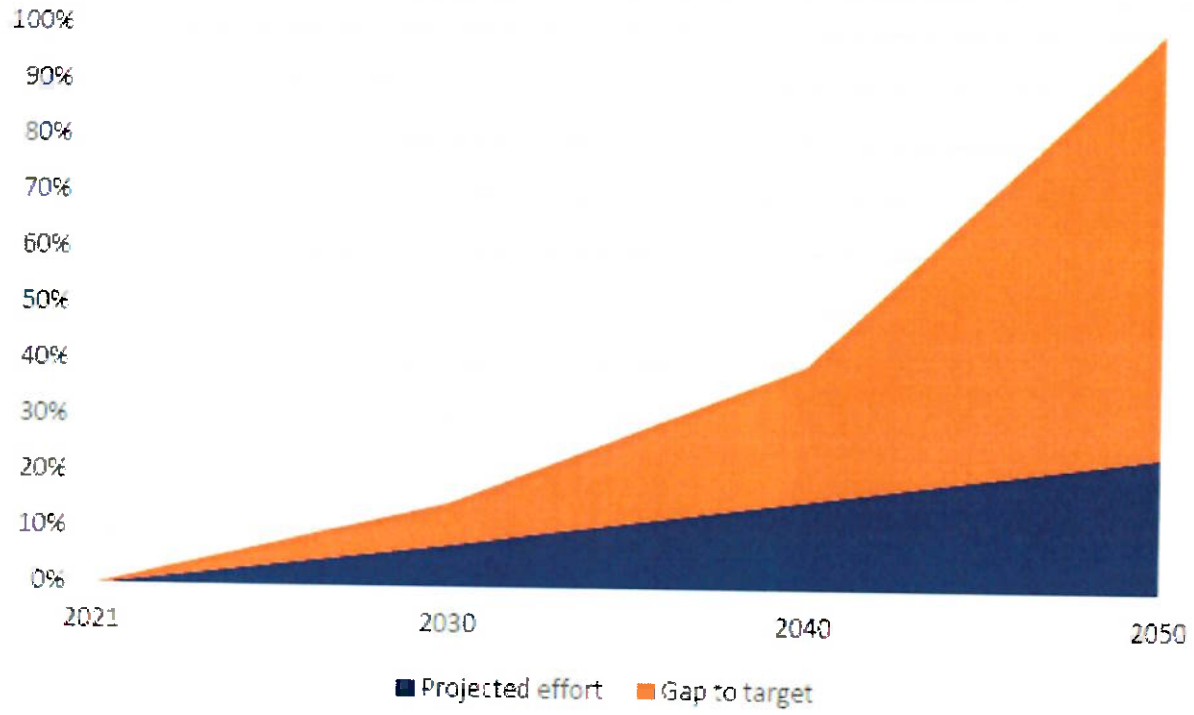


Table 5-1 Potential Ecosystem-specific Targets for Restoration in Step 1 of Stepwise Approach

SELECTED TARGETS FOR STEP 1
WETLANDS (incl. Peatlands, marshlands & coastal wetlands)
- Restore all HD Annex I wetland habitat area to good condition, with all necessary restoration measures completed on 30 % (or 15 %) of degraded areas by 2030, 60 % (or 40 %) by 2040 and 100 % by 2050.
- *For peatlands only*: Re-wetting at least 25 % of HD Annex I peatland habitat area degraded due to drainage by 2030, 50 % by 2040 and 100 % by 2050 so that the water table is at, or with 15cm of the surface. - Recreate 30 % (or 15 %) of additional habitat area required to achieve favourable conservation status of HD Annex I wetland habitats by 2030, 60 % (or 40 %) by 2040 and 100 % by 2050. - Restore and re-create the area as necessary to enhance the conservation status of species listed in Annex II, IV and V of the Habitats Directive as well as wild birds associated with wetlands in view of achieving their favourable conservation status by 2050, with at least 30 % achieved by 2030 and at least 60 % by 2040.

Table 6-1: Overview table of likely dimensions impacting on the prioritisation of certain ecosystem types over others in implementing an overarching target

Key: Blue=Criterion is likely to encourage restoration of this ecosystem within an overall target; Orange=Criterion may have a moderate or mixed effect in encouraging restoration of the ecosystem; Red=Criterion may discourage restoration of this ecosystem within an overall target.

Please note: The scope of this impact assessment also includes pollinators and soils which, due their cross-cutting nature, were not included as a separate ecosystem in this table. Their restoration needs would however need be integrated in the implementation of the overarching target under different ecosystem types.

Ecosystem	Ecosystem extent	Technical feasibility	Need for coordinated international action	Cost per hectare	Benefit:Cost ratio	Opportunity cost/ stakeholder resistance	Contribution to climate mitigation and adaptation	Contribution to disaster prevention and protection	Overall assessment
Peatlands and wetlands	Low	Re-wetting of most drained semi-natural peatland is straightforward, full restoration of highly degraded peatland is difficult	Moderate	Moderate per hectare costs	Good B:C ratios	Low for Annex 1 habitats	Exceptionally high potential for carbon storage and sequestration, improved water retention can also contribute to adaptation	High in flood prone catchments where reversing drainage reduces run-off rates and downstream flooding	Likely to be a priority for restoration for those MS with degraded peatlands, given strong climate mitigation benefits.

Table 6-2 Overview table of all ecosystem-specific target options screened in and assessed for this Impact Assessment study

Ecosystem	Target	Intended impacts			
		Biodiversity	CC mitigation	CC adaptation	Ecosystem services (other)
Inland wetlands and peatlands	The full recovery of Habitats Directive Annex I peatlands to good ecosystem status (i.e. favourable conservation status), including through the following: • Re-wetting at least 25% of HD Annex I peatland habitat area degraded due to drainage by 2030, 50% by 2040 and 100% by 2050 so that the water table is at, or with 15cm of the surface. • Restore all HD Annex I peatland habitat area to good condition, with all necessary restoration measures completed on 15% / 30% of degraded areas by 2030, 40% / 60% by 2040 and 100% by 2050 • Re-create the area necessary to achieve Favourable Conservation Status of HD Annex I peatlands at national biogeographical level by 2050, with 15% / 30% achieved by 2030 and 40% / 60% by 2040, and 100% achieved by 2050.	*****	*****	****	****
	Marshes- to maintain, restore and re-create marshlands as necessary to achieve the favourable conservation status of species associated with marshlands listed in Annex II, IV and V of the Habitats Directive, and the secure status of wild birds associated with marshlands, by 2050, with at least xx% achieved by 2030 and at least xx% by 2040.	****	*****	*****	****
	Peatland converted to cropland- Reduce the area of managed or drained organic soils that are losing carbon by 15% by 2030, 40% by 2040 and 100% by 2050.	***	*****	****	****

Table 6-7 Estimated benefits for each ecosystem under the two scenarios

Overview of benefits for the preferred option - until 2070 (Present Value)				
	Scenario A (15-40-100% targets for 2030-2040-2050)		Scenario B (30-60-100% targets for 2030-2040-2050)	
Restoration of ecosystem type	Carbon benefits in EUR million	Benefits from all ecosystem services (including carbon) in EUR million	Carbon benefits in EUR million	Benefits from all ecosystem services (including carbon) in EUR million
Peatlands	10 629	38 702	13 042	47 488

Table I: Restoration needs of habitats listed in Annex I of the Habitats Directive based on reporting by Member States (2013-2018). Romania is excluded because its reported Annex I areas exceed the terrestrial area of the country. Source: EEA.

Ecosystem based on Annex I types (N° of Annex I habitat types)	Surface[1] Annex I habitats in km²	Condition in km² & %			Overall restoration needs in km²	
		Good	Not good	Unknown	Area re-establishment (min/max)	Improvement in condition (min/max)
Wetlands[2] (inland & coastal) (28)	174 400	62 950 36%	27 100 16%	84 300 48%	3 131 6 910	27 100 111 400
Forests[3] (69)	357 952	162 300 45%	79 210 22%	116 444 33%	3 487 8332	79 210 195 000
Agro-habitats and grasslands[4] (35)	177 442	84 150 47%	31 180 18%	62 100 35%	2 431 8 798	31 180 93 000
River, lakes, alluvial and riparian habitats[5] (52)	96 480	52 970 55%	21 560 22%	21 950 23%	894 2 743	21 560 38 000
Heath & scrub[6] (21)	78 582	43 420 55%	6 590 8%	28 600 36%	405 928	6 586 35 000
Rocky and (Coastal) & dunes (41)	65 135	30 048 46%	6 619 10%	28 500 44%	355 1 458	6 619 35 100
Total Terrestrial	**949 990**	**435 838** **46%**	**172 259** **18%**	**341 894** **36%**	**10 703** **29 169**[8]	**172 255** **505 500**[9]
				Total restoration terrestrial:	**182 985 – 536 669 km²** [10]	
Marine[7] (4)	240 036	36 810 15%	34 830 15%	168 390 70%	1 622 3 424	34 828 203 200
				Total restoration marine:	**36 450 – 206 624 km²** [11]	

Table II: Overall restoration needs, by Member State, of habitats listed in Annex I of the Habitats Directive, based on reporting by Member States (period 2013-2018) under Art.17 of the HD – EU27 (excluding Romania for data quality reasons). Source: EEA.

Member State	Member State surface in km²	Overall restoration needs (all ecosystems) in km² TERRESTRIAL				Overall restoration needs in km² MARINE
		Area re-establishment (min/max)	Area improvement (min/max)	Total restoration area (min max)	% of MS territory (min max)	(min/max)
Ireland	70 699	313 / 640	5 180 / 5 657	5 493 / 6 297	7.8 / 8.9	3 014 / 24 542

Table III: MINIMUM restoration needs, by Member State and by Annex I habitat, based on reporting by Member States (period 2013-2018) under Art.17 of the HD – EU27. Source: EEA.

		MINIMUM ecosystem areas (km²) for restoration (improvement + re-establishment)						
	MS area (km²)	Wetlands	Rivers & lakes	Grasslands & agri	Forests	Heath & scrub	Rocky & dunes	Terrestrial
IE	70.699	3.753	928	692	19	54	47	5.493

Table IV: MINIMUM restoration needs, by improvement/re-establishment, by Member State and by Annex I habitats, based on reporting by Member States (period 2013-2018) under Art.17 of the HD – EU27. Source: EEA

Condition: area reported in 'not-good' condition: in need of improvement. Zeros often reflect that most areas have been reported as 'unknown condition'

Additional: for re-establishment: based on minimum Favorable Reference Areas.

	MINIMUM ecosystem areas (km²) for restoration (improvement and re-establishment)												
	Wetlands		Rivers & lakes		Grasslands		Forests		Heath & scrub		Rocky & dunes		
	condition	Additional	condition	Additional	condition	addition al	condition	addition al	condition	addition al	condition	addition al	Terre-strial
IE	3.527	226	928	0	611	82	19	0	54	0	42	4	5.493

Reference Number 168 : Scottish Government, Scottish Natural Heritage, SEPA (2017) Peatland Survey. *Guidance on Developments on Peatland*

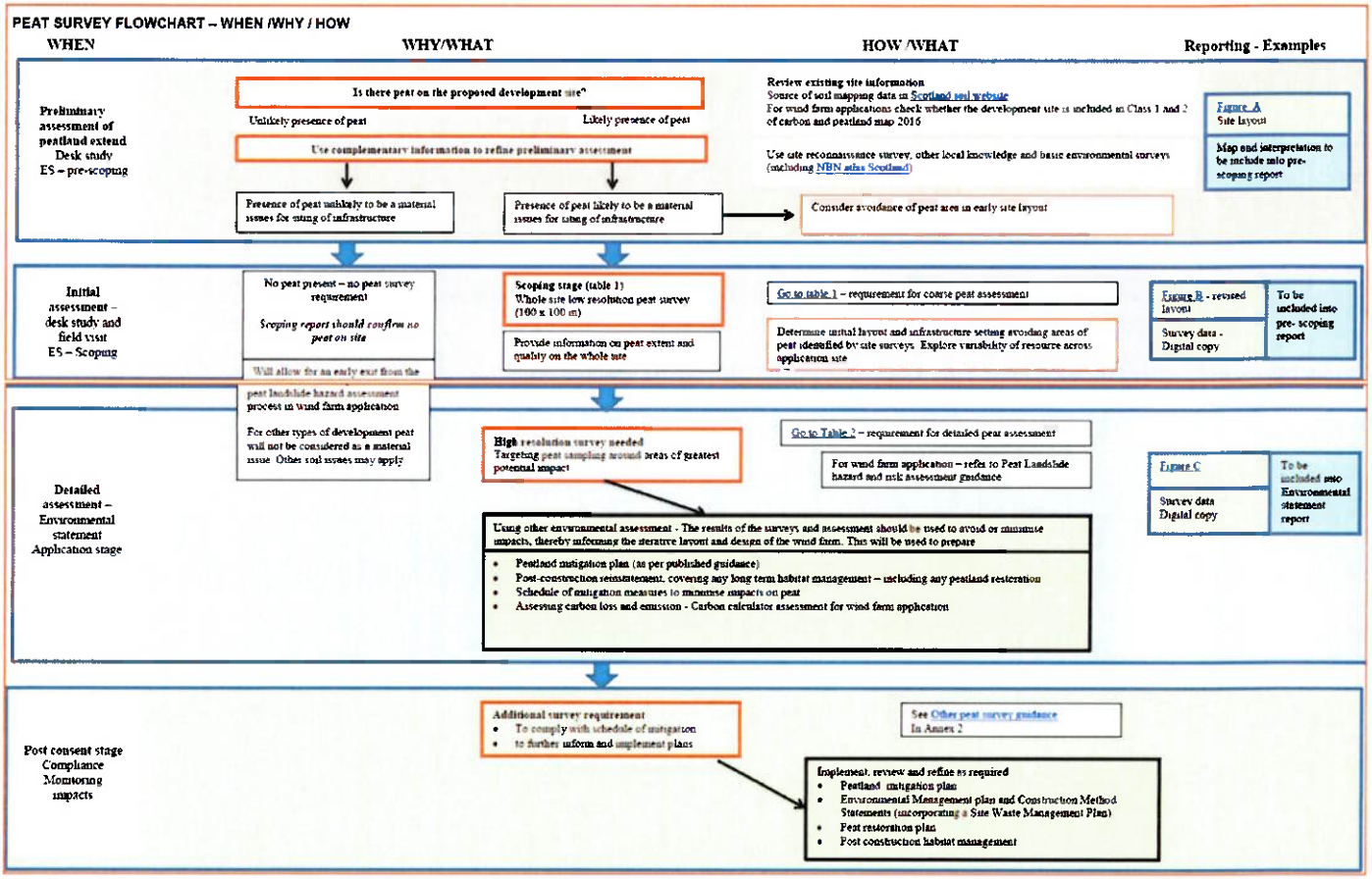


TABLE 1 – PRELIMARY ASSESSMENT OF PEATLAND EXTENT AND CONDITIONS

A field evaluation at low resolution will determine the presence of peat across the whole site. This is usually undertaken at an early stage in the EIA process.

Area coverage	Whole proposed development site
Peat depth survey resolution	Low resolution - Usually 100 m X 100 m on a regular grid pattern across the whole area proposed for development. Greater intensity surveys will not be required for areas that are unlikely to be developed.

A- Information to be sampled and gathered during peat depth survey	**B- Other ancillary information to be recorded during field visit**	**C- Other information collected as part of Environment statement**	**D- Methodology for peat depth survey**	**E-Data interpolation**
1- Location of each individual sampling point - Grid reference of each sampling point (at least precision to 100 cm) – use of GPS device is essential.	1- Contextual information, including surface drainage conditions	1- Detailed Phase 1 Habitat Survey whole site and National Vegetation Classification (NVC) Survey in locations where infrastructure is proposed which provide identification of Annex I habitats and Ground Water Dependent Terrestrial Ecosystems.	1- Peat depth surveys are usually conducted using peat probes (sometimes referred to as depthing rods). Probes should be long enough to cover the whole peat depth.	1- Detail on the geo-statistical procedure used to generate the estimated peat distribution map from the scattered set of peat depth values (i.e. interpolation using natural neighbor, IDW, Spline function, Kriging using QGIS, ARCGIS or other software)
2- Depth of the peat deposit – all occurrence of peat deposit (even if less than 50cm) should be recorded with at least a 10 cm precision. When no peat deposit is present a value of zero should be entered.			2- More information can be collected using a gouge auger – such as information on peat stratification and localized surface hydrological conditions. (See A-3)	
3- Composition of the soil column / type of peat (fibrous, semi-fibrous or amorphous) / moisture within the soil column where a auger is used instead of peat rods (see additional information in Annex 1)	2- Photography at selected viewpoints to provide a visual context of the spatial data		**E- Information presentation (see section 4, figure A)**	
4- Slope and other pertinent features such as active, incipient or relict instability should be recorded to inform the Peat Landslide Hazard & Risk[1] Assessment that will inform whether these areas should also be avoided.			• Geo-referenced peat depth data provided in a table • Peat distribution map • Peat depth data and interpolated distribution map provided as GIS shape file • Habitat Maps – Phase 1 and NVC	

[1] http://www.gov.scot/Publications/2006/12/21162303/1

TABLE 2 - FURTHER ASSESSMENT OF PEATLAND EXTENT AND CONDITIONS

For areas potentially to be developed to determine where peat is and how deep it is. This is so that developments can be designed to avoid the areas of deepest peat and minimise the impacts on peat and peatland environment, as much as possible

Area coverage & resolution	Targeted sampling regime tailored to potential development areas within the proposal boundary. Sampling should focus on areas of greatest potential impact from development including:
	• full targeted probing along all tracks, at all turbines/hard standings, turning points and passing places, site compounds, substation, borrow pits and met mast locations
	• detailed survey on a 10m by 10m grid basis around the centre of each proposed turbine base or other infrastructure including borrow pits and proposed temporary storage sites. Need to take account of potential micro-siting limits.
	• Detailed survey at 10 to 50m intervals along proposed track/road locations using 10m right angled offsets. Need to take account of potential micro-siting limits.

A - Information to be sampled and gathered during peat survey	**B- Other ancillary information to be recorded during field visit**	**C- Methodology for peat depth survey**	**D- Data interpolation and analysis**
1- Grid reference of each sampling point (precision at least 50 cm) – use of GPS device is essential.	1- Photography of areas of proposed infrastructure	1- Survey should use hand held GPS device with at least 50 cm resolution. This is used to record and locate sampling points and markers to identify the grid pattern being applied across the site.	1- Detail on the method used to calculate the depth and volume of peat that will be excavated at different locations
2- Total depth of the peat deposit at each sample point (accurate measurement with at least 5 cm precision – including in areas where peat is less than 50cm, or is absent.)	2- Contextual information and other information that is collected as part of the Environment statement	2- Conduct surveys using an auger to identify the thickness of peat deposits, as well as providing an indication of peat stratification and localised surface hydrological conditions. Peat probes are not sufficient for collecting samples at depth.	2- Detail of any geo-statistical procedure used to generate the estimated peat distribution map from the scattered set of peat depth values (i.e. interpolation using natural neighbor, IDW, Spline function. Kriging using QGIS, ARCGIS or other software)
3- Description of the soil core column including texture, depth and moisture content. These should be provided using recognised field assessment protocols (see additional info below about *Soil survey of Scotland Peat survey methods*)	3- Results of detailed habitat and vegetation surveys including Phase 1 Habitat Survey across the whole site and National Vegetation Classification (NVC) Survey in locations where infrastructure is proposed, which will provide identification of Annex I habitats and Ground Water Dependent Terrestrial Ecosystems	3- Soil augers or Russian peat samplers/corers, capable of extracting peat samples for carbon analysis, bulk density measurements and the degree of decomposition are required. Surveys should be undertaken by suitably skilled surveyors. This should be capable of reaching total core depth, and extension rods should be used where required. The minimum number of samples should reflect the diversity of habitats (4 samples in most cases). Selected samples should be representative of peat in areas where development is planned. The results can be checked against nationally derived estimates of bulk density and total carbon content to ensure accuracy	
4- Peat bulk density samples for laboratory analysis		4- Samples collected should be carried back for laboratory assessment in labeled, air and water tight containers (or polypropylene bags) prior to analysis.	**Information presentation (see section 4, figures B and C)**
5- Details of peatland characteristics such as surface vegetation cover density, vegetation type, artificial drainage features, signs of historic and current erosion (gullies, rills or hags) and peat stability on slopes. Note some of this may have been undertaken as part of any habitat survey		5- Additional habitat survey sampling protocol based on quadrats to describe the vegetation. Phase 1 and NVC guidance[9,10] should be used to provide a representative survey across the site. This should be undertaken by suitably qualified ecologists.	• Tabulated survey results - Geo-referenced and including all information collected at each sampling / survey points • All map of peat distribution map should include an overlay all proposed infrastructure locations • Interpolated map should include location and depth of surveyed points as an overlay. • Peat depth data point and interpolated distribution map provided as GIS shape file • Average peat depth and maximum peat as required in the Carbon Calculator assessment • Volume of excavated peat to inform the Peat Management Plan • Drawings and tables demonstrating how and where peat will be re-used • Calculations relevant to peat hazard and risk assessment

Annex 1 - Additional information – extract of Soil survey of Scotland Scottish Peat survey methods

Relevant sections of the 1964 Soil Survey of Scotland Scottish Peat Survey methods[2] methodology shown below will inform the conduct of an appropriate site survey to determine peat stock and condition on site. Note S.I unit must be used.

Soil survey of Scotland Scottish Peat survey methods

Section 1 to 2 no included

Section 3 - FIELD WORK

a) to c) not included

d) Surface firmness estimation

It is necessary to make some estimate of the bearing capacity of the bog surface as this will influence the type of machines recommended for initial and subsequent exploitation. Modem bog tractors have a ground pressure of less than 2 lb. per square inch but the total pressure applied is also affected by the character and density of the vegetation and whether the tractor carries or pulls its loads. A miller or rotavator for instance imparts a forward push to a tractor.

An average man standing on one foot applies a pressure to the ground of between 5 and 6 lbs. p.s.i. and this fact is used to estimate the bearing capacity. The following symbols are used to denote the pressure the ground will stand.

Firmness of surface (P)

- PO = Surface too soft to walk on
- P1 = Surface just passable
- P2 = Surface fairly firm
- P3 = Surface firm

As an example, Table 1 shows data from White Moss, Mainland, Orkney.

P0		P1		P2		P3		Total number of observations
No	Percent	No	Percent	No	Percent	No	Percent	
0	-	1	16.7	3	50.0	2	33.3	6

In practice these data mean that some 83 per cent of the bog could be developed with mechanical equipment without much difficulty. On 17 per cent of the area some care would be required but this softer part would be expected to become firmer as drainage began to have a consolidating effect.

Table 2 shows to some extent the relationship between the surface moisture content (for the stratum 0-20 in. (0-0.5 m)) and the estimated bearing capacity.

P-value / Moisture content (%)	P1	P2	P3
Average (range)	93.8 (92.4-94.7)	92.2 (86.5 -94.5)	89.0 (79.4-92.2)

(No data for areas rated P0)

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[2] Soil Survey of Scotland Scottish Peat Surveys, 1964. http://www.gov.scot/Topics/Business-Industry/Energy/Energy-sources/19185/17852-1/CSavings/PS1964

Although the differences in terms of percentage water in the peat appear small, it is important to note that a 1 per cent increase in water content at or near the figure of 90 per cent which is common for peat, results in a decrease in solids content of 10 per cent and the peat becomes appreciably more fluid and less able to bear applied pressure without collapse.

e) Observations on the vegetation

The plants growing within a radius of 49 to 66 ft (15-20 m) round each bore hole are recorded, as are the boundaries between well-defined plant communities which are noted during traverses across the bog.

f) Observations on the peat

i. *Botanical* origin

The range of vegetable remains easily identifiable in the field is strictly limited and laboratory analyses of the many hundreds of samples taken in anyone season would be vastly time-consuming. However, it is usually possible to ascertain the main peat-forming species in the field and this is done for all samples examined.

The universal peat formers found in both Blanket and Raised Basin Bogs are species of *Sphagnum*. Also found in most bogs are the remains of *Eriophorum vaginatum*, the leaf-sheaths of which contain fine fibres which are extraordinarily resistant to the processes of decomposition, and small twigs of *Callana vulgaris* which are generally found in the upper strata. The usual type of peat found in the lower horizons of Basin Bogs is a mixture of the remains of *Carex* species with smaller amounts of *Phragmites, Typha, Equisetum* and *Menyanthes,* all or some of which are usually present. Wood remains are frequent, even in areas which are now treeless such as Shetland. The commonest wood is *Betula* but *Pinus* is not uncommon and it is probable that *Salix, Alnus* and Cory*lus* occur more often than they are recognised. Field identification of wood fragments is somewhat uncertain.

ii. Degree *of humification* - von POST SCALE

The degree of humification of peat samples is estimated in the field according to the method devised by the Swedish botanist L. von Post.

A small amount of peat is squeezed in the hand and the water and! or peat exuded indicates, by its colour and consistency, the degree to which the peat has undergone humification or, more correctly, a type of decomposition which includes breakdown under anaerobic conditions. This is one of the most important observations to be made on the peat and, because it is entirely subjective, one of the most difficult to make with a minimum of error. As far as possible, the same person makes all such observations and experience counts for a great deal. It is necessary to make allowance for moisture content, oxidation of the surface horizons and for the botanical origin of the peat. Obviously for example, pieces of wood do not squeeze between the fingers and yet the matrix in which the wood fragments are embedded may be very highly humified. A very dry peat may appear to be less well humified than it actually is and vice versa. Attempts have been made by various workers to develop an objective method for the estimation of degree of humification but without conspicuous success. The von Post scale ranges from 1 to 10, the higher the number the higher the degree of humification. The full scale is as follows:

DEGREE OF HUMIFICATION - von POST SCALE

H1	Completely undecomposed peat free of amorphous material. On squeezing, clear colourless water is pressed out.
H2	Nearly undecomposed peat, free of amorphous material, yielding only yellowish brown water on pressing.
H3	Very slightly decomposed peat, containing a little amorphous material. On squeezing, muddy brown water but no peat passes between the fingers. Residue is not pasty.
H4	Slightly decomposed peat containing some amorphous material. Strongly muddy brown water but no peat passes between the fingers. Residue is somewhat pasty.
H5	Moderately decomposed peat containing a fair amount of amorphous material. Plant structure recognisable though somewhat vague. On squeezing, some peat but mainly muddy water issues. Residue is strongly pasty.
H6	Moderately decomposed peat with a fair amount of amorphous material and indistinct plant structure. On pressing, about one third of the peat passes between the fingers. Residue is strongly pasty, but shows the plant structure more distinctly than in unsqueezed peat.
H7	H7 Strongly decomposed peat with much amorphous material and faintly recognisable plant structure. On squeezing, about one half of the peat is extruded. The water is very dark in colour.
H8	Strongly decomposed peat with much amorphous material and very indistinct plant structure. On squeezing, two thirds of the peat and some water passes between the fingers. Residue consists of plant tissues capable of resisting decomposition (roots, fibres, wood, etc.).
H9	Practically fully decomposed peat with almost no recognisable plant structure. Nearly all the peat squeezed between the fingers as a uniform paste.
H10	Completely decomposed peat with no discernible plant structure. On squeezing, all the peat, without water, passes between the fingers.

Mean H-values are calculated for each bog and its sub-areas if required and also for each 20 in. (0.5 m.) layer from the surface to the bottom. The variation with depth is shown graphically in the Bog Reports. The usual pattern is for the H-value to increase more or less steadily with increasing depth unless the origin of the peat changes drastically. When *Carex* peat occurs near the bottom of a deposit, the degree of humification generally falls to a value similar to that found in the upper layers of the bog.

Peats of low degrees of humification are those commonly described as "light" or "brown" and are used as moss litter and in horticulture. The highly humified "black" or "blue" peats comprise good fuel types. In recent years horticulturalists have been less insistent on having the very light peats since rather darker qualities have been found equally useful for many purposes.

Inspection of humification data from the surveys shows that the extremes of the von Post scale are rarely encountered (i.e. H1 and H10). The majority of samples lie about the centre of the scale with small shifts of the average towards the lower or higher values depending upon whether the peat in the bog is of a fuel or a moss litter type.

iii. Fibre

The fibre content of each peat sample is estimated visually and the amounts of the two types (classified 'fine' or 'coarse') are noted on a scale ranging from 0 to 3 as shown below. Accurate quantitative determinations are made later on bulk samples in the laboratory as described in section 4(f).

Fine fibres, mainly derived from *Eriophorum spp.* (F)

F0 = Nil
Fl = Low content
F2 = Moderate content
F3 = High content

Coarse fibres, mainly rootlets (R)

R0 = Nil
Rl = Low content
R2 = Moderate content
R3 = High content

iv. Wood

Wood remains, especially if they are large and resistant, may conceivably cause a certain amount of difficulty during the exploitation of a bog. An attempt is therefore made when sampling to assess the extent of wood. It is estimated on a scale ranging from 0 to 3 as detailed below.

Wood remains (W)

W0= Nil
Wl = Low content
W2 = Moderate content
W3 = High content

Extensive wood remains of a type that might prove a serious obstacle to exploitation are not frequent but bogs with this feature have been surveyed in Sutherland and Aberdeenshire.
In Blanket Bogs, impenetrable wood is found mainly in sheltered valleys; in Raised Basin Bogs it tends to occur at the margins of the deposits.

v. Other *observations*

When peat is freshly sampled and before it darkens by oxidation, note is taken of its colour, stratification, the presence of visible mineral matter and any other features of interest.

Section 4 - OFFICE AND LABORATORY WORK

a) not included

b) Calculation of the volume of raw peat

This calculation is based on the area of deep peat and the average depth in that area. If the bog is divided into sub-areas, the volume of peat in each sub-area is calculated separately. The accuracy of the calculation depends largely upon the accuracy of the calculation depends largely upon the accuracy of the calculated average depth. In this connection the Scottish Statistical Office has carried out Standard Error calculations on the depth measurements for some bogs and, for example, in the Moss of Cree, Wigtownshire survey, found the S.E. to be ± 0.0971. There is a high degree of probability that the true average depth lies within the limits: calculated average depth plus or minus twice the S.E. In this case therefore the true average depth is probably within the range 10.64-11.92 ft. (3.246- 3.634 m.) and the true volume of peat will lie between 17.8 and 19.9 million cu. yd. (13.6-15.2 million cu. m.). (Survey results indicate an average depth of 11.3 ft. (3.44 m.) and a volume of 18.8 million cu. yd. (14.4 million cu. m.)).

The calculation of the exact volume of peat is not the most important task in a bog survey. It must be established which part or parts of a deposit may be most economically developed and for what purposes. The data should also indicate which of the several possible methods would be the choice in particular circumstances. It should also be noted that, although the total amount of peat present in a bog may be fairly accurately estimated, it is usually the case that not all this material could be exploited because of various factors, the most important of which is the variation in depth due to changes in level of the bog floor. In practice not more than approximately 70 per cent of the total volume could be utilised in the majority of deposits.

An example of data from one of the surveys is given in Table 3.

Sub-area	Area of deep peat (over 20 in. (0.5m)		Average depth		Volume of raw peat	Solids	
	acres	hectares	Feet	meter	Millions of cubic metres	Percent	Millions of tons
I	2,342	948	13.5	4.1	37.38	8.1	3.03
IA	215	87	9.8	3.0	3.15	7.2	0.23
II	917	371	9.2	2.8	10.21	9.3	0.95
III	1,275	516	7.5	2.3	14.69	8.7	1.28
IV	1,883	762	8.2	2.5	16.45	9.3	1.58
total	6,632	2,684	-	-	81.86	-	7.07

(1 cu. m = 1.308 cu. yd)

c) Moisture and solids contents

Earlier surveys of many Scottish bogs by the International Survey Company, a British Company which worked in conjunction with Peco Ltd., were not sufficiently detailed to allow an accurate estimation of the moisture content to be made. The current series of surveys has shown that these early estimates of moisture content tended to be rather low.

The estimation of moisture content entails considerable work which must be done within a short time of the samples being collected in order to avoid error by evaporation and mechanical loss. The number of samples to be taken is a matter of judgment, bearing in mind the degree of accuracy required, the time available for field work and the capacity of the laboratory. No rigid routine is followed.

d) Bulk density

The bulk density of the peat solids, including ash, is determined in the laboratory as follows:-

i. the sample is completely dried and ground to pass a 1 mm. screen.
ii. the ground sample is put into a graduated container and exposed to a standard number of controlled taps on a tapping machine.
iii. the volume after compaction is noted and, related to the weight, gives the bulk density in g. per cc.

A certain degree of correlation can sometimes be demonstrated between the degree of humification, the bulk density and the calorific value but comparisons are subject to the probable error introduced by the subjective estimation of the degree of humification.

e) Ash content

The content of ash in peat is an extremely variable factor and is in no sense diagnostic.
It is useful to know the ash content of any particular peat in that it may have some bearing on the suggested utilisation of the bog but it can be so greatly affected by numerous outside agencies that its value as a factor in classification is virtually nil. For example, coastal bogs exposed to on-shore winds tend to be high in ash due to the long-continued deposition of wind-borne sand and spray; valley bogs also tend to have high ash contents because of the continual inflow of ron-off from the surrounding slopes carrying mineral particles eroded from these slopes. Peat areas subject to flooding are frequently grossly contaminated with mineral matter deposited by flood water, often in distinct strata visible to the eye.

f) Fibre content

Large samples are taken for laboratory estimation of fibre content, each being a mixture of peat from all levels of one bore hole. Each sample is washed through sieves to remove the finely divided material and the fibrous residues are dried and weighed. The results are expressed as a percentage of the total solids content which is separately estimated on another similar sample.
The data shown in Table 4 are collected from a number of bog reports.

Table 4 – Fibre content

Name of deposit and location	Classification of bog peat	Fibre (per cent of total solids)		
		Fine	Coarse	Total
Achaim, Caithness	Blanket	7.3	8.6	15.9
Altnabreac, Caithness	Blanket	11.75	2.6	14.35
Kame, Shetland	Blanket	4.5	12.2	16.7
Garror, Perthshire	Raised Basin	3.7	12.9	16.6
Mindork, Wigtownshire	Raised Basin	4.9	13.2	18.1
Cranley, Lanarkshire	Raised Basin	5.9	8.8	14.7

It should be mentioned that the fibre content varies considerably from place to place even within one bog area. The data obtained are, therefore, only a guide to the amount of fibre present.

Section 5 ASSESSMENT OF DATA

a) drainage

All data relevant to the drainage possibilities of a bog are collected during the survey and include information on water levels, outfalls, catchment areas and any deep basins or "pockets" in the floor of the bog which might pose special problems in the drainage of the bottom should the peat be removed.
Existing ditches are examined and are mapped if in reasonable condition and capable of future use. Non-functioning ditches are noted but not recorded in detail.
Tentative drainage schemes suggested for a particular bog usually include a layout of at least the main ditches for the bog itself and an assessment of the work that would be required to carry run-off to the nearest convenient outlet.

Reference Number 169 : The extent of windfarm infrastructures on recognised European blanket bogs. Guaduneth Chico, T. Clewer, N. G. Midgley, P. Gallego-Anex, P. Ramil-Rego, J. Ferreiro, E. Whayman, S. Goeckeritz & T. Stanton. Scientific Reports | (2023) 13:3919 | https://doi.org/10.1038/s41598-023-30752-3

Peatland environments are the Earth's largest terrestrial carbon store and have the potential to act as carbon sinks. However, the development of windfarms on peatlands is affecting their morphology, hydrology, ground-level climate conditions, carbon functions and vegetation, and long-term consequences still need to be assessed. Blanket bogs are a rare type of ombrotrophic peatland that are typical of oceanic areas with high precipitation and low temperatures. Their distribution has been mapped across Europe, where they are mainly located on hill summits where wind energy potential is higher, making them attractive sites for windfarm developments. The promotion of renewable energy is currently a priority given the environmental and economic drive to increase low-carbon energy production. Establishing windfarms on peatland in pursuit of greener energy, therefore, risks compromising and undermining the green-energy transition. Despite this, the extent of windfarm infrastructures on blanket bogs have not yet been reported at the European scale. This research reports the extent of windfarm infrastructures on recognised blanket bogs, with a geographical focus on Europe, where blanket bogs have been mapped systematically. Under the EU Habitats Directive (92/43/EEC), there are 36 European regions NUTS level 2 with recognised blanket bogs. Of these, 12 have windfarm developments, including 644 wind turbines, 253.4 km of vehicular access tracks and an affected area of 207.6 ha, mainly in Ireland and Scotland where the extent of blanket bogs is also higher. However, despite Spain having under 0.2% of Europe's recognised blanket bogs area, this was the most affected country. In Scotland, a comparison of the recognised blanket bogs under the Habitats Directive (92/43/EEC) with blanket bogs recorded in national inventories indicates that the extent of windfarm developments was higher, with 1,063 wind turbines and 634.5 km of vehicular access tracks. Our results highlight the extent of windfarm developments on blanket bog habitat, both in areas where peatlands are broadly distributed across the landscape, and also in areas where this recognised habitat is particularly rare. There is a pressing need to assess the longterm impacts of windfarms on peatlands to ensure that efforts to meet energy targets result only in carbon sequestration, and do not jeopardise ecosystem services. Blanket bogs represent a particularly vulnerable habitat, the study of which should be prioritised updating national and international inventories to protect and restore this habitat.

Peatland environments are recognised as a potential carbon sink when in either restored or pristine condition.

This terrestrial habitat only covers 2.84% of Earth's land surface, but they represent over 25% of the total terrestrial carbon.

In Europe, only 5.2% of the land is covered by peatlands, where Nordic countries concentred most of this habitat.

There are several peatland classifications based on environmental factors, such as climate, geomorphology and vegetation; however, there is not a single factor classification system.

The hierarchical classification provides a method to study peatlands in relation to the scale of analysis with specific criterion for each level of analysis (e.g. nanotope, microtope, mesotope, macrotope and supertope). This enables the combination of vegetation, landforms, and hydrology to provide a better understanding of the relationships within peatlands environments.

There are two types of bogs based on the water sources and their topographical location; blanket bog and raised bog. The main geomorphological difference is whether they are covering the topography as a located in valleys or around water courses.

Blanket bogs are a rare ombrotrophic (rain-fed) type of peatland commonly found in hyperoceanic conditions with high precipitation (> 1000 mm yr-1), low temperature (< 15 °C) and low seasonal temperature variability; although some exceptions are found in areas with lower precipitation (e.g. The Falkland Islands) highlighting the need of a global classification approach for this habitat. Globally, it has been estimated that blanket bogs cover around 10 million ha mainly in the Northern Hemisphere.

In Europe, the most important and extensive blanket bogs are found in the British Isles with some occurrence in Norway, France, Austria, Sweden, Spain and Portugal (Azores Islands). Blanket bogs usually cover large extensions of the landscape, although they could be covering small areas in certain locations, mainly because of topographical limitations (e.g. high slope). Peat depth can vary from a few centimetres to several metres depending on the climatic conditions and topography.

Notwithstanding the extensive peatland restoration projects (e.g. LIFE programme) and their positive implications for peatland ecosystem services, a large proportion of these blanket bogs are currently in an unfavourable condition.

Blanket bogs with favourable status are only found in France, Sweden and Portugal, where they represent less than 2% of the total extent of recognised blanket bogs across the EU and the UK.

Pressures such as peat extraction for fuel and horticulture, forestry, overgrazing, drainage, burning for recreational activities and anthropogenic infrastructures, have affected the stability of blanket bog habitats for centuries. Current threats frequently included in Habitat Directive conservation status reports for blanket bogs are variable across Europe (Table 1), although agriculture, drainage, and intensive grazing are the most common issues. However, morerecently, windfarm developments, have been highlighted as a concerning pressure for this habitat having impacts on peatland hydrology, ground-level climatic conditions and habitat biodiversity, contributing to vegetation changes and habitat transition. This pressure not only affects the areas where turbines are installed, but also where associated infrastructures, such as tracks, sub-stations and associated facilities are built. Windfarm infrastructures have an impact on the peatland surface affecting the hydrological units, as well as promoting vegetation changes and habitat loss.

The Directive EU 2018/2001 on the promotion of the use of energy from renewable resources aims to promote the use of renewable energy across the EU27 based on Article 194 of the Treaty on Functioning of the European Union, requiring member states to promote energy efficiency and saving. By 2030, at least the 32% of the energy consumed across the EU should be renewable. In 2020, 36% of the EU renewable energy was produced by windfarms, demonstrating the importance of this technology in reducing our carbon emissions. Although the need to expand international renewable energy capacities is clear, it is important that the pursuit of legislative energy requirements and targets does not compromise the aims of alternative environmental legislation. Therefore, a legislative conflict exists between the Habitats Directive and Renewable Energy Directive that must be acknowledged and addressed. Both directives aim to reduce carbon emissions by restoring carbon sinks and promoting renewable energy transitions and, though windfarm development is permitted on Natura 2000 sites or recognised blanket bogs under the Habitats Directive, if they negatively affect the integrity of the site and the impacts cannot be mitigated by additional measures, authorisation for the development should not be granted.Noting the lack of understanding regarding the long-term impacts on the peatland carbon sink function and the fact that windfarms installed on non-degraded peatland would not result in a net long-term carbon benefit, windfarm developments need to be carefully assessed.

Country		Wind and Energy	Intensive grazing	Agriculture	Peat extraction/ cutting	Invasive species	Forestry	Drainage	Abiotic processes	Tourism / Sport/ Recreation	Infrastructure/ Mining	Air pollution	Climate Change	Burning	Management of game	Other
Spain	Pressure	M	M	M	H	M								M		
	Threat	M	M	M	H			M					M	M		
Republic of Ireland	Pressure	M	H	H	H		H	M	M					H		
	Threat	M	H	H	H		H	M	M				M	H		
United Kingdom	Pressure	M	H		M	M		H				H	M	H	H	M
	Threat	M	H		M	M		H				H	M	H	H	M
Portugal	Pressure		H	H			H	H	M	M						M
	Threat		H	H			H	H	M	M						M
France	Pressure															M
	Threat			M				M	M			H	H			
Austria	Pressure		H					M		M		M	M			
	Threat		H					M		M		M	M			

Table 1. Pressures and threats on recognised blanket bogs across the EU and UK according to the last habitat assessments. Sweden has not reported this information in their last habitat assessment. H = High, M = Medium.

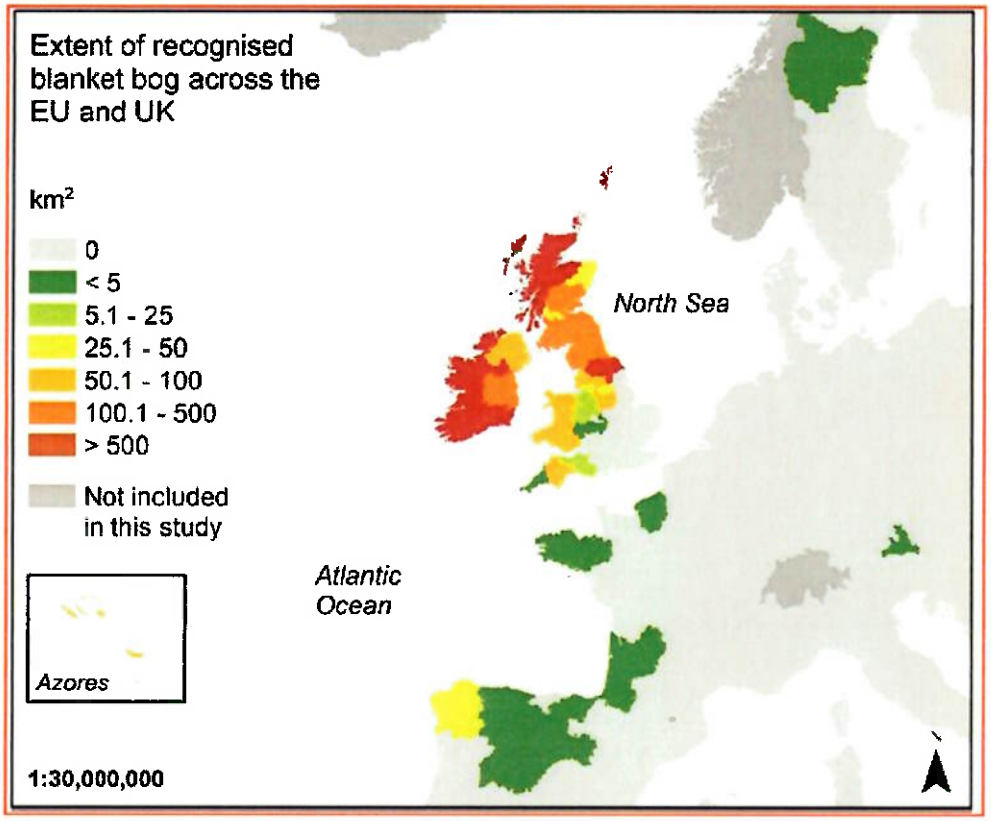
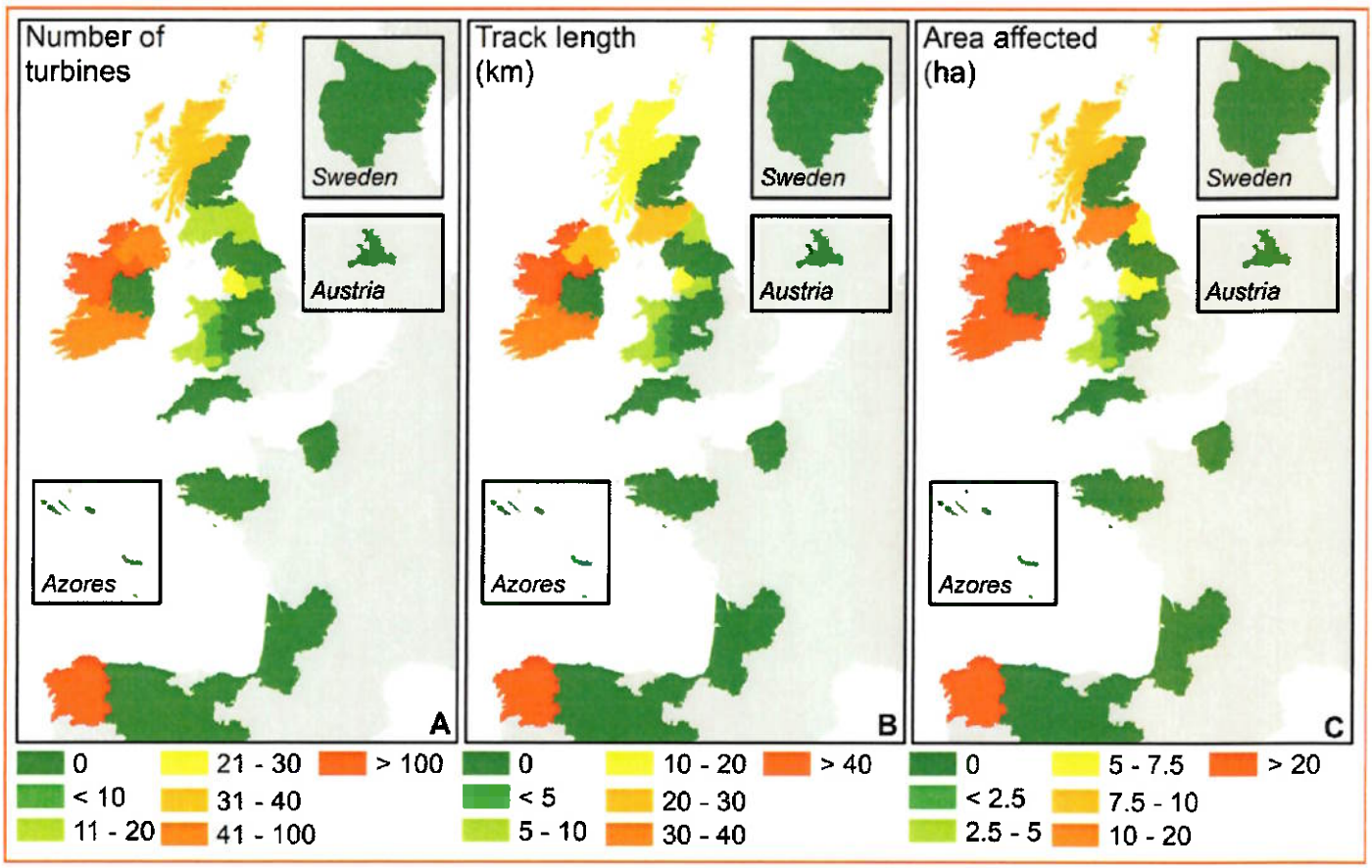
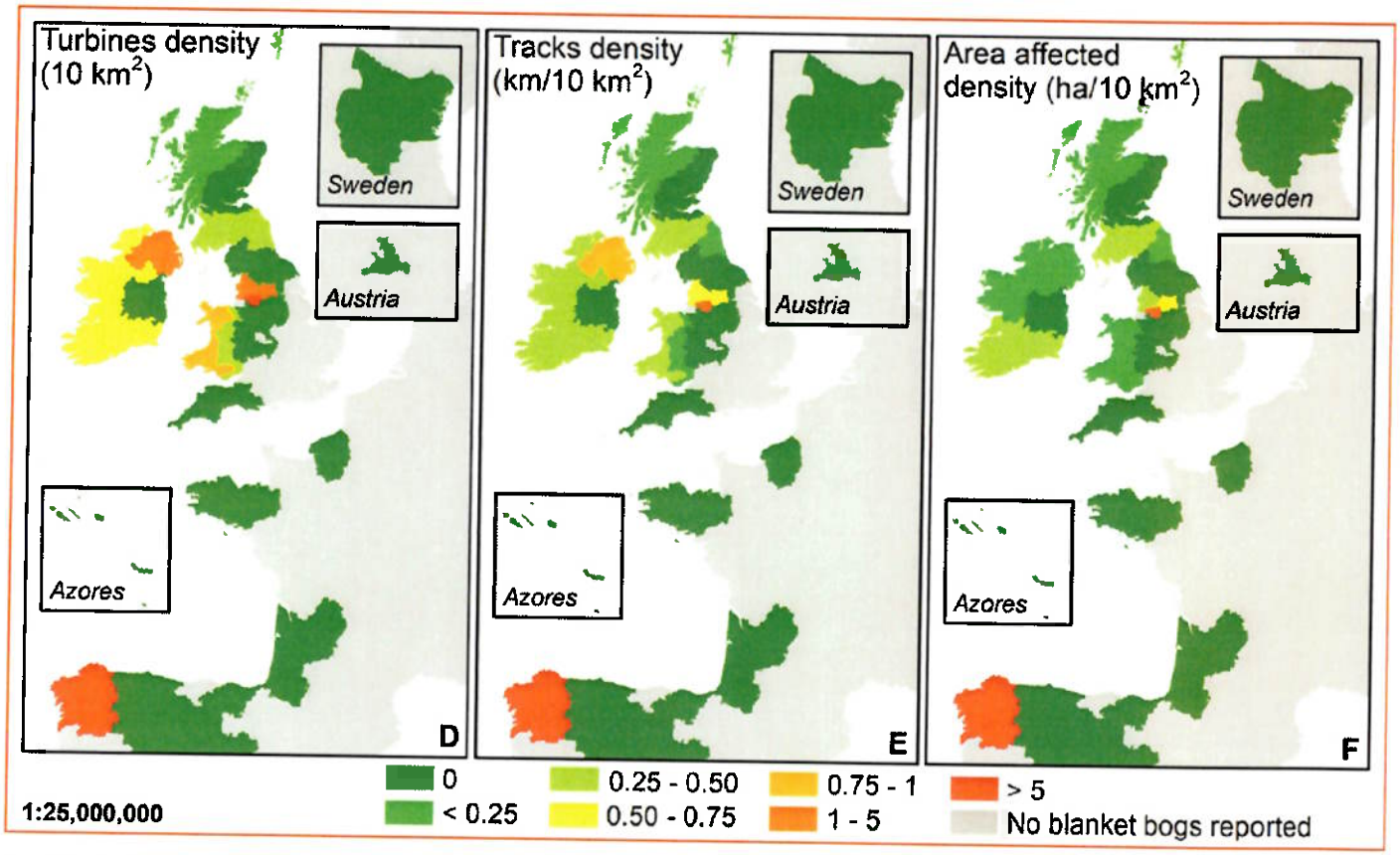


Figure 1. Total extent of the recognised blanket bog by European regions NUTS level 2 based on the Habitats Directive (92/43/EEC) including the last update from the UK before Brexit. Map created in ArcGIS 10.8.1.





the 2013–2018 conservation status report prior to Brexit by European regions NUTS level 232. *Note: Boundaries of the regions have not been added to improve legibility. The political geographical regions do not represent the extent of blanket bogs.* (**A**) Total turbines on blanket bog habitat 7130. (**B**) Tracks length on blanket bog habitat 7130. (**C**) Total area affected by windfarm developments on blanket bog habitat 7130. (**D**) Density of turbines per 10 km2 of blanket bog habitat 7130 by European regions. (**E**) Density of tracks per 10 km2 of blanket bog habitat 7130 by European regions. (**F**) Density of area affected by windfarm developments per 10 km2 of blanket bog habitat 7130 by European regions. *Datasets for blanket bog habitat 7130*: Austria, Portugal, Sweden and France, Scotland; England; Wales; Republic of Ireland and Spain.

Dataset for peatlands (only priority habitat): Northern Ireland. The location of mapped regions in the Azores, Austria, Sweden, and the full extent in Spain is shown in Fig. A (Supplementary materials). Map created in ArcGIS 10.8.1.

Country	Recognised as blanket bog habitat 7130			Recognised as blanket bog habitat 7130 and protected under Natura 2000 network		
	Turbines	Track length (km)	Track area (ha)	Turbines	Track length (km)	Track area (ha)
Spain	252	70.7	46.3	233	65.9	43.7
Republic of Ireland	186	92.2	82.9	24	12.1	9.3
England	72	36.4	28.1	0	0	0
Wales	24	7.8	5.4	0	0.07	0.06
Scotland	55	26.6	25.5	0	1.4	0.9
Northern Ireland	430	203.2	213.9	0	0	0

Table 2. *Windfarm developments on recognised blanket bog habitat 7130 compared with recognised blanket bog habitat within a Natura 2000 site. No relationship between the extent of recognised blanket bog and number of turbines ($p = 0.30$), length of tracks ($p = 0.40$) and total affected area ($p = 0.46$) was found. of Ireland (including Republic of Ireland and Northern Ireland) represents one of the most extensive hotspots for the conflict between windfarm developments and recognised blanket bog habitat. Within the island of Ireland, the northwest (Co. Donegal) is the most affected by windfarm developments by total extent (Fig. 3A–C). When assessing densities (Fig. 3D–F), this area concentrates a high proportion of the total extent of the island's recognised blanket bogs (> 20%) meaning a lower density of windfarm infrastructures. Similar conclusions can be drawn in some areas of the east of the Republic*

of Ireland (Co. Kerry and Co. Mayo) and southwest of Northern Ireland (Co. Fermanagh and Omagh; Fig. 3). Together, these locations represent almost 60% of Ireland's recognised blanket bogs. Beyond these four areas, blanket bogs in central Ireland (Co. Roscommon) had a particularly high density of windfarm infrastructures (Fig. 3D–F). Despite the small extent of recognised blanket bogs across Co. Roscommon (8.5 km2), extensive windfarm infrastructure has been developed across blanket bog in the county.

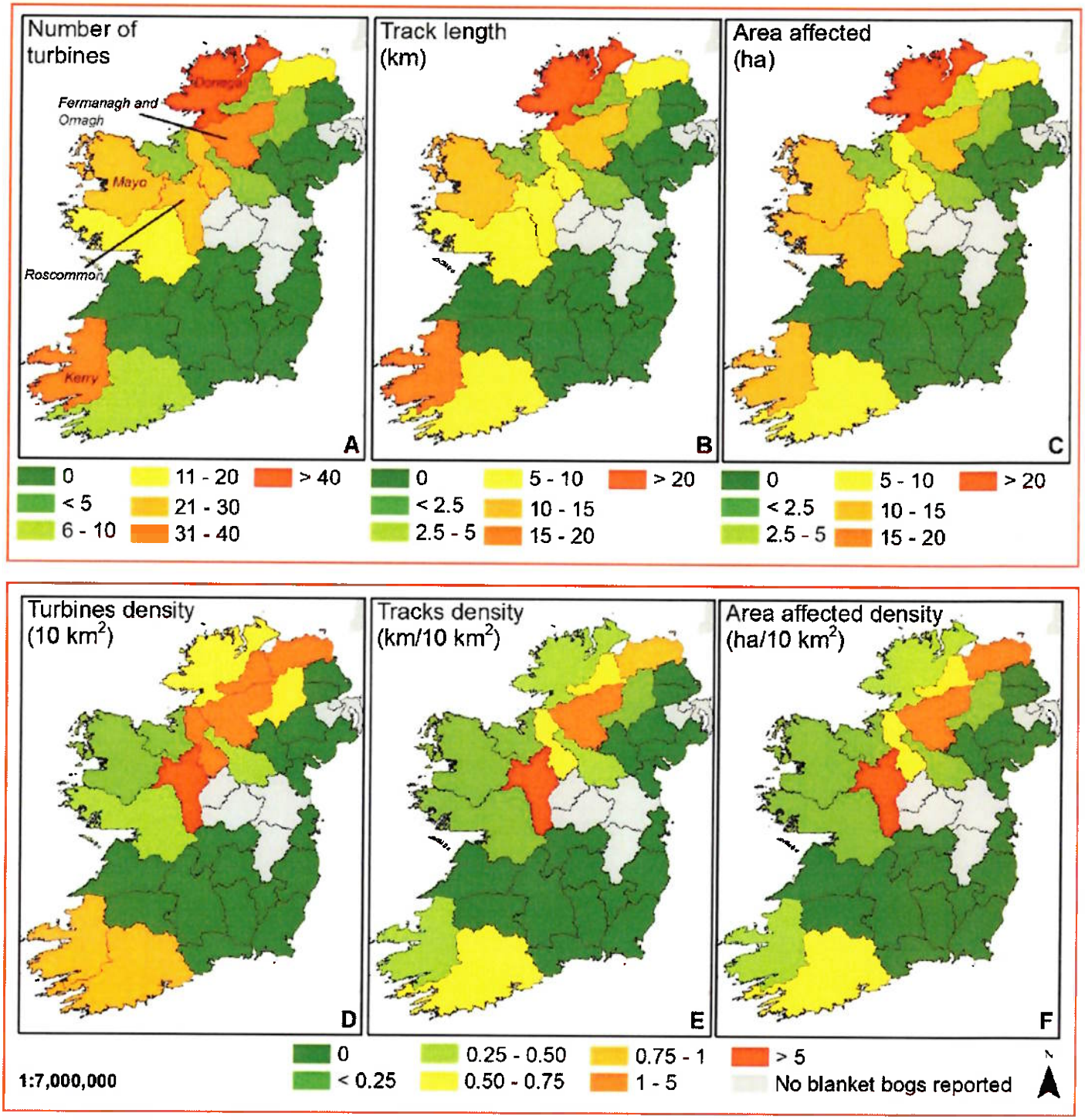


Figure 3. The extent of windfarm developments across the island of Ireland on blanket bog habitat 7130 at county level for the Republic of Ireland and intact or pool complex after blanket bog visual assessment for peatlands on Northern Ireland. (**A**) Total turbines on blanket bog habitat by county. (**B**) Tracks length on blanket bog habitat by county. (**C**) Total area affected by wind farm developments on blanket bog habitat by county. (**D**) Density of turbines by 10 km2 of blanket bog habitat by county. (**E**) Density of tracks by 10 km2 of blanket bog by county. (**F**) Density of area affected by wind farm developments by 10 km2 of blanket bog habitat by county. *Dataset for blanket bog habitat 7130*: Ireland. *Dataset for peatlands*: Northern Ireland. Map created in ArcGIS 10.8.1.

In Scotland, the pressure of windfarm developments on blanket bogs is also evident, where the Scottish Planning Policy considers classes 1 and 2 as areas of significant protection; although, windfarm developments may be possible under some circumstances as is permitted under the Habitats Directive across the EU29. However, to assess the impacts of windfarms on peatlands in a consistent way and evaluate the environmental impact of potential new developments on carbon-rich soils, a carbon calculator has been developed by the Scottish Government. The carbon calculator allows users to estimate the carbon savings of windfarms installed on peatlands, although they highlight the importance of long-term management in relation to the final net carbon calculation. Nonetheless, installing windfarms on non-degraded peatlands has been reported as unlikely to reduce carbon emissions even when the management has been considered carefully and it should be avoided. Therefore, peatlands under classes 1 and 2 considered by the Scottish government as a priority should be excluded from any windfarm developments (currently representing over 16% of onshore turbines. Table 3); especially considering the current policy of increasing onshore windfarms in Scotland.

Long-term research is needed to fully assess the impacts before new windfarm developments are installed.

Country	Total number of turbines	Turbines on blanket bog	% of turbines on blanket bog
Spain	21,574[51]	252	1.2
Republic of Ireland	1896**[47]	186	9.8
England	2138*[52]	72	3.4
Wales	1177*[52]	24	2
Scotland	6322*[52]	55 (protected)	0.9
		1,063 (Class 1 & 2)	16.8
Northern Ireland	1950*[52]	54 (only intact blanket bogs)	2.8
		430 (all priority peatlands)	22.1

Table 3. Total % of turbines on blanket bog (recognised/national inventories) in relation with the total turbines installed by country. *Include wind turbines consented, operational and under construction. **Include proposed, constructed and under construction.

In this novel research, the extent of windfarm developments across all recognised European blanket bogs under the Habitats Directive have been assessed. Large extents of blanket bogs have already been damaged, concentrated in the edge-of-range of this habitat and directly affecting hundreds of hectares of blanket bog across the rest of Europe. The full potential long-term damage to the habitat functionality is still unclear, but scientific evidence supports the negative impacts of windfarm developments on this critical habitat. European blanket bogs need further scientific evidence to demonstrate the real benefit of incentivising the reduction of carbon emissions by installing onshore windfarm infrastructures on peatlands which are causing the degradation of the most important long-term natural carbon sink and storage ecosystems. A strategic restoration plan and appropriate relevant legislation would be beneficial to promote the safeguarding of blanket bogs in the UK after Brexit. An urgent revision and compliance of the legislation regarding the protection of blanket bogs needs to be implemented, especially under the current trend of promotion and increasing legislation on renewable energy to reduce carbon emissions. An improvement of the national inventories across the EU and UK protected area networks is critical to implement the recognition, protection, and restoration of this habitat, in order to guarantee its favourable conservation status and its function as a long-term carbon sink to mitigate climate change.

16 Major Accidents and Natural Disasters

Chapter 16: Major Accidents and Natural Disasters of the EIAR describes the likely significant adverse effects on the environment arising from the vulnerability of the Proposed Project as detailed in Chapter 4 to risks of major accidents and/or natural disasters, as well as the potential of the Proposed Project itself to cause potential major accidents and/or natural disasters.

Major accidents or natural disasters are hazards which have the potential to affect the Proposed Project and consequently have potential impacts on the environment. These include accidents during construction, operation and decommissioning caused by operational failure and/or natural hazards. The assessment of the risk of major accidents and/or disasters considers all factors defined in the EIA Directive that have been considered in this EIAR, i.e., population and human health, biodiversity, land, soils (peat stability), water, air quality, climate, material assets, cultural heritage and the landscape.

A desk study has been completed to establish the baseline environment for which the proposed risk assessment is being carried out. This will influence both the likelihood and the impact of a major accident or natural disaster. Local and regional context has been established prior to undertaking the risk assessment to development an understanding of the vulnerability and resilience of the area to emergency situations.

Chapter 16 outlines the baseline environment of the site, with due regard to the detail outlined in Chapter 11: Climate relating to the baseline environment and future environment relative to climate change. The climate change risk assessments included in the Offaly Local Authority Climate Action Plan (LACAP)8 detail the major risks posed from climate change to the county as being river flooding, pluvial flooding, severe windstorms, heatwaves, and drought. As outlined in Chapter 11 and Chapter 16, Ireland is experiencing and will continue to experience climate change in line with global trends, with current projections indicating that these effects will intensify in the coming decades. The design of the Proposed Project has considered the potential climate change effects under both the baseline and future environment, and it is considered that the Proposed Project will not be negatively impacted by climate change, nor will it have a negative impact on climate change over its 35-year design horizon.

A wind farm is not a recognised source of pollution. It is not subject to Industrial Emissions Directive regulation or any other Environmental Protection Agency (EPA) environmental regulatory consent. Should a major accident or natural disaster occur, the potential sources of pollution onsite during the construction, operational and decommissioning phases of this type of development are limited and of low environmental risk. Sources of pollution with the potential to cause significant environmental pollution and associated negative effects such as bulk storage of hydrocarbons or chemicals, storage of wastes, management of flammable materials, etc., are limited and so there is an inherent low level of environmental risk associated with major accident or natural disaster impacting the Proposed Project and causing environmental damage.

The scenarios with the highest risk score in terms of the occurrence of major accident and/or disaster during construction, operation and decommissioning, were identified as identified as 'Fire/Explosion' and 'Contamination'. In addition, the next highest score was for 'Adverse Weather Conditions', 'Flooding', and 'Major Road Traffic Incident' during construction, operation, and decommissioning.

The Proposed Project has been designed and built in accordance with the best practice measures set out in this EIAR and, as such, mitigation against the risk of major accidents and/or disasters is embedded through the design.

8 Offaly County Council, 2023. Climate Change Risk Assessment. Available at: https://www.offaly.ie/app/uploads/KPMG_OffalyCoCo_LACAP_Final-Report_20230202-1.pdf

The risk of a major accident and/or disaster during the construction of the Proposed Development is considered 'low' in accordance with the 'Guide to Risk Assessment in Major Emergency Management' (DoEHLG, 2010).

It is considered that when the mitigation and monitoring measures outlined in the CEMP (Appendix 4-4) are implemented and adhered to there will be no significant residual effect(s) associated with the construction, operation and decommissioning of the Proposed Project.

17 **Interaction of the Foregoing**

Chapter 17 of this EIAR identifies the interactions of the potential significant environmental effects that may occur in terms of Population and Human Health, Biodiversity, Birds, Land, Soils and Geology, Water, Air Quality, Climate, Noise and Vibration, Cultural Heritage, Landscape and Visual, Material Assets and Major Accidents and Natural Disasters, as a result of the Proposed Project. All potential significant effects of the Proposed Project and the measures proposed to mitigate them have been identified in the preceding EIAR Chapters. However, for any development with the potential for significant environmental effects there is also the potential for interaction between these potential significant effects. The result of interactive effects may exacerbate the magnitude of the effects or ameliorate them or have a neutral effect. A matrix is presented in Chapter 17 of the EIAR to identify interactions between the various aspects of the environment already discussed in the EIAR. The matrix highlights the occurrence of potential positive or negative impacts during the construction, operational and decommissioning phases of the Proposed Project.

Where any potential interactive impacts have been identified, appropriate mitigation is included in the relevant sections (Chapters 5—16) of the EIAR. The implementation of these mitigation measures will reduce or remove the potential for effects. Information on potential residual effects and the significance of effects is also presented in each relevant chapter. On this basis the effects arising from the identified interactions are Not Significant, with the exception of 1 no. location (VP11) resulting in a Significant interaction between Population and Human Health and Landscape and Visual.

18 Schedule of Mitigation and Monitoring Proposals

Chapter 18: Schedule of Mitigation and Monitoring Proposals provides an easy-to-audit list of all mitigation and monitoring measures relating to the pre-commencement, construction, operational and decommissioning phases of the Proposed Project as set out in the relevant chapters of the EIAR.

All mitigation which will be implemented during the various phases of the Proposed Project are presented in Table 18-1. All monitoring measures which will be implemented during the pre-commencement, construction, operational and decommissioning phases of the Proposed Project are outlined in Table 18-2.

The tabular format in which the information is presented can be further expanded upon during each Proposed Project phase to provide a reporting template for site compliance audits.

The proposals for site inspections and environmental audits are set out in the Construction and Environmental Management Plan (CEMP) which is included as Appendix 4-4 of the EIAR. It is intended that the CEMP will be updated where required prior to the commencement of construction to include all mitigation and monitoring measures, planning conditions and/or alternative monitoring and mitigation measures should they emerge during the course of the planning process and would be submitted to the Planning Authority for written approval prior to the commencement of development

Appendix No 1; Mike Stigwood response in relation to 2019 Draft WEG.

MAS
ENVIRONMENTAL

Ireland's Draft

Wind Energy Development Guidelines 2019

Review of guidelines by

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19th February 2020

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Appendix A - Institute of Acoustics article on noise

1.0 Executive Summary

1.1 MAS Environmental have exceptional expertise in relation to wind farm noise effects on residential neighbours and draw upon 45 years experience as well as its considerable background in research. MAS have been fundamental in identifying noise issues and how to evaluate them and provide wholly independent analysis of the draft guidelines.

1.2 Observations are based on our considerable experience and extensive wind farm noise database that is unrivalled in the information it provides.

1.3 Intended principles of tighter controls and addressing some AM character as well as low frequency noise is supported but the methods and wording adopted result in the guidelines permitting substantially more noise and undermine any enforcement of controls due to extensive ambiguity and misdirection of statements.

1.4 The approach adopted does not follow the science of acoustics, permits higher noise during periods of adverse impact due to long term averaging and applies insignificant penalties. I understand similar inappropriate averaging was recently considered in the case of *Lies Craeynest and others v Brussels Hoofdstedelijk Gewest and Others 2019* in an opinion of Advocate General Kokott.[1] At around paragraph 85 it was stated:

> *"There is a risk of adverse effects on health wherever the limit values are exceeded. Appropriate measures must be taken there in order to prevent adverse effects. It is only of limited importance to that risk whether an exceedance applies to the entire zone or agglomeration on average. This is clearly illustrated by the joke about the statistician who drowns in a lake even though it averages only a few centimetres in depth."*

1.5 Notwithstanding the averaging problem, procedures proposed to be adopted have been shown using our extensive database to fail to recognise the main forms of amplitude modulation experienced and that proposed for low frequency

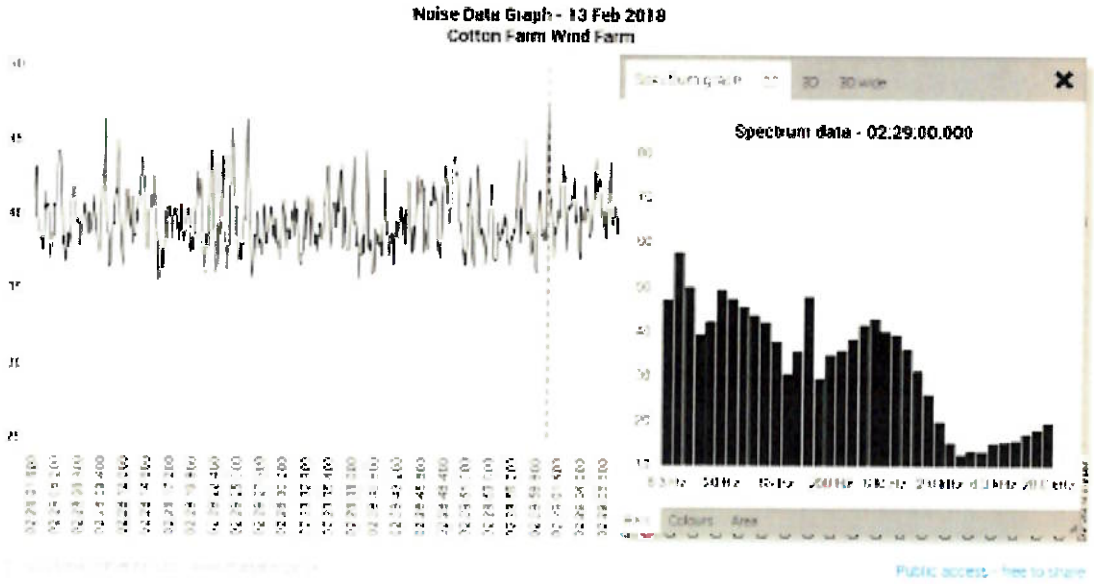
[1] http://curia.europa.eu/juris/document/document.jsf;jsessionid=CC659AAC994F94CDA0EA7FC24F86309F?text=&docid=211190&pageIndex=0&doclang=EN&mode=req&dir=&occ=first&part=1&cid=6525478

noise can only be used post development inside dwellings. This contradicts the objective of using external measurements only and reliance on prediction that is incapable of identifying this problem.

1.6 At the link directly below the noise shown and audible using good quality headphones attracts a penalty but is still compliant with the guidance as the penalty is small. This is before the period with the penalty is averaged with those periods when the noise impact does not arise and no penalty is applied. In reality even with the noise demonstrated in the graph and which can be listened to using the link, substantial margin remains through averaging. The spectrum graph on the right shows a significant low frequency peak at the point of an AM peak. This is common.

1.7 https://www.masenv.co.uk/webgraphs/cotton_farm_180213

On-line graph shows a level of AM wind farm noise compliant with proposed guidelines occurring 02:28 at night. Compliance arises when considered in isolation and before long term averaging



1.8 A substantial number of wind farms in Ireland cause widespread community complaints. The planning controls recommended in the WEDG do not address these problems and more insidiously would give the appearance of addressing noise issues without resolving the nuisance caused. The controls do not

correlate with protection of living standards or residential amenity. A different approach is required.

1.9 There are some positive points in the draft guidelines but ambiguity within terminology and phraseology permitting multiple interpretations is a major problem and is avoidable. Methods of control are employed which operate contrary to the science of acoustics and noise such any minor penalty arising will not change adverse noise into an acceptable level or form of noise. Intrusive characteristics will remain dominant and prominent resulting in inconsequential changes.

1.10 Attempts to reflect the WHO use of Lden exacerbates impact as erroneous adjustment for character is applied. An appearance of protection is given with prolonged investigation and measurement but incapable of preventing impact.

1.11 The procedures permit substantially more noise than other commercial and industrial sources when using BS4142:2014. There is no justification for this especially as wind farm noise can impact 24/7/365.

1.12 Benevolent interpretation of controls is required which ensures the most lenient interpretation would have to be applied regardless of intent. This is avoidable with clearer phrasing of the guidance. It can be concluded the methods of assessment being adopted facilitate the wind farm development to the detriment of all other concerns.

1.13 Good evidence of the extent of problems now exists but has not been drawn upon to evaluate the proposals. Many noise characteristics are ignored including important forms of AM. Further the prosed penalty becomes diluted by averaging in a manner not used in other guidance rendering it entirely insignificant.

1.14 Procedures in BS4142:2014 are entirely applicable and effective for wind farm noise and would place them on "a level playing field" with all other sources of industrial and commercial noise.

1.15 Guidance in England and Wales has moved away from specifying decibel limits due to the failure of such an approach and has not led to difficulties. The decibel level is a minor consideration in the human response to noise in cases where

impact is due to dominance or prominence. In England and Wales each case is assessed on its merits. A framework can readily be formulated that is fair, as found in BS4142 and that would be wholly applicable to wind farm noise mixing sound energy and noise character control requirements.

1.16 There is widespread support for adopting a different approach instead of the recognised flawed ETSU-R-97 approach. There are fundamentally two types of noise and their assessment and control for each differ significantly. Both arise with wind farms but separating their assessment and control is wholly undermined by the draft guidelines. Noise with special character affects people moment by moment and the frequency and duration of adverse incidents needs to be addressed. This is not addressed through long term averaging when incidents of impact are lost through averaging. Long term averaging can apply and assist with benign steady wind farm noise but not the moment by moment characteristics which impact due to their dominance and prominence at the time.

1.17 Wind noise has significantly different spectrum content to turbine noise as experienced at residential receptors. Even when of a similar level wind does not mask turbine noise. The exceedance permitted indicates it can always be dominant and prominent and comply. Furthermore, when moving inside dwellings the difference in spectrum means the wind noise is differentially reduced far more resulting in increased dominance by turbine noise inside. What is required is to ensure periods of significant adverse impact rarely occurs as it is masked.

1.18 Additional key findings include:

a) Most wind farms causing noise nuisance appear as compliant with the planning guidance now proposed.

b) Ambiguity in any guidelines serve to compound issues over their interpretation. There could be compliance despite serious adverse impact upon local communities.

c) There are repeated cases that arise where data shows serious intrusion, but assessment of planning guidance leads to arguments of compliance.

Adoption of these procedures as part of the Irish guidelines can only be likely to produce the same conflicts and contradictions.

d) The MAS website includes a case accepted as causing nuisance but which complies with the proposed Irish guidelines as benevolently interpreted.

e) The wording of the document introduces considerable ambiguity and this permits application of the most lenient interpretation following the need to meet criminal standards of proof. These problems and contradictions can readily be addressed.

f) Long term averaging of what already is the average level, using the LA90 index (the wind farm's quietest 10%) is being adopted in these draft guidelines. This is contrary to commercial noise guidance equally applicable such as contained within BS4142: 2014.

g) Adverse impact from wind farms most commonly occurs when background sound levels are lowest and worst case AM, thumping and other characteristics such as low frequency effects are greatest. This is lost through averaging.

h) Long term averages are useful in terms of benign sources of continuous noise occurring 24/7/365 that lack significant attention drawing character. Noise which draws attention due to its character and also non-acoustic elements is unsuitable for assessment using such methods.

i) Adjusting such long term average limits to reflect special character in the noise with an average penalty is fundamentally flawed as it needs to relate to its dominance and prominence moment by moment. It can be described as a "smoke and mirrors" procedure that does not address the problems.

j) No support for the procedures adjusting the noise controls adopted in these draft guidelines are found in the WHO European Guidelines 2018. Instead they provide significant warnings.

1.19 Low frequency noise has been shown as a major and common problem with modern wind farms but this appears denied in the draft guidelines. We have routinely measured low frequency noise problems at wind farms in Ireland and

the UK. Procedures to address this are not adequately formulated in the draft guidelines and mislead.

1.20 Reference is made to the Defra curve but this is an internal procedure where different time periods of measurement could be applied. There are other methods for low frequency noise not considered. The draft guidance argues against internal measurements. There are various misrepresentations summarised as follows:

1) Internal impact is commonly very different to external impact.

2) Various internal measurement locations can be utilised giving different results so no consistency.

3) Argument arises how external levels relate to internal levels.

4) The Defra method does not consider varying amplitude modulation as a form of low frequency noise nor impulse content.

5) It is impractical to measure its effects pre-development.

6) Alternative external procedures based on detailed research have been developed but are ignored.

1.21 Analysis of background sound levels is misleading. Graphs used falsely show levels barely dropping below 20dB LA90 but this is dictated by the limitations of instruments. A serious problem arises over false indication of higher that actual background sound due to common use of instruments with limitations. This is not addressed in the draft but perpetuated and misleads. At MAS we use special microphones with a noise floor between 6.5-8dBA. We routinely record level externally in rural Ireland as low as 10-12dBA.

1.22 Arguments ETSU-R-97 and therefore the draft guidelines reflect BS4142 is seriously misleading. It is stated in ETSU-R-97 but false. In this document I demonstrate this is wrong in relation to averaging, index used, analysis of background sound applied, the way penalties are applied and their extent and principles of acceptability. Simple comparison reveals the draft guidelines indicate acceptable noise when BS4142 identifies unacceptable noise.

1.23 The draft guidelines wrongly argue changes to ETSU-R-97 reflect development of modern large turbines. The converse is true. They operate to hide the added impact of large turbines.

1.24 For example, there is the adoption of standardised wind speeds rather than wind near the ground that reflects wind masking noise. This means true wind speeds are ignored at any moment in time and a standardised one is substituted. The greatest adverse impact arises under an atmospheric state called "stable atmosphere". This is a common occurrence at night. During these conditions the blades experience high wind speeds at the top of their rotation but at ground level there is extremely little wind due to high wind sheer. In terms of background sound it is quiet.

1.25 Standardised wind speeds assume much higher masking winds at ground level that arise and much higher background sound levels are assumed.

1.26 The outcome is that the worst periods of adverse impact occur with very low masking noise but much higher background sound levels are assumed. Resulting in significant understatement of impact.

1.27 The method of evaluating Amplitude Modulation (AM) proposed has been shown to manifestly fail to reflect or be triggered for two critical forms of AM. No explanation why such a flawed methodology is proposed or recognition that it has been shown to fail. There are various serious flaws:

a) Extensive ambiguity how to apply the procedures permitting a range of outcomes and interpretations.

b) Penalties are applied to the LA90 index general noise but AM is not measured by it and requires separate control. At most it means very slightly lower energy levels are permitted but without any change to the adverse impact.

c) Averaging of the penalties wholly diminishes any adjustment they might apply..

d) Evaluation of correct application is impractical.

e) False positives and more commonly false negatives are common.

f) It does not relate to actual impact during any period other than potentially identifying one form of AM arose. It misses much AM.

1.28 It is questioned why a set of procedures which knowingly miss many forms of adverse character impact and result in minor and irrelevant penalties are proposed. Annual averaging also renders the analysis and adjustments impractical.

1.29 There is reliance on ETSU-R-97 based procedures but Defra wind farm nuisance guidance confirms its lack of usefulness. This is not addressed.

1.30 The procedures underrate or wholly miss the effects of:

a) Erratic and irregular AM

b) Simultaneous occurrence of whistling and whirring in some cases with the AM.

c) Occurrence of low frequency noise with the AM which may or may not also modulate.

d) The effect of very large variations which can be up to 15dBA on a second by second basis.

e) Changes in the character and spectral content of the AM beats on a moment by moment basis such that successive beats exhibit a different pitch or characteristic.

f) Changes in impulsivity of AM beats where some rise more gradually and others have distinct impulse content with sudden change.

g) Directional effects where different forms of AM arise in different directions.

h) The additional underlying roar of general wind farm noise on top of the characteristics identified.

1.31 There is selective reporting of the guidance provided by the WHO 2018 in the draft guidelines. The WHO's precautionary application of an Lden also includes

substantial concerns and caveats regarding noise character that the Lden does not cover or address.

1.31.1 Due to a lack of high-quality evidence, as defined by the WHO, the recommendations on wind turbine noise are conditional and for many of the investigated health effects there was insufficient evidence. However, the WHO has set a recommendation for reducing noise levels from wind turbines below 45dB Lden.[2] It is also noted within the guidelines that below this exposure level there might still be a risk of annoyance. In addition, and of note, the WHO caveats that the descriptors Lden and Lnight may not be appropriate for describing wind turbine noise and this may limit the ability to draw associations between wind turbine noise and health effects.

1.32 The Lden precautionary recommendations cannot differentiate locations such as being adjacent a motorway, within a dock or large industrial complex where there are high levels of masking noise. These do not compare to a remote rural area where there is no mechanical or industrial noise other than the wind farm. The application of the same limits to both is illogical and not intended.

1.33 There is no basis to try to adjust the Lden based on averaging penalties especially when the index is viewed highly precautionary. Such an approach is in scientific terms, perverse. Penalties can apply to short periods of noise impact but not in relation to long term values in this way.

1.34 The WHO lists several characteristics of wind farm noise that may exacerbate impact compared to the sound energy level alone and why the Lden and Lnight descriptors may not be appropriate. This is a case of inappropriateness and not trying to adjust them by minor penalties that are unrelated to the impact at the time. They state:

[2] The Lden is a long term average noise level. It is calculated assuming that there is an equal (or equivalent) level of noise over a whole day. Greater weighting is given to periods where more freedom from noise is expected, evening and night time. It is a descriptor typically used for transportation sources. It can be used to investigate noise dose; however, caution must be exercised when looking at sources such as wind turbine noise where there are specific characteristics to the sound which may cause adverse reaction at lower levels than sources without these characteristics. The Lden cannot describe how the sound environment changes on an hourly, minute by minute or second by second basis.

"Wind turbines can generate infrasound or lower frequencies of sound... The noise emitted from wind turbines has other characteristics, including the repetitive nature of the sound of the rotating blades and atmospheric influence leading to a variability of amplitude modulation, which can be a source of above average annoyance (Shäffer et al 2016). This differentiates it from noise from other sources and has not always been properly characterized. Standard methods of measuring sound, most commonly including A-weighting, may not capture the low frequency sound and amplitude modulation characteristics of wind turbine noise (Council of Canadian Academies, 2015).

1.35 Rather than apply an averaged penalty to an Lden value the WHO caution against use of A weighted values. The WHO guidance reinforces a common theme recurring throughout recent noise guidance and research that context and character play a large part in determining human response to sound. The WHO were unable to determine a separate night time criteria for protecting health from wind farm noise. This seriously undermines the attempted adjustments which are unsupported by WHO advice.

1.36 Adopting the guidelines as written is predicted to lead to continued serious land use conflicts where local residents have abandoned their homes or live in continuous stress with no relationship whatsoever between acceptable noise in the home and the levels permitted by the proposed guidelines.

1.37 Recognition of the lack of utility of decibel based controls has progressively led to the abandonment of planning guidance other than in a minor way in the UK that is based on decibel levels. The findings of the WHO support the serious need for caution. However an effective method is found, with minor adjustments in BS4142:2014 and such an approach is recommended.

1.38 Part 2 of this submission provides extensive research which demonstrates the principles and observations made in this part.

2.0 Expertise of MAS Environmental and background to comments

2.1 MAS Environmental Ltd. (MAS) have unrivalled expertise in wind farm noise impact upon local communities which is combined with its unique work and experience in nuisance investigations. We employ a team of five environmental noise specialists four of whom work extensively in relation to wind farm noise.

2.2 Our main research and publications are found on our website at the link below along with a large number of wind farm noise samples which demonstrate many of the characteristics. The second link connects with more of our work and actual samples of wind farm noise.

https://www.masenv.co.uk/publications

https://www.masenv.co.uk/windfarms

2.3 Much of the work of MAS is focussed in assessment of apparently compliant wind farms but which result in serious and continued community complaints. We consider we are able therefore to provide extensive guidance on the proposed guidance.

2.4 MAS operate internationally and in collaboration with researchers across the world. This includes providing data for other researchers from our extensive database obtained from a community monitoring station which has run continuously for over six years. We are responsible for some of the most exhaustive studies and international papers looking at wind farm noise characteristics which cause extensive problems within homes. s that affect people inside their homes.

2.5 Our work identified amplitude modulation as a common and serious problem through a survey of 18 wind farms 9 years before this was finally admitted by the industry in the UK and similarly spearheaded research showing there were significant low frequency problems.

2.6 At MAS we hold potentially the largest database of wind farm noise in the world which correlates with community complaints and as a result have been able to test different measurement methods for their efficacy. We also have extensive

survey within dwellings which demonstrate real life impacts permitted by planning limits.

2.7 MAS pioneered listening room experiences to better understand industrial wind farm noise and are responsible for exposing the wide range of amplitude modulation forms and how they impact residential neighbours differently.

2.8 Our internationally recognised expertise is supplemented by extensive work on nuisance determination and separately issues with constructing enforceable planning conditions.

2.9 **Independence.** Throughout all our research and work on wind farms MAS Environmental have maintained a complete independent position where all our research is self funded.

2.10 **Support for wind farm development.** MAS strongly support wind farm development and consider this is best achieved through better identification and understanding of any impact in order that these can be appropriately balanced.

2.11 We have been extensively involved in noise issues relating to wind farms since 2004. We highlighted the problems of amplitude modulation and low frequency noise from that time including presenting evidence at Institute of Acoustics meetings from 2009.

2.12 **Industry denial of wind farm noise problems.** Denial of these problems within the UK by wind industry acousticians continued until 2013 when publishing our work internationally at the same time the Japanese released their almost identical findings but with more extensive study marked a turning point. This led to what can best be described as reluctant acceptance albeit seven years on effective controls are still not in place.

2.13 Low frequency noise problems are still denied by many UK acousticians despite my releasing data in 2009, months before the majority of the industry acousticians released a statement stating there are not low frequency noise problems. I understand, many of them maintain resistance to such findings. This arises even though the WHO now recognise this aspect of the problem and

others providing extensive independent study of research confirm the situation[3]. In part 2 of this response I also provide some references of the independent study.

2.14 Denial of AM and low frequency noise problems from wind farms in the UK at the time of ETSU-R-97 and since persists and as a result it is recommended little weight is given to what happens in terms of UK guidance. Independent research such as contained in the Colin Hansen book identified in footnote 1 demonstrates significant criticism of the ETSU-R-97 methods upon which the Irish draft guidelines seek to rely.

2.15 In my experience most nuisance cases being pursued in the UK and Ireland relate to AM and low frequency noise character as well as the general level of noise and all the cases I am aware of are argued as compliant with the UK and Irish planning guidelines. There is now widespread acceptance of serious low frequency noise problems, especially by the WHO. This is discussed further below and in part 2 of these comments.

2.16 **Cotton Farm permanent monitoring station.** In 2013/2014 the MAS team established a permanent monitoring station with the community and have over 6 years of continuous data with probably the most comprehensive database of wind farm noise that is directly correlated to community complaints, in the world. This has enabled us to provide extensive independent research and also test metrics proposed for testing features such as AM.

2.17 Tests show the UK IoA method manifestly fails in many respects and serious concern arises that the Irish guidance is looking at adopting it. Simply put the metric has failed to adequately characterise the noise in every single nuisance case we have looked at since around 2013.

2.18 **Independent Noise Working Group.** MAS were asked to assist and provide research for an independent group reviewing wind farm noise issues in the UK and have been instrumental in relation to significant parts of their work.

[3] See for example the comprehensive study in "Wind Farm Noise : Measurement, Assessment, and Control" 2017 by Colin Hansen. This detailed book provides extensive study by experienced and neutral academics.

2.19 **Work in Ireland in relation to wind farms.** At MAS we have been working on wind farm noise issues in Ireland since 2013.

2.20 **Support for the intention of lowering limits.** The draft guidance appears to present stricter controls compared to 2006 and as a concept MAS support this principle. There is also an indicative intent to control amplitude modulation and low frequency noise. Regretfully due to the way these controls are formulated, experience demonstrates they will make control and restriction farm more difficult and effectively and extensively fail their intended purpose.

3.0 Discussion and principle conclusions of MAS analysis

3.1 It can be concluded a substantial number of wind farms in Ireland cause widespread community complaints. The planning controls recommended in the WEDG do not address these problems and more insidiously would give the appearance of addressing noise issues without resolving the nuisance caused. This includes every case recognised as causing nuisance or where people are complaining that I am aware of, including many where residents have abandoned their homes.

3.2 The extent of noise nuisance permitted by these draft guidelines is readily demonstrated in an example case on the MAS Environmental UK website at the link below:

https://www.masenv.co.uk/windfarms

3.3 As far as we can establish, to date the noise limits proposed show no correlation with protection of communities and the proposed draft guidelines do not have any credible evidence to substantiate their application to control noise nuisance in an Irish context where there is extensive dispersed rural settlement.

3.4 **Need to address core guidance issues.** As a result of the serious and almost universal lack of any correlation between controls and impact upon humans, attempts to address minor technical issues without addressing the core noise nuisance problems serves as a "smoke and mirrors" coverup of the real issues. Whilst increased controls and stricter limits is to be encouraged, without relating them to the factors that actually affect humans discredits and undermines their use.

3.5 **The ability to protect communities and permit wind turbine development** requires a different approach to the problem that cannot be addressed through a technical review of the current draft proposals.

3.6 Whilst there are some positive points arising in relation to the wind farm guidelines, issues of serious professional concern arise. To take two main points:

3.7 **Ambiguity within terminology and phraseology**. This permits multiple interpretations is a major feature. This was present in the 2006 guidelines leading to current abuse. As an example it is argued reference to ETSU-R-97 in the 2006 guidelines meant variations developed to procedures re-interpreting ETSU-R-97 in the UK post 2006 are also applicable to the Irish guidelines. This appears to have been accepted in a large number of cases in Ireland which then introduced the application of long term averaging. This effectively undermined the controls. This long term averaging was contrary to how ETSU-R-97 was written and introduced much later. In the new draft guidelines controls applied could be interpreted in an extremely lenient format which in effect results in no control. This widespread and extensive flaw appears to arise in part through misunderstanding how some of the procedures operate. Thus problems found with the 2006 guidelines over interpretation are repeated in the current draft guidance. It is avoidable and it is questioned why this is not addressed. Ambiguity and multiple interpretations relate both to the main limits and procedures for AM and low frequency noise.

3.8 **Unscientific forms of control.** Methods of control are employed which operate contrary to the science of acoustics and noise. This arises as it adopts a limited decibel penalty adjustment for the effects of character content in the noise. This fails to recognise the important premise that reducing a highly intrusive noise slightly in level but without it then being masked and / or no longer dominant does not address the effects it has on humans. This should be obvious to experienced acousticians.

4.0 Summary review of key issues and proposal.

4.1 It is my expert finding that the draft guidelines adopt a fatally flawed approach to assessment and now increasingly recognised as not reflecting impact upon people. This is exacerbated due to the attempt by its authors to try and reflect the precautionary interim limit proposed by the WHO in 2018. However, the WHO limit relates to long term permanent health effects regardless of character content but not harm to amenity or nuisance.

4.2 **False appearance of protection.** The approach adopted will subsequently present an appearance of protection as it will involve prolonged measurements and data filtering but which is ultimately incapable of reflecting or addressing the impacts that occur moment by moment and thus not remotely protecting homes. This is due to misapplication of the science of how noise intrudes.

4.3 Thus the approach adopted does not follow the science of acoustics, permits higher noise during periods of adverse impact due to long term averaging and applies insignificant penalties.

4.4 I understand similar inappropriate averaging was recently considered in the case of Lies Craeynest and others v Brussels Hoofdstedelijk Gewest and Others 2019 in an opinion of Advocate General Kokott. At around paragraph 85 it was stated:

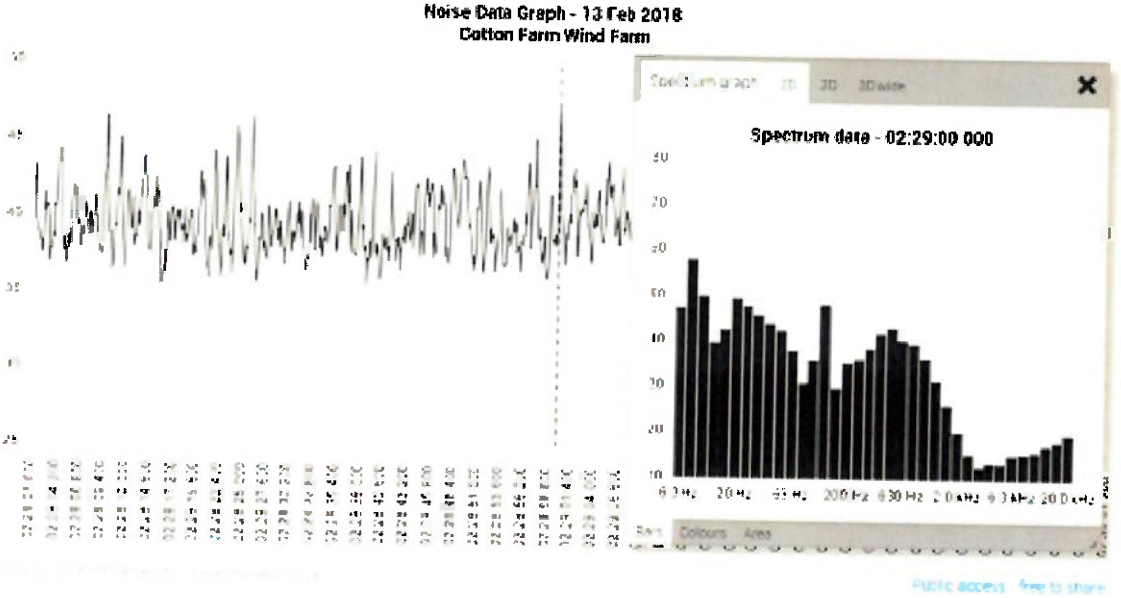
> *"There is a risk of adverse effects on health wherever the limit values are exceeded. Appropriate measures must be taken there in order to prevent adverse effects. It is only of limited importance to that risk whether an exceedance applies to the entire zone or agglomeration on average. This is clearly illustrated by the joke about the statistician who drowns in a lake even though it averages only a few centimetres in depth."*

4.5 Notwithstanding the averaging problem, the procedures proposed to be adopted have been shown using our extensive database to fail to recognise the main forms of amplitude modulation experienced and that proposed for low frequency noise can only be used post development inside dwellings. This contradicts the objective of using external measurements only and reliance on prediction that is incapable of identifying this problem.

4.6 At the link directly below the noise shown in the interactive graph and which is audible with good headphones attracts a minor penalty but is still compliant with the guidance as the penalty is small. This is before the period with the penalty is averaged with those periods when the noise impact does not arise and no penalty is applied. In reality even with the noise demonstrated in the graph and which can be listened to using the link, substantial margin remains through averaging.

4.7 https://www.masenv.co.uk/webgraphs/cotton_farm_180213

On-line graph shows a level of AM wind farm noise compliant with proposed guidelines occurring 02:28 at night. Compliance arises when considered in isolation and before long term averaging



4.8 **Permitting of higher noise than other industrial sources.** The methods proposed allow substantially more noise than any other industrial sources such as factories, warehouses, docks, transport depots and other commercial sites. These are commonly assessed using BS41432:2014. There is no basis for permitting substantially more of a source of noise especially where it is recognised as highly intrusive compared to other industrial sources. This is particularly relevant in remote rural areas where such noise is an alien and incongruous element. In context it would normally be the case that such rural locales would be given higher protection due to the absence of mechanical and

industrial noise other than in relation to farming machinery which is normally limited in occurrence.

4.9 It is instructive that most industrial sites are quiet or quieter at night and weekends but in the case of wind farms there is no distinction and they function 24/7/365 days a year. In context and having regard to rural pastoral type sound environments, stricter standards would be expected rather than substantial relaxation.

4.10 Interpretation of planning controls.

4.11 Benevolent interpretation of any controls applied would be necessary for enforcement or compliance assessment purposes. In turn this favours developers as any enforcement would need to consider criminal standards of proof. Reference in the draft guidelines to Lden, an annual averaging method strongly supports such benevolent interpretation as using long term averaging.

4.12 In practice use of long term averaging renders enforceable conditions which follow the draft guidelines impractical. Monitoring cannot extend a full year and would operate contrary to the Human Rights Convention as such a period of loss of sleep before evaluating effects cannot be reasonable.

4.13 An annual method can be used for prediction purposes where variations are known statistically but not as a measurement procedure. The averaging of periods of no or minimal impact with those of significant impact and assessing the average does not consider the actual impact and the effects of variations at the time it occurs. Concern arises over the failure to recognise this fundamental limitation.

4.14 The outcome of benevolent interpretation is the permitting of serious and uncontrolled nuisance. There is a plethora of evidence that shows this. Some is discussed in this document.

4.15 Frequency and duration of impact varies with distance.

4.16 At distances of only 500m the most serious and intrusive forms of noise arise including both upwind and downwind impact, meaning those dwellings at such

distances would not get respite even when the wind was towards the turbines. Work by MAS in its six year study and at sites in Ireland have shown this.

4.17 The draft guidelines provide no advice in relation to frequency and duration of exposure to noise. It is no consolation when there is a sustained wind direction resulting in residents being seriously impacted until the wind changes direction again. Long term averaging would undermine this impact by averaging it with periods of little or no impact.

4.18 Balance in favour of wind farm development over residential needs.

4.19 It can be concluded the methods of assessment being adopted facilitate the wind farm development to the detriment of all other concerns. This was not the case to the same extent with the 2006 guidelines as they did not consider long term averaging as now applied and any period of exceedance could be argued a breach in isolation. It is important to recognise; the historical guidelines were developed on a basis the noise was of a type that was benign and devoid of character such as AM except when very close to the turbines. In effect it was misled by the discussions in ETSU-R-97 that have consistently been shown as flawed and are widely criticised[4].

4.20 The former 2006 guidelines were formulated at a time it was believed levels below 43dB LA90 at night would not disturb and that there was not a plethora of intrusive characteristics contained within the wind farm noise. This has been consistently shown as erroneous. The erroneous statements and beliefs in 2006 are therefore understandable.

4.21 The draft guidelines now proposed are produced at a time when there is a plethora of good evidence of the adverse effects of wind farm noise. A starting point would be to consider the book by Colin Hansen, Con Doolan and Kristy Hansen, 2017 on wind farm noise as discussed in this submission as it represents an entirely independent set of views reliant wholly on research. This independent scholarly book contradicts a lot of what is reported in the draft guidelines.

[4] See the 2017 book by Colin Hansen for a resume of some of these.

4.22 Multiple wind farm characteristics arise additionally to AM.

4.23 Low frequency noise and amplitude modulation are important regular features of wind farm noise impact but are part of a wider range of effects and it is disappointing there is a failure to consider the wider range of effects. It is questioned why this is not recognised.

4.24 Adopting a procedure recognised in research as missing the majority of AM incidents and especially erratic and irregular AM and that is more intrusive because of these factors, is of serious concern.

4.25 Failure of decibel penalty as wholly inadequate.

4.26 Applying a penalty structure that permits AM to remain dominant and prominent and therefore its intrusiveness does not reduce, is of serious concern. This should have been obvious to the authors. It provides an illusion of control that is ineffectual and it is asked why this is being replicated.

4.27 In noise impact terms, rendering a noise slightly less loud but that remains dominant and prominent does not stop its effects on the unconscious listener and its distracting effects. It does provide argument noise character has been taken into account but then fails to address its effects. It is akin to cladding a building in a slightly less flammable cladding arguing it is better as a result. In the event of a fire it will still rapidly combust as temperatures significantly exceed their point of combustion. It is similarly like reducing flood water levels with better drainage. Reducing the flood level to half a metre than 1 metre does not stop complete disruption and loss of the home. Rendering a noise less intrusive but still exceeding the point it seriously disrupts is effectively an insignificant change in the same way. This is effectively what is provided in this case, especially as many features including two main types of AM do not trigger a penalty and it only applies to the impacted periods which are then averaged.

4.28 Existing effective procedure available.

4.29 A perfectly good procedure (albeit it has some elements which could be better defined) exists in the form of BS4142:2014. This industrial and commercial noise guidance would place wind farm noise "on a level playing field" with other

sources of industrial noise. No basis for ignoring such a set of procedures as developed and evolved since 1967 has been put forward. BS4142 is wholly unlike either ETSU-R-97 or the Irish Guidelines despite a statement to the contrary in the draft Irish guidelines. This is further discussed below. The critical difference is that it includes decibel penalties that place far more weight on the noise character than the sound energy level. It also appropriately uses LAeq and not LA90 for source noise.

4.30 Concerns with RPS analysis.

4.31 The RPS analysis fails to recognise and correctly apply the principles of the science of noise and acoustics, inappropriately mixing methods that were shown not to work previously but still using them as they were used before. This is inappropriate with current understanding and as a result can only continue to lead to the serious land use conflicts now commonly arising in rural Ireland.

4.32 In simple terms the guidelines are ineffectual in controlling noise impact due to the ambiguity and resulting ability to formerly look at long term averaging. In addition there is the use of procedures which ignore many characteristics in the wind farm noise including many forms of AM at the same time combining periods of less and more noise. It is also skewed by adopting unrealistic adjustments such as averaging periods where penalties are applied with perids that are devoid of a penalty. Also assuming a standardised wind speed applies which in turn hides impact during worst case conditions by adopting an unrealistically high background sound level.

4.33 The lengthy and complex algorithms built into the procedures devised by acousticians and as now proposed to be adopted rather than the more simplistic approach previously identified leads to significant and prolonged data processing. Whilst this raises acoustician's fees it is effectively indecipherable and incapable of mirroring or reflecting elements in the noise that actually impact upon people. In contrast measuring the noise as it impacts people on a moment by moment basis relates the character of the noise to the effects and their regularity and duration. The long term averaging both hides this but is also incapable of providing a realistic boundary between acceptability and unacceptability. One important reason for this is two wind farms can produce

identical average levels but in one case impact is minor as periods of high noise character arise when it is masked and the converse arises in the other case. The long term average cannot be analysed in a way that shows how dominant or prominent the noise is and separating the differences. Nor can it address when this occurs and what the corresponding background sound level was at that time. It cannot show what was disrupted nor for how long.

4.34 The mathematical procedures introduced are not understood by many acousticians and lead to an automated process that cannot be properly examined or related to actual impact upon people as they occur and clearly does not match human experiences.

4.35 In 2020 it is clear the introduction of long term averaging and adopting character penalties but which ignore much of the noise character or apply small penalties when averaged, is contrary to the science as to how such noise impacts upon people. It allows substantial noise although appearing, simplistically, to introduce tighter controls than those in 2006. It does not introduce tighter controls . The approach is wholly undermined by the science. The main problem is the application of ambiguous terms and phrases which permit various inappropriate interpretations. This transfers into a lack of control in practice.

4.36 Move of UK planning guidance away from decibel limits.

4.37 For many years planning guidance in England and Wales on noise has moved away from setting decibel controls that cannot relate to non-acoustic characteristics and attention grabbing special characteristics within noise. This is seen in the England and Wales National Planning Policy Framework and Planning Practice Guidance with only wind farms and minerals sites remaining that need revision. This change arises mainly as it is recognised the decibel level is a minor consideration in the human response to noise.

4.38 Abandonment of decibel based limits in guidance in England and Wales has not led to chaos and decibel controls remain an important element but are informed on a case by case basis adjusting to the circumstances.

4.39 A framework can readily be formulated that is fair, as found in BS4142 and that would be wholly applicable to wind farm noise. For the avoidance of doubt wind

farm noise in the UK can and is appropriately assessed using BS4142: 2014. This arises as it is only disapplied where other guidance applies and ETSU-R-97 only relates to town and country planning considerations. Where subsequently complaints arise BS4142 is appropriate and helpful.

4.40 Wider support of MAS observations.

4.41 Many of my findings are supported by the comprehensive book Wind Farm Noise: Measurement, Assessment, and Control, 2017 by Colin Hansen and colleagues. Various other supporting guidance is also provided in summary in part 2 of these comments. Whilst I have raised this here the independent views of the book by Colin Hansen and his colleagues warrant further consideration, especially in relation to procedures following ETSU-R-97 methodologies and low frequency noise.

4.42 Types of noise.

4.43 It is well recognised there are effectively two types of environmental noise[5] when considered simplistically. The methods adopted in ETSU-R-97 and now being considered in the draft Irish guidelines were formulated on the basis the noise was steady and relatively benign, readily being masked by wind noise. This was factually incorrect and misleading. Wind farms do exhibit general wind farm noise considered similar by some to road traffic on a concrete road which roars in a relatively steady way but it also includes a wide range of noise forms that draw attention and trigger adverse human responses not related to level but audibility, dominance and prominence of their attention drawing features.

4.44 Wind noise has significantly different spectrum content to the wind farm noise as experienced at residential receptors and even when of a similar level does not mask it. Furthermore, when moving inside dwellings the difference in spectrum means the wind noise is differentially reduced far more than the wind turbine noise. As a result the latter becomes even more dominant, prominent and obtrusive.

[5] To properly address the range of noise types and differences would require an extensive document but to provide some insight the attached article in Appendix A and published recently in the IoA journal provides some background.

4.45 The long term averaging and applying an averaged penalty as now proposed in the draft Irish guidelines in relation to the latter form of noise (containing special characteristics) including obtrusive and inobtrusive periods offends the science of how the human brain is triggered and runs contrary to long established principles how humans react to such noise.

4.46 Reaction to noise with special character is a moment by moment response depending on a range of factors such as what is disrupted, how often, how avoidable, importance of the living elements disrupted, duration, frequency of occurrence, expectation and neuron development of memories in relation to the noise along with other elements. Importantly UK planning guidance on noise is now recognising these factors and the seriously limited assistance of the decibel level. Ultimately we need decibel level controls but many features inform how they are to be derived when containing special characteristics.

4.47 In simplistic terms to consider a noise which perhaps seriously disrupted sleep for a period of five nights during a particular month and led to lower quality sleep another five nights, as acceptable is wrong. Just because on average over the 30 nights, levels were, on average, okay, is to seriously mislead as to impact. This is effectively what the methods appear to adopt. It is accepted there is significant ambiguity in the draft guidance but this simply permits such an interpretation. What is required is to ensure periods of significant adverse impact rarely occurs as it is masked.

4.48 Findings based on experience

4.49 Some important findings in my 45 years of experience of noise impact and the detailed studies of wind farm noise I have been involved with since 2004 are discussed below. It generally shows and can be demonstrated that:

a) most wind farms causing noise nuisance and serious repeated complaints in the UK and Ireland may appear as compliant with the planning guidance now proposed.

b) Ambiguity in any guidelines serve to compound issues over their interpretation and their application as to whether it is complied with. However, in general the contradiction still arises that there could be

compliance despite serious adverse impact upon local communities. Despite this the draft guidelines appear to seek procedures that will continue the lack of correlation between impact and guideline level.

c) MAS Environmental have reviewed repeated cases that arise where data shows serious intrusion, extensive and continued community complaints arise but assessment of planning guidance leads to arguments of compliance. This includes where the procedures proposed as in these draft guidelines are applied. In one case in England there are literally thousands of complaints and six years of data corroborating them but it is argued as compliant. Adoption of these procedures as part of the Irish guidelines can only be likely to produce the same conflicts and contradictions.

d) The MAS website includes a case accepted as causing nuisance but which complies with the proposed Irish guidelines as benevolently interpreted. There are many cases where homes have been abandoned due to impact of this level and type and what would be considered acceptable under the proposed guidelines. This contradiction could be addressed in revised guidelines that reflect human response.

e) The procedures being adopted and the wording of the document introduce considerable ambiguity and multiple interpretations as to how they apply. In turn this then permits application of the most lenient interpretation following the need to meet criminal standards of proof. These problems and contradictions can readily be addressed but as worded are permitting continuation of such ambiguity. It is not understood why this is so worded.

f) A long term averaging approach of what already is the average level, using the LA90 index (the wind farm's quietest 10%) is being adopted in these draft guidelines, contrary to commercial noise guidance equally applicable such as contained within BS4142: 2014. There is no basis for such differentiation for what is simply a mechanical and industrial noise impact significant rural areas of Ireland.

g) Evidence shows adopting the long term average using an index that is itself a statistical average of the quietest emissions of wind farm noise leads universally to compliance outcomes. Thus even in worst cases of noise and

community complaints, compliance is commonly indicated. This is instructive that the proposed procedures do not remotely relate to actual moment by moment and day by day impact. They are also wholly impractical to determine in practice. Critically though it permits substantially more noise as it averages quiet and noisy periods together compared with averages of low and high background sound levels.

h) Adverse impact from wind farms most commonly occurs when background sound levels are lowest and worst case AM, thumping and other characteristics such as low frequency effects are greatest. This low background versus high noise containing lots of intrusive character is lost through averaging.

i) Long term overall exposure limits are recognised as useful in terms of benign sources of continuous noise occurring 24/7/365 and lacking significant attention drawing character. In terms of this aspect of wind farm noise in isolation it can have value. However, noise which draws attention due to its character and also non-acoustic elements is unsuitable for assessment using such methods. This is partly why the WHO are clear in their 2018 guidelines that their guidelines do not apply to industrial and commercial sources of noise, other than leisure noise and wind farms to a limited extent.

j) Adjusting such long term average limits to reflect special character in the noise is fundamentally flawed as it needs to relate to its dominance and prominence moment by moment. This is how it impacts. In contrast BS4142 applies penalties designed to achieve loss of dominance and prominence. Applying small penalties to sources with special character as arises with the procedures proposed offends the science of acoustics in this regard as it mixes loudness and character methodologies but does not counter the effects of either. It can be described as a "smoke and mirrors" procedure that does not address the problems. Simply it does not stop the impact of AM and low frequency noise etc. and results in barely perceptible changes in loudness if at all.

k) No support for the procedures adjusting the noise controls adopted in these draft guidelines are found in the WHO European Guidelines 2018. The

precautionary adoption of an Lden of 45dB LAeq by the WHO relates to all forms of communities exposed and is subject to various caveats. These are ignored by the draft guidelines. If those procedures proposed in the draft guidelines were remotely appropriate, it is reasonable to conclude the WHO would indicate this. Instead they provide significant warnings, discussed later in this document.

4.50 Low frequency noise.

4.51 This has been shown as a major and common problem with modern wind farms but this appears denied in the draft guidelines. It is instructive this problem is recognised by the WHO but virtually ignored in the draft guidelines. Denial of low frequency noise was long made by industry acousticians even after I released data showing its presence in relation to the well documented case of Deeping St. Nicholas in 2009. Denial has continued by a number of acousticians since despite the WHO recognition of it and recognition by other serious independent researchers.

4.52 At MAS we have routinely measured low frequency noise problems at wind farms in Ireland and the UK.

4.53 Procedures to address low frequency noise are not adequately formulated in the draft guidelines leading to serious ambiguity. Reliance on the Defra curve is flawed as it is internal criteria, which when reached serves to confirm a problem. Problems arise at lower decibel levels than this curve applies but is not considered in the draft guidelines nor are the procedures for assessing this.

4.54 The Defra procedure can only be used post development so fails as a tool used to assess acceptability of a planned development. This can be readily addressed but has not been.

4.55 Analysis of background sound levels is misleading.

4.56 Graphs used show levels barely dropping below 20dB LA90 but the reality is this is dictated by the instruments used with have a noise floor (limit that they cannot record below) of 18-20dBA and corruption affects recorded levels up to around 28dBA. This means a recording of say 20dBA is possibly and most likely only

showing electrical noise generated within the instrument. This wholly misleads as to the true sound environment.

4.57 At MAS we use special microphones with a noise floor between 6.5-8dBA. In turn this means a measurement of 20dBA is an accurate reflection of levels unlike that used in the draft guidance. We routinely record level externally in rural Ireland as low as 10-12dBA. Limitations on equipment seriously corrupts data and has led to a common misunderstanding that normal background sound levels are in excess of 20dBA and typically 30dBA or more. It is noted many acousticians report internal bedroom levels of 30-35dBA as normal when it actually relates to levels where critical health effects, even from benign sources of noise are likely.

4.58 There is an extensive problem of instrument limitations leading to false readings and it is concern this has filtered into the draft guidelines.

4.59 Wrongly argued adopt BS4142 principles.

4.60 The Draft guidelines claim ETSU-R-97 is based on BS4142 and in effect it is adopting those principles. This is seriously misleading. Demonstrating this is wrong requires extensive examination so some key points demonstrating this are provided only. Whilst the ETSU-R-97 document states this, it is clearly not the case and simple application of BS4142 to wind farm noise reveals the stark difference in results. In other words apply both and the ETSU-R-97 and Irish draft guidelines indicate acceptability when BS4142 shows significant adverse impact.

4.61 ETSU-R-97 as now applied (not as originally intended) uses long term arithmetic averaging ranging from two weeks to 6 months. This was never the intent but an interpretation permitted through ambiguity in wording and so adopted by operators as it permits substantially more noise. The draft guidelines aim to extend this to a year. Human response to noise is moment by moment. If an alien sound wakes someone as we commonly find wind farms do. they do not assess acceptability of that incident based on either a two week or six month average and now annual noise level. Impact relates to the noise at the time but the draft guidelines indicate this is to be ignored. BS4142 as worded at the time

ETSU-R-97 was developed assessed impact over a 5 minute period at night with no averaging of that. This is a fundamental difference.

4.62 The approach now adopted in the draft guidelines means any intrusive noise events which intrude due to their frequency and duration of occurrence as well as the times they occur, what they affect and the nature and character of the noise, would now be viewed in terms of its annual average. These events are averaged as part of the overall long term decibel level. It cannot relate to the circumstances of the case or the intrusion experienced. This averaging approach can work in relation to road traffic noise that is relatively continuous every day of any year and that does not commonly and unconsciously draw attention due to any special characteristics. However, it would not work if there were regular horn sounding and tyres screeching but this is rare experience and the norm is a background steady roar. Averaging includes periods of little or no noise and so hides the impact from wind farm noise which is highly variable.

4.63 **Typical analogy.** This averaging approach to noise is equivalent to saying an individual's driving is safe because their annual average speed is below the speed limit. In the same way this does not relate to safe driving on a particular road, in particular circumstances. The annual wind turbine noise dose does not reflect how many awakenings or periods of disruption occur and has very limited utility.

4.64 **Flaws using LA90 index.** The draft guidelines adopt the LA90 index for the source noise. BS4142 does not as this excludes important elements and it is lower in level, typically 2dB less. This difference can be much more when the noise is erratic. BS4142 adopts the LAeq value that takes variations into account. Not only does BS4142 compare the level of background masking sound at the time of impact rather than an average, it seeks to ensure any noise which intrudes more during a period than other periods, due to its character, is actually at or below the background sound level to mask it. In contrast the draft guidelines allow an exceedance of the background sound level by 5dB using the LA90 index. This translates to a 7dBA exceedance when comparing the BS4142 methods. Thus, as a minimum the draft guidelines and ETSU-R-97 equate to an exceedance of background sound by 7dB when using the LAeq index as applied in BS4142. This equates to a substantial difference to BS4142. This 7dB level

is a point where the noise is wholly dominant and prominent even when it is absent any intrusive character such as AM and thumping.

4.65 ETSU-R-97 and the 2006 Irish guidelines adopted the LA90 index on the basis levels were believed to be steady. At times they are but critically at times of high intrusion they are erratic and very unsteady.

4.66 **High decibel penalties in BS4142.** The decibel penalties used in BS4142 serve to require the resulting noise to be progressively masked the more the character in the noise draws attention. The principle is a good one where intrusive character is masked to minimise its unconscious attention drawing features. The greater it draws attention the lower it must be in relation to background masking sound. In contrast the draft Irish guidelines apply an extremely limited penalty which adopts the IoA method that in turn misses most forms of amplitude modulation, especially the erratic and irregular forms. It is not in practice a 5dB penalty. The penalty is only applied to the periods it was observed meaning it is further averaged out and would rarely be at 5dB in any event. Commonly a 1-2dB penalty might arise from the process but only applied to the periods where it was triggered meaning that even if triggering 50% of the time it would add half this. The outcome that results is permissible levels remain dominant and prominent and continue to draw attention. The adverse effects are not prevented. Conversely BS4142 now applies penalties that could, in theory total 21dB and penalties of 10-12dB are common.

4.67 **Different background levels used compared to BS4142.** BS4142 uses a typical background sound level so that protection is based on what is commonly occurring. In other words it looks for the most commonly occurring background sound level and how the sound emerges above this. ETSU-R-97 and the Irish draft guidelines do not, they apply an arithmetic average which, in relation to rural localities is always higher due to windy periods that would be ignored when using BS4142. These differences increasingly add up to substantial differences between intruding noise and masking background levels.

4.68 Human response does not apply background sound experienced during windy periods to the wind farm noise but periods of little or no noise. This is how human memory and characterisation occurs. Applying a higher background

level based on higher wind is misleading. Furthermore, high wind shear conditions also mean this is a false comparison.

4.69 BS4142 applies a penalty to a wide range of sound characteristics that increase intrusiveness simply due to their presence. ETSU-R-97 and the Irish guidelines, as interpreted by Irish acousticians working for wind energy developers have been applying fractions of the penalties based on the fraction of periods when they occur. This further understates their impact. Such interpretations are permitted by the proposed guidelines but not applied in BS4142. Furthermore, a significant range of intrusive characteristics are ignored by the draft Irish guidelines and the ETSU-R-97 procedures, meaning many elements that intrude are simply ignored. BS4142 does not ignore them and has another penalty category for other characteristics within a source of noise.

4.70 Summary in terms of BS4142. It can be seen the procedures adopted in BS4142 are manifestly different to ETSU-R-97 and the Irish draft guidelines. To imply otherwise is to mislead in precisely the same way the original ETSU document misled.

4.71 Whether adjustments to ETSU-R-97 reflect impact from modern turbines?

4.72 To argue this is the case as the draft guidelines do is to seriously mislead. The draft guidelines, if adopted provide added protection to the wind farm industry but seriously diminish it for residents. One simple example is adoption of standardised wind speeds. This means true wind speeds are ignored at any moment in time and a standardised one is substituted.

4.73 The greatest adverse impact at night arises under an atmospheric state called "stable atmosphere". This is a common occurrence and in our six year data study this can arise typically up to 80% of night time periods although occurrence will vary. During these conditions the blades experience high wind speeds at the top of their rotation but at ground level there is extremely little wind (pin drop quiet). This happens as there is high wind sheer and lack of atmospheric friction leading to atmospheric layers. This means faster winds high up do not transmit down to ground level where it becomes still and in terms of background sound it is quiet.

4.74 Standardised wind speeds assume that when the wind turbine is at maximum noise output there are much higher masking winds at ground level that arise in reality with high wind sheer. In turn much higher background sound levels are assumed and compared than actually occur.

4.75 The outcome is that during the worst periods of adverse impact the assessment method planned to be adopted assumes a much higher background sound level to compare against. This understates impact. It is also the case that greatest AM occurs during these stable atmospheric conditions as the blades encounter the greatest range of wind speed differences from top to bottom of a rotation and cannot be pitched appropriately for the range of wind speeds using standardised wind speeds. AM thumping commonly occurs during these meteorological conditions. However, the method adopted assumes a much higher and false level of masking noise. This problem is exacerbated as measurement equipment uses standard microphones which cannot go low enough to show the true difference between the very low background sound levels during stable atmospheric conditions and the resulting high levels of turbine noise and thumping AM.

4.76 In summary, the critical point is that the worst impact arises when weather effects generate minimal masking noise and there is an expectation of quiet and tranquillity. Instead this is precisely when the most serious forms of noise intrusion commonly occur. Rather than address this the adoption of standardised wind speeds hides this impact.

4.77 The draft guidelines make little reference to wind speed but adopting the language it has and procedures proposed, it will have to use standardised wind speeds which then hide the periods of greatest adverse impact.

4.78 Method of evaluating Amplitude Modulation.

4.79 The method proposed to be adopted has been shown to manifestly fail to control two critical forms of AM which arguably are the most intrusive. There is no explanation why such a flawed methodology is proposed or even recognition that it has been shown to fail as identified. In effect no effective control is applied.

4.80 There are many serious flaws with the method proposed to be adopted. Some are outlined here:

a) There is extensive ambiguity how to apply the procedures permitting a range of outcomes and interpretations.

b) Penalties are applied to the general more steady wind farm noise which is measured using the LA90 index. AM is not measured by it. This is contrary to the need to separately control noise with special characteristics as a standalone problem. This penalty approach means at most very slightly lower energy levels are permitted but without any change to the noise impact itself.

c) Averaging of the penalties as interpreted as permitted in the procedure by only applying them to individual periods where it is triggered further reduces its effect. This results in a false element of protection produced which in fact does not change impact as it does not take the character in the noise below any point where it no longer draws attention or unconsciously disrupts thought processes, including leading to awakening.

d) The complex technical procedures render it hard to evaluate whether any analysis using data has properly or reasonably been applied in the evaluation of the data.

e) False positives and more commonly false negatives are highly common with the process wrongly indicating periods do not contain such noise when they do. There is no method of addressing this.

f) The dense virtually indecipherable procedures cannot be related to the impact experienced at any point in time and therefore it cannot properly be tested for efficacy. Our analysis has shown it repeatedly fails to trigger when erratic and irregular (arguably the worst forms) AM occur.

4.81 In summary it is to be questioned why a set of procedures which knowingly miss many forms of adverse character impact and result in minor and irrelevant penalties that permit the intrusive noise to continue are being adopted.

4.82 Averaging noise over an annual basis would also effectively render assessment of the effects of noise character impractical. This does not reflect the intent of the WHO where predictive methods are primarily used to look at and compare general noise exposure.

4.83 **Defra nuisance guidance identifies limitations of ETSU-R-97.** The UK ETSU-R-97 procedures have been recognised as not reflecting impact upon people where UK Defra guidance on investigating nuisances from wind farms reflect this by recognising the lack of usefulness of ETSU-R-97 in that regard. Furthermore ETSU-R-97 recognises this. Despite this it is proposed to adopt procedures following these methods.

4.84 **Recognition the procedures fail to protect communities.** Despite extensive and clear international evidence wind farms commonly introduce noise character that intrudes at very low decibel levels and which the UK ETSU-R-97 procedures ignored, and continue to fail to address, the draft Irish guidelines seek to mimic their flawed and failed procedures. These have now been long exposed as failing to protect communities.

4.85 Almost universally wind farms which cause complaints of nuisance and that are corroborated by independent investigation could show compliance with the proposed planning guidance. Where they are not compliant, extremely minor adjustments of a decibel or two could potentially render them compliant. This level of difference falls within the range of uncertainty in sound level meters and could not be enforced.

4.86 Approach adopted is contrary to science.

4.87 The approach to noise control adopted operates contrary to the science of noise impact. I have already discussed this above but set out some additional points here. In summary:

a) We can apply threshold values to sources such as benign road traffic which mainly impact due to triggering neurons in the brain relating to loudness in isolation. We cannot apply this to noise containing special character which triggers many more and differing neurons. This relates to constant brain surveillance of our environment for threats or the need to apply attention /

action. These lead to unconscious attention grabbing and thus disruption of day to day activities, especially rest and relaxation.

b) Noise with intrusive attention grabbing character intrudes where it is either prominent, dominant or sufficiently alien that it draws attention. The effect of alien and incongruent noise is long recognised. Later when we have adjusted to recognising the alien noise, attention is drawn due to the associated memories of adverse effects with that noise. We therefore sensitise to it. For example, hearing a noise which led to loss of sleep before an important interview would trigger memories associated with the adverse outcome. This noise is not assessible by application of a decibel penalty unless that ensures the noise is primarily masked preventing any trigger. The penalties proposed in the draft procedures do not remotely cause an outcome where they are masked or hidden unlike those applied when using BS4142.

c) There are a wide range of interacting characteristics which intrude for a variety of reasons and applying an average and small penalty to just one category which is broadly identified as AM but in fact the methods miss most forms of AM means it cannot follow the science. Broadly there are three forms of AM and only the regular unchanging form is adequately picked up using the procedure proposed. The procedures underrate or wholly miss the effects of:

- Erratic and irregular AM
- Simultaneous occurrence of whistling and whirring with the AM.
- Occurrence of low frequency noise with the AM which may or may not also modulate.
- The effect of very large variations which can be up to 15dBA on a second by second basis despite the procedures considering such variation is not possible. It is recorded and whilst not common is a startling effect.

- Changes in the character and spectral content of the AM beats on a moment by moment basis such that successive beats exhibit a different pitch or characteristic.
- Changes in impulsivity of AM beats where some rise more gradually and so the rate of change is not so stark and others have distinct impulse content with sudden change.
- Directional effects where different forms of AM arise in different directions.
- The additional underlying roar of general wind farm noise which the AM emerges above. This means there is a contributory industrial type noise that exacerbates the effects of AM in many cases.

4.88 WHO (2018). Environmental Noise Guidelines for the European Region.[6]

4.89 There is selective reporting of the guidance provided by the WHO 2018 in the draft guidelines. The WHO's precautionary application of an Lden also includes substantial concerns and caveats regarding noise character that the Lden does not cover or address. The Lden precautionary recommendations cannot differentiate locations such as being adjacent a motorway, within a dock or large industrial complex where there are high levels of masking noise. Compare these to a remote rural area where there is no mechanical or industrial noise other than the wind farm. The application of the same limits to both is illogical and contrary to the science of human response to noise. The effects of this cannot be factored into the WHO recommendations and the WHO express significant caution.

4.90 In 2018 the WHO published their updated guidance for Europe for protecting human health from exposure to environmental noise. Whilst the guidelines focus mainly on transportation and leisure noise, they include a section on wind turbine noise. Key points are summarised below.

[6] World Health Organisation (WHO) (2018). *Environmental Noise Guidelines for the European Region.* Copenhagen : WHO

4.91 The 2018 guidelines recommend exposure levels aimed at protecting human health. This includes cardiovascular and metabolic effects, annoyance, effects on sleep cognitive impairment, hearing impairment and tinnitus, adverse birth outcomes, quality of life, mental health and well being. As such, they concern effects of greater consequence than comfort and convenience, harm to amenity or unreasonable interference with the use and enjoyment of land. The latter is, in my understanding, part of the definition of nuisance. Whilst the WHO discussion on impact is helpful for reference, the recommended exposure level should be treated with some caution when considering comfort and convenience or unreasonable interference.

4.92 Due to a lack of high quality evidence, as defined by the WHO, the recommendations on wind turbine noise are conditional and for many of the investigated health effects[6] there was insufficient evidence. However, the WHO has set a recommendation for reducing noise levels from wind turbines below 45dB Lden.[7] It is also noted within the guidelines that below this exposure level there might still be a risk of annoyance. In addition, and of note, the WHO caveats that the descriptors Lden and Lnight may not be appropriate for describing wind turbine noise and this may limit the ability to draw associations between wind turbine noise and health effects.

4.93 The WHO lists several characteristics of wind farm noise that may exacerbate impact compared to the sound energy level alone and why the Lden and Lnight descriptors may not be appropriate.

Wind turbines can generate infrasound or lower frequencies of sound ... The noise emitted from wind turbines has other characteristics, including the repetitive nature of the sound of the rotating blades and atmospheric influence leading to a variability of amplitude modulation, which can be a source of above average annoyance (Shäffer et al 2016). This differentiates it from noise from

[7] The Lden is a long term average noise level. It is calculated assuming that there is an equal (or equivalent) level of noise over a whole day. Greater weighting is given to periods where more freedom from noise is expected, evening and night time. It is a descriptor typically used for transportation sources. It can be used to investigate noise dose; however, caution must be exercised when looking at sources such as wind turbine noise where there are specific characteristics to the sound which may cause adverse reaction at lower levels than sources without these characteristics. The Lden cannot describe how the sound environment changes on an hourly, minute by minute or second by second basis.

other sources and has not always been properly characterized. Standard methods of measuring sound, most commonly including A-weighting, may not capture the low frequency sound and amplitude modulation characteristics of wind turbine noise (Council of Canadian Academies, 2015).

4.94 The importance of assessing impacts in context is also raised as a key consideration for wind turbine noise and this accords with other recent editions of guidance (for example BS4142:2014).[8] The difference in human response to wind turbine sound in comparison with other sources, for example transportation noise, is also noted.

Wind turbines... size and type have increased significantly over recent years. As they are often built in the middle of otherwise quiet and natural areas, they can adversely affect the integrity of a site. Furthermore, residents living in these areas may have greater expectations of the quietness of their surroundings and therefore be more aware of noise disturbance... These situational variables and the values and preferences of the population may differ between wind turbines and other sources...

4.95 Whilst the WHO provide a recommendation for prevention of health effects using the Lden value, the guidance also highlights uncertainty with the appropriateness of the descriptor for describing the full nature of impact from wind turbine noise. The WHO guidance reinforces a common theme recurring throughout recent noise guidance and research that context and character play a large part in determining human response to sound. The WHO were unable to determine a separate night time criteria for protecting health from wind farm noise.

4.96 Methods of assessing low frequency noise

4.97 Reference is made to the Defra curve but this is an internal procedure where different time periods of measurement could be applied. Despite this the draft guidance argues against internal measurements. There are various misrepresentations summarised as follows:

[8] British Standards Institution (2014) *BS4142:2014: Methods for rating and assessing industrial and commercial sound*. London: BSI.

a) Internal impact can be very different to external impact due to room dimensions which affect levels.

b) A variety of different internal measurement locations can be utilised giving different results.

c) There will be argument how external levels relate to internal levels. In one case where I used international research on the likely difference as the houses were not built, extensive disagreement still arose.

d) Whilst the Defra method does consider varying low frequency noise it was never derived to address regular second by second low frequency noise including in case where it also exhibits impulse content.

e) When proposing a wind farm it is impractical to measure its effects inside residential property and there are a significant number of variables that affect the results.

f) Alternative external procedures based on detailed research have been developed but are ignored.

4.98 Summary key problems with guidelines as written

4.99 The two most fundamental problems that arise which if adopted as written render the guidelines toothless and formulated to enable serious land use conflicts between wind farms and residential uses:

4.100 Adopting the procedures and an approach first applied in the UK document ETSU-R-97 that assumes impact upon people is as found for benign and anonymous (no related adjacent land use) transport sources despite no supporting evidence. Further that this can be adapted by applying minimal decibel penalties. It is noteworthy the extensive Canadian Health studies has shown human response to wind farm noise is typically equivalent to road traffic noise 16dBA higher. It follows the wind farm noise would need to be about 16dB lower than road traffic levels for equal impact. The procedures do not remotely follow this.

4.101 In adopting language to which there is significant ambiguity and multiple interpretations serves to permit application of the most lenient methods such as long term averaging of background sound, source noise, penalties and low frequency noise. An example would be considering the noise both downwind and upwind. Upwind noise can sometimes be of the order 12dBA lower than downwind. Only the downwind noise may be causing problems but the method would allow the averaging of both.

4.102 Need for listening experience to better understand impacts

4.103 MAS commonly create a listening experience where noise experienced in homes is reproduced to enable parties and the courts to understand how the noise actually experienced impacts residents. In turn this can inform on what is being proposed as permitted by the draft guidelines.

4.104 MAS will happily set this up to inform the Irish Government what the guidelines actually translates to and will permit residential neighbours to have to suffer. As a starting point please visit the MAS website at

https://www.masenv.co.uk/wind-farm-case-study

4.105 The draft guidelines would permit these sources of noise to occur and they would likely comply with the guidelines. This is a case recognised and agreed at court as causing a legal nuisance. It was considered a serious nuisance by those affected.

4.106 Some additional findings:

a) The wording is ambiguous and confused in a manner allowing multiple interpretations and in doing so permit far more noise than might at first appear. Eg. A limit of 43dBA can be interpreted as a long term arithmetic average of 43dBA meaning 50% of the time it could be substantially higher.

b) 3dBA increase is recognised as noticeable but the minimum change permitted here is 7dBA in terms of the average noise over the background LA90 sound level. Stating it as 5dBA by using the LA90 is misleading.

c) Background sound levels of 20-25dBA are commonly accepted but in reality they fall well below 20dBA on a common basis and this often coincides with the worst windfarm noise impact.

4.107 Ambiguity

4.108 There is a plethora of issues with ambiguity including:

a) The process of relating noise limits to wind speed at hub height even though masking noise commonly does not relate to this and human response also does not. We do not tolerate more noise because it is windier.

b) Long term arithmetic averaging of limits. This has arisen due to failure of UK conditions to prevent such a process and a court decision permitting professional judgement / interpretation meaning where wind energy acousticians choose to permit long term averaging of both background sound and turbine noise including when each are high and low due to different meteorological conditions, all the data points are averaged. This completely ignores the original intent of ETSU-R-97 to look at the impact on each individual night and also it no longer maps over time individual periods of high wind farm noise when background sound levels are low. Instead compliance is argued as can be based on very long term averaging as a professional judgement permits this. Taking periods of serious intrusion and averaging them with periods of no or little intrusion leads to compliance even when there are substantial periods of intrusion.

4.109 The issue is that the generation of highly attention drawing and therefore intrusive characteristics which include a variety of forms of amplitude modulation, mechanical noise sources, low frequency sources and irregularity in the noise lead to serious adverse impact unless the noise is sufficiently masked and no longer dominant or prominent.

4.110 The approach adopted in the draft guidelines is to treat the noise as equivalent to a benign, anonymous type source which when containing special character that prevents climatization and habituation and conversely draw attention and cause sensitisation, making it slightly lower in energy addresses the problem. This is perverse. The introduction of the character changes human response

and its loudness is then of limited relevance. Simply put making a loud (in relative terms) and dominant noise slightly less loud but which still disrupts and draws attention unconsciously in a manner you cannot stop it doing because it remains sufficiently dominant or prominent is a barely perceptible improvement.

4.111 There is no basis for adopting such a flawed approach to noise. Whilst this approach is partially accepted in the UK to address failings with the deeply flawed ETSU-R-97 it has not led to any cases where unreasonable and intolerable noise intrusion has been rendered even remotely acceptable. ETSU-R-97 was developed on the basis intrusive attention drawing character other than limited tonality was absent. It was formulated long before a reasoned understanding of the WHO guidelines and its misconstrued approach developed on the basis all noise was more or less acceptable below certain thresholds. Conversely the WHO guideline values were not setting acceptable values but the onset of critical health effects for transport sources devoid of specific characteristics.

4.112 If the UK Government had permitted wind farm development to be undermined through acceptance of the increasingly recognised flaws in ETSU-R-97 it would have had serious consequences for its entire renewable energy programme. It is instructive that in the case of all the wind farm developments considered or demonstrated as causing civil nuisance in the UK all comply with wind industry interpretation of ETSU-R-97 despite widespread evidence of nuisance.

4.113 Simply put, adopting the guidelines as written will lead to continued serious land use conflicts where local residents have abandoned their homes or live in continuous stress with no relationship whatsoever between acceptable noise in the home and the levels permitted by the proposed guidelines. It is instructive the UK ETSU-R-97 guidelines and adaptations for amplitude modulation have not led to a single situation where those affected have been able to use the controls to achieve protection from nuisance.

4.114 It is also instructive recognition of the lack of utility of decibel based controls has progressively led to the abandonment of planning guidance other than in a minor way in the UK based on decibel levels. These only really now remain for minerals developments and wind farms. In the main National Planning Policy Framework

and the Planning Practice Guidance emphasis is placed on the effects upon humans and changes in life style such as having to close windows and not decibel levels. Decibel levels still form valuable controls and will commonly be applied as a backstop control but the inability to set a single value due to the variables in how noise affects people value is now well established. Thus for example two sources of noise and background levels may be the same (e.g. compressor noise) but different limits would be applied because one is in an industrial area where such noise is common but the other a rural area near a major road and so the sound environment is different. Each case has different factors which influence. Thus the WHO Lden value for wind farm noise and adverse health effects rather than on comfort and use of the home is an upper limit that will consider wind turbines in industrial areas and near motorways as well as remote rural areas. The idea this precautionary Lden value of 45dB is a suitable control in isolation in the extremely remote, quiet areas of Ireland which normally widely experience natural sounds and some farming is a perverse interpretation.

4.115 Consequences of adopting the new guidelines.

4.116 Much of the differences and reasons why the draft guidelines are discussed below. In the case of the 2006 guidelines, there is the clear argument their age is such the statements which now mislead over wind farm noise arise due to the lack of adequate understanding at the time. This defence could not be said about any guidelines adopted in 2020. Not only are the scientific failings of what is proposed very clear in 2020 but a substantial number of cases have arisen with a large number of actions being pursued where the wind farms that are causing serious problems for residential neighbours may be wholly compliant with the draft guidelines now proposed. A simple test of this can be seen on the MAS Environmental website, in a case accepted at court as causing serious nuisance but wholly compliant with the draft guidelines.

5.0 Background to the assessment of sound and relevant wind farm controls.

5.1 Principles to be applied - Assessment of sound and noise

5.2 Human hearing has been referred to as "the sentinel of senses".[9] Its capacity to respond to information and changes to that information in light, dark, consciousness and sleep is incredibly sophisticated.[9] As noted by Jones et al (2010) it appears that human hearing is obligatory, we cannot help but hear, attend to (specifically or inadvertently) and respond to our aural environment.[9] It is a fundamental human response and dates back to our evolutionary past when certain sounds would have had significant meaning. Many of these basic responses remain engrained and are even exploited, for example in music and film, to elicit emotional response.[10]

5.3 Our environment is made up of many different natural and man made sounds. Human responses to sound combine both physiological responses, i.e. a response to the disturbance of a sound wave moving through the air and through our auditory pathways, and psychological responses. Psychological responses can be influenced by physiological responses, how these responses are processed by the brain and many other subjective factors including non acoustic factors such as attitudes to the sound source.

5.4 The difference between sound and noise is dependent on a number of subjective, personal and situational variables. Subjective responses may be acoustic and non acoustic and can depend on factors such as age, absolute decibel level, character of the sound, time of the day at which the sound occurs, personal attitudes to the sound and historical experiences, the attitudes of those generating the sound, character of the area etc. As defined by others, "sound can be measured by a sound level meter or other measuring system. Noise is

[9] Davis H. Preface. In Stevens SS, Warshofsky F, ed. (1970) Sound and hearing. Netherlands: Time Life Books. Cited in Jones DM, Hughes, RW, Macken WJ. (2010). Auditory distraction and serial memory: The avoidable and the ineluctable. Noise Health. 12:201-209.

[10] For example the lack of wildlife sounds and silence in woodland scenes to indicate danger or the Jaws theme, a low frequency sound increasing in pace and getting louder indicating advancing danger.

related to a human response and is routinely described as unwanted sound, or sound that is considered undesirable or disruptive".[11]

5.5 The distinction between sound and noise at an individual level is subjective. Just as there are different preferences for musical taste the judgement of sound versus noise can vary widely from person to person. This includes differences both in sounds that are considered pleasant and unpleasant but also individual sensitivities to noise, for example hearing thresholds.[12]

5.6 The assessment of whether sound is noise and whether that noise is unreasonable is not always simple but most people will commonly recognise levels and types of noise that they find unpleasant and that materially affect the use of property especially in relation to rest and relaxation.

5.7 There are certain features of sound that are generally considered to increase annoyance and reduce tolerance and these can be treated as exacerbating factors of noise impact. These are mainly features that attract attention, rendering a sound more discernible. They include impulsivity, tonality and intermittency. Steady, continuous, anonymous sounds, for example distant road traffic noise, are generally considered easy to acclimatise to and habituation can arise relatively quickly.

5.8 Sounds that have an identifiable source, impart a particular message, are variable, unpredictable and have specific identifiable characteristics such as a hum or drone are more annoying at lower sound levels than steady continuous sounds. These attention drawing sounds typically spark adverse reaction and ongoing complaints without acclimatisation. In many cases increased sensitivity to the sound source can arise and it is generally accepted that this aspect of sensitisation is a normal and typical response.

5.9 Our brains are constantly analysing and interpreting our sensory environment. As noted in Baars & Gage (2010) "The central role of the auditory perception

[11] British Standards Institution (2014) *BS4142:2014: Methods for rating and assessing industrial and commercial sound*. London: BSI.

[12] With regards to assessment it is generally accepted that those who are hypersensitive to noise are not protected.

system is to extract information from the listening environment in order to determine what is happening around us".[13] Attention can be drawn to sounds voluntarily or involuntarily. It is often involuntary attention that can cause annoyance as this disturbs other tasks to which we are trying to direct our attention. On hearing a loud or unexpected sound we become instantly alert, entering a state of heightened arousal in assessing what the noise was and where it came from. This is also true when there are changes in our auditory environment that perhaps are unexpected or cannot be easily explained. The effect is described by Baars (1997) in relation to the Orientating Response (OR):[14]

Suppose you hear the sound of a refrigerator pump – a series of noise bursts of a certain duration, spectral distribution, onset, offset envelope, location in space, cycle time, and so on. If the sound is not painfully loud, people will tend to lose awareness of it rather quickly, but they will tend to be conscious of the noise again as soon as any parameter of the sound changes: The noise can become louder or softer, the time between the noise bursts can change, the intensity envelope can change, or the noise bursts can just stop. Any of these changes will trigger a new OR, just as we may become aware of the noisy refrigerator as soon as the noise stops. [15]

5.10 Theories relating to our expectations of sound and how we react to and perceive events that do not correlate with our previous experiences have been much discussed in relation to our perception of music. The same basic principles can be applied more generically to sound and noise. Constant sound with little change to volume, pitch / frequency or character will be easily accustomed to and requires little cognitive appraisal or attention. Negative responses are more likely to be associated with unexpected changes in loudness, frequency content and more generally by sounds not behaving in a predictable manner.

[13] Baars, B. & Gage, N.M. (2010). *Cognition, Brain and Consciousness: Introduction to Cognitive Neuroscience*. 2nd ed. Oxford: Elsevier.

[14] The orientating response, or orientating reflex, is a response to a change in an organism's environment usually elicited by novel stimuli.

[15] Baars, J. B. (1997) Contrastive phenomenology, in: Block, N.J. Flanagan, O. and Güzeldere, G. (eds) The nature of consciousness, philosophical debates. Massachusetts: MIT, p. 191

5.11 Furthermore, our previous associations and memory of sound will influence and guide future reactions and interpretations. For example, one night of disrupted sleep due to an irritating mechanical hum may elicit an early adverse response to any future occurrences of the hum compared to the first experience due to the pre existing associations with sleep disturbance. Much of this again relates to the character of the noise and the interpretation of any message imparted by the noise in assessment of noise impact.

5.12 Restful and relaxing environments are typically those with a lack of attention drawing characteristics and with positive associations. For example, music labelled as 'relaxing' typically has a slow tempo with predictable, consonant harmony and minimal melodic, dynamic and harmonic variation. The same is true for relaxing soundscapes, which typically have a higher proportion of natural (biological) sounds such as water running (a predictable, smooth sound) and fewer sources of loud mechanical sounds (impulsive, harsh sounds).

5.13 In seeking rest and relaxation, we are therefore typically searching for 'quiet'. This can have several relevant meanings with respect to noise and sound as described in Andringa and Lanser (2013). 16 Firstly and most simply it can refer to a lack of (or little) noise / sound. Secondly, 'quiet' can also refer to a lack of activity or disturbance, for example the relaxing music with minimal changes in melody / harmony or one simple noise source as opposed to multiple different noise sources. Finally 'quiet' can refer to mind states that are not disturbed or interrupted, i.e. a lack of attention drawing character such as the constant, broadband noise from a fan compared to a mobile phone with a melodic ring tone that keeps ringing.[16]

5.14 Consideration of sound versus noise is not simply limited to level (decibel level / loudness) but specific features of the noise / sound and how they interact with and influence our environment. As noted by van den Bosch et al (2018) "...auditory appraisal is greater than the sum of its decibels... the very definition

[16] Andringa, T.C., & Lanser, J.J.L, (2013). How Pleasant Sounds Promote and Annoying Sounds Impede Health: A Cognitive Approach. *International Journal of Environmental Research and Public Health*. 10 pp 1439-1461

of 'noise' as unwanted sound entails appraisal on the dimension of desirability that has no obvious relation to decibels".[17]

5.15 Notwithstanding the above, the decibel level is commonly used to measure and quantify sound. Whilst it provides a universal measure of sound energy, it should be treated with caution if used in isolation to describe the impact of a sound or noise on the human population.

5.16 The human hearing mechanism is incredibly sophisticated, perceiving sounds from around 0-130 decibels (dB) over a range of 20 cycles a second (Hz) - 20kHz. The human ear can adjust to and be startled by very quiet sounds especially when there is little or no other sound, for example a twig breaking in the countryside at night time. At the other extreme the human ear can perform temporary threshold shifts to adjust the auditory threshold and protect itself from very high and / or sudden exposure to sound (for example a loud rock concert).

5.17 The human ear is more sensitive to certain frequencies, typically between 1kHz and 4kHz (approximately the top two octaves on a piano) as this is an important part of the range of speech. However, when a sound is dominated by lower frequency content, typically below around 200-250Hz, it is also recognised as more intrusive than noise that has a more 'balanced' spectrum and so warrants special attention.[18] The A weighting decibel scale (dB(A)) is used to adjust the absolute sound levels measured to reflect the approximate sensitivities of the human ear, though it is recognised it cannot reflect all elements of the noisiness and intrusiveness of a sound, especially low frequency sounds.

5.18 Sound is most commonly measured in decibels, though there are other means for assessing sound, for example using loudness scales. Some common sound sources and approximate decibel levels are given below. A change of 3dB(A), in

[17] van den Bosch, K. A., Welch, D., & Andringa, T. C. (2018). The Evolution of Soundscape Appraisal Through Enactive Cognition. *Frontiers in psychology*, 9, 1129.

[18] See Leventhall H G. Low frequency noise and annoyance. Noise Health 2004;6:59-72. A balanced spectrum has an accepted fall off in noise level per octave. In an office an acceptable fall of per octave was found to be 5dB / octave. Where there is an excess of low frequency noise this is typically perceived as a 'rumble'. The difference between C weighted and A weighted levels (see glossary for definitions) has also been found to indicate dominance of low frequency noise. If the difference between C weighted and A weighted values is greater than around 20dB then there is a potential for a low frequency problem. Caution should be exercised in low noise environments.

a sound without other change in its content, is just noticeable to most people in an environmental location and an increase of 10dB(A) in the sound level is typically perceived to be twice as loud.

5.19 Some examples of typical decibel levels measured by MAS are given in table 2 below as a guide. However, it is noted that these are decibel levels alone and do not include a description or penalty for character or context of the noise which in reality would contribute to its acceptability / unacceptability.

Table 1: Typical short term decibel levels for common sources of noise[12]

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

[12] 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 OBD

[23] Noise impact has long been recognised as relating to so much more than its decibel level. I understand a noise can be effectively immeasurable above ambient or background levels and still be a nuisance where it is incongruent and depending on its nature and character (see for example Godfrey v Conwy County BC (2000)).

- character - both of the noise and of the area
- duration
- time of occurrence
- loudness
- message imparted by the noise
- variation in noise over time
- spectral content of the noise
- frequency of occurrence
- regularity / predictability of the noise
- respite from the noise, length / duration of respite
- how easily the noise can be avoided
- impact of the noise on basic needs such as sleep and communication
- cumulative impact of noise intrusions (different noise sources from single or multiple sites)
- the necessity of the noise also in relation to greater society
- decibel level of the noise
- visual or other impacts associated with the noise

5.23 Assessment of impact on the use and enjoyment of premises can relate to both human responses such as annoyance and irritation but also the coping strategies adopted by people and how they try to adapt to the noise. Coping strategies can relate to changes in behaviour including complaining, trying to mask the noise with other sounds, avoiding the noise through leaving the house to find respite, not using gardens, avoiding social events such as family events, keeping windows and doors closed and in extreme cases, moving house. The coping strategies adopted provide evidence of actual outcomes and are not restricted to evidence based on emotional descriptors. These inform extensively on wind farm impact where abandoning homes is higher than for any other noise case we have ever come across.

5.24 I understand that a noise nuisance and annoyance is not only disturbance and adverse impact but that this disturbance and impact is unreasonable, exceptional or excessive in a material way, affecting the use and enjoyment of a property. It is not trivial impact.

5.25 Assessing wind farm noise impact

5.26 Initial assessments of noise impact from a wind farm (once the wind farm is operational) concerns planning approval noise limits. Currently these types of assessment most commonly look only at average noise level (dB), but is just one factor of many that affect perception and impact of sound in an environment.

5.27 In many cases long term averages are considered that do not relate even to the noise level and how it dominates at any moment in time. Thus, it is common for assessments to report the noise level alone often adding comment that at this 'low (sound energy) level' adverse impact cannot arise. This is seriously misleading and indicates a failure to understand noise.

5.28 In these cases, complaints often continue. This should not be surprising given that the factors commonly contributing to the annoyance (i.e. factors outside of the decibel level alone) have not been included in planning assessments. Thus, the conclusion that noise is not capable of being highly intrusive because sound energy levels are low is incorrect. Notably, UK guidance on wind farm noise nuisance recognises the importance of noise character and the limitation of the decibel level.[24]

5.29 Understanding why wind farm noise can cause complaints is related to many of the basic principles of our perception of sound and noise as discussed above. A human perception of sound or noise is relative to our sound environment. Many of the factors that this relative approach includes cannot be described by an absolute decibel level alone. Wind turbine noise intrudes mainly because of the psycho-acoustic characteristics it exhibits, the sensation level of the noise, how dominant or prominent the noise is in the environment, its relative audibility and the extent to which it draws attention. A similar set of principles arise with music noise where mere audibility at night-time, or where impact occurs regularly, is recognised within guidance as unacceptable.[25]

[24] See paragraph 7.13 below for discussion on "Wind Farm Noise and Statutory Nuisance Complaint Methodology" (NANR 277)

[25] The Institute of Acoustics (IoA) (2003) *Good Practice Guide on the Control of Noise from Pubs and Clubs* St Albans: IoA.

5.30 Wind farm noise annoyance.

5.31 Wind farm noise complaints pertain largely to noise annoyance and similar adverse responses, i.e. the noise is not painfully loud but is considered highly annoying, irritating or affects uses of the dwelling such as quiet relaxation. The assessment of noise impact and annoyance is often related to decibel levels and whilst this offers an easy approach to assessment it often oversimplifies the judgements and interacting factors that occur in reality. The WHO (2000) state:

Whilst sound can be measured with the help of acoustical instruments such as sound level meters, the actual extent of noise nuisance cannot be measured in this way. One of the negative noise effects is annoyance. Large-scale population studies show that only one third of noise annoyance can be accounted for through exposure to varying sound levels. Non-acoustical factors, including personal factors such as noise sensitivity, and social factors, can have as much effect as the sound level. [26]

5.32 The WHO use the word "annoyance" to describe a wide range of human responses which go beyond the lay use of this word. The relationship between noise and annoyance is well summarised by Guski et al (1999).[27] In reality, annoyance is likely to be influenced by a combination of acoustic and non acoustic factors. Guski et al (1999) found that annoyance was mainly a result of *"(1) immediate behavioural noise effects aspects like Disturbance and Interfering with intended activities, and (2) evaluative aspects like Nuisance, Unpleasantness and Getting on one's nerves"*. Guski et al (1999) define annoyance as *"a psychological concept which describes a relation between an acoustic situation and a person who is forced by noise to do things he/she does not want to do, who cognitively and emotionally evaluates this situation and feels partly helpless"* [my emphasis].

5.33 These definitions go a long way towards identifying why wind farm noise can be highly intrusive and annoying even at lower decibel levels. By interfering or

[26] World Health Organisation (WHO) (2000) *Noise and Health* Copenhagen: WHO

[27] Guski, R., Felscher-Suhr, U. & Schuemer, R. (1999). The Concept of Noise Annoyance: How International Experts See It. *Journal of Sound and Vibration*. 223(4) pp 513-527

disrupting activities in the home (by attracting attention away from the intended activity) and because of variable and tonal noise characteristics (typically evaluated as unpleasant noise characteristics) wind farm noise satisfies two basic and influential factors associated with annoyance.

5.34 Nuisance (and annoyance) as defined above concerns interference with rest and relaxation. A primary consideration therefore is whether there are features or aspects of the wind farm noise that directly impact this i.e. causing reduced ability to relax, rest and be calm, disrupting 'quietness'. Andringa and Lanser (2013) note the importance of a quiet environment in promoting restorative behaviour (rest, calm etc.) and highlight the detrimental and disruptive affect that annoying sounds can have.[28]

5.35 Andringa and Lanser (2013) use the figure below as a means of describing how the appraisal of our sound environment influences our reaction to that environment, what we feel like as a result and how we respond. The right hand side figure influences the left hand side figure, which in turn influences how we interact with our environment. The left hand side figure shows the relationship between unpleasant and pleasant feelings (horizontal axis) and arousal (deactivation and activation) (vertical axis). This is influenced by our appraisal of the sound environment, shown in the right hand side figure. The horizontal axis shows unpleasant and pleasant sounds and the vertical axis sound 'eventfulness'.

[28] Andringa, T.C., & Lanser, J.J.L. (2013). How Pleasant Sounds Promote and Annoying Sounds Impede Health: A Cognitive Approach. *International Journal of Environmental Research and Public Health*. 10 pp 1439-1461

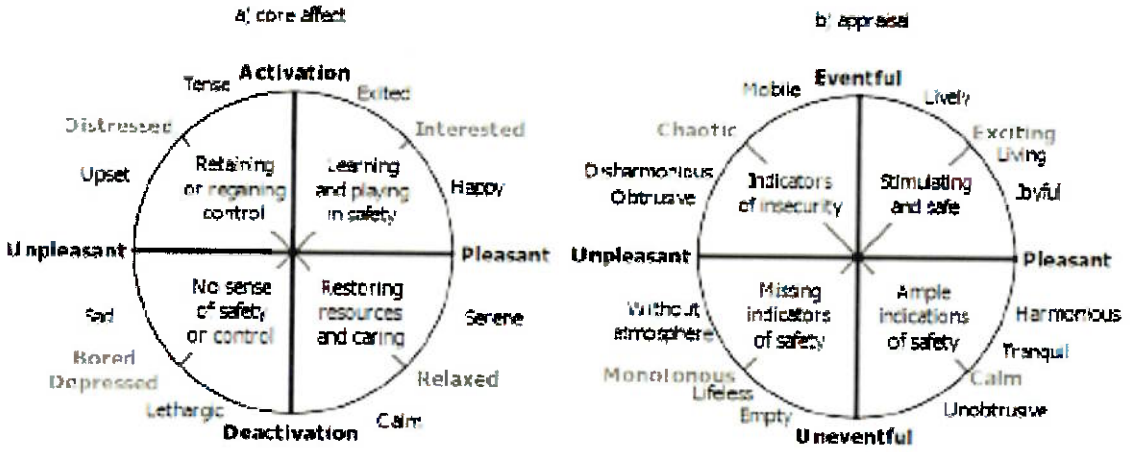


Figure 1: Interaction between appraisal of noise and how this influences emotional experience and arousal

5.36 With respect to wind farm noise, if either of the left hand side quadrants of the appraisal figure (right hand figure) are satisfied then a negative response, such as annoyance, will arise. For example, looking at the top left hand side quadrant, if the wind farm generates sound judged as unpleasant (e.g. loud compared to the underlying sound environment, or highly tonal sound) and eventful or chaotic (e.g. containing many characteristics, intermittent characteristics, unpredictable and changeable characteristics) then this will result in behavioural affects and emotional responses associated with being tense, distressed and upset. It will require more attention thus disrupting other activities by drawing on mental capacity.

5.37 The relationship between the perception of our sound environment and positive / negative feelings and arousal (core affect), and in turn how this can then impact on rest and relaxation (quiet) is described by the authors below:

"...boring sonic environments and sonic environments that contain annoying sounds lack safety indicators or are indicative of potential or actual danger. These environments function as exogenous motivators that force us to be more alert and/or to attend particular sources that then may come to dominate mind-states. Prolonged presence in annoying sonic environments reduces the freedom to self select adaptive behaviour, reduces opportunities for the proactive optimization of long-term needs, and leads to ensuing health effects." Andringa & Lanser (2013) [my emphasis]

5.38 The conclusions of Andringa and Lanser (2013) are concordant with Guski et al (1999). Annoyance is generated by interference and disruption of activities in the home and being forced by the noise to behave in a manner that was not intended or sought.

5.39 Wind turbine noise character.

5.40 There are many factors to consider when assessing noise impact. Historically the character of the noise, how this varies with time, frequency and duration of the noise and the character of the area have all been considered relevant to the existence of annoyance or nuisance. Many of these factors are referenced in the way that wind turbine noise is described by those affected.

5.41 Wind turbine noise and AM is commonly described by affected residents in various ways. Some of the descriptions are collated below and show the range of analogies and features attributed to the noise.[29] It is suggested that such a range of descriptions arise due to the alien nature of the noise, which those impacted struggle to try to correlate with other familiar and commonly arising noises in an environment.

[29] These are collated primarily from large wind turbines but many are equally appropriate for small wind turbine descriptors.

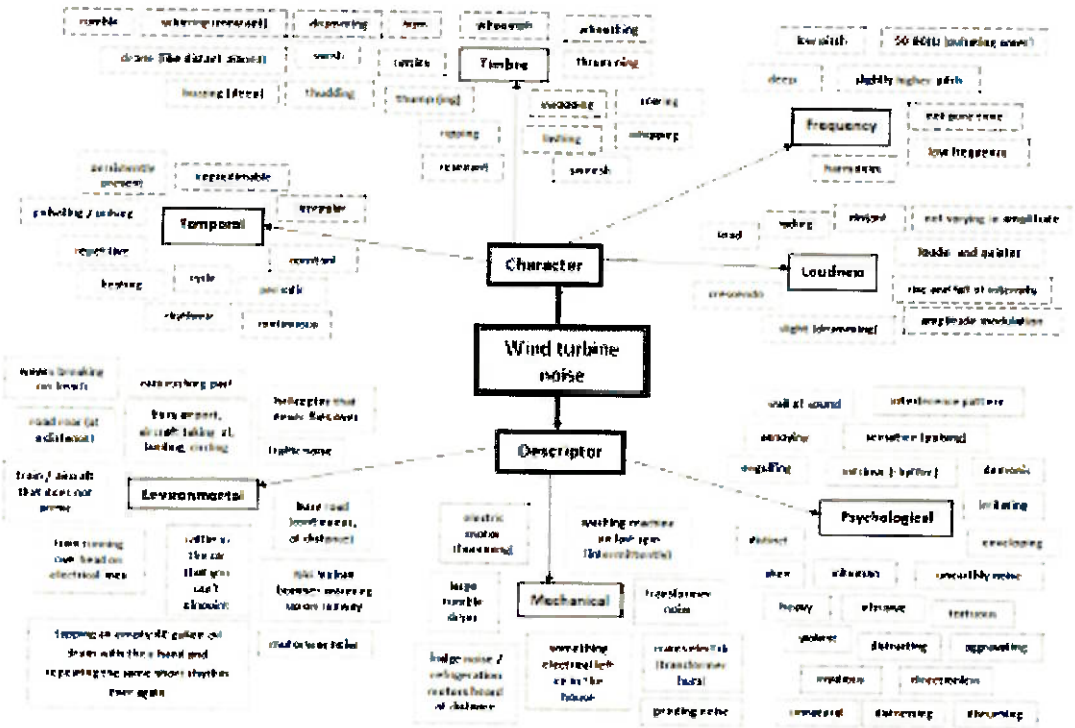


Figure 2: Terms used by affected residents to describe wind farm noise and AM

5.42 Amplitude modulation, which is a major feature of wind farm noise, itself exhibits different characteristics. Categories or types of AM could quite easily form a sub group of wind farm noise characteristics including, for example:

Regular AM where there is little variation or change in the level of AM (this could be linked with the 'repetitive' descriptor often used by those affected).

b) Erratic AM, where there is not a clear periodicity or rhythm but with individual AM peaks (often with a high peak to trough difference) can arise with little warning.

c) Intermittent AM, where the AM comes and goes, fades in and out - this is a fairly common feature.

5.43 The figure below shows some of the factors that can be considered when trying to assess the extent and severity of AM impact.

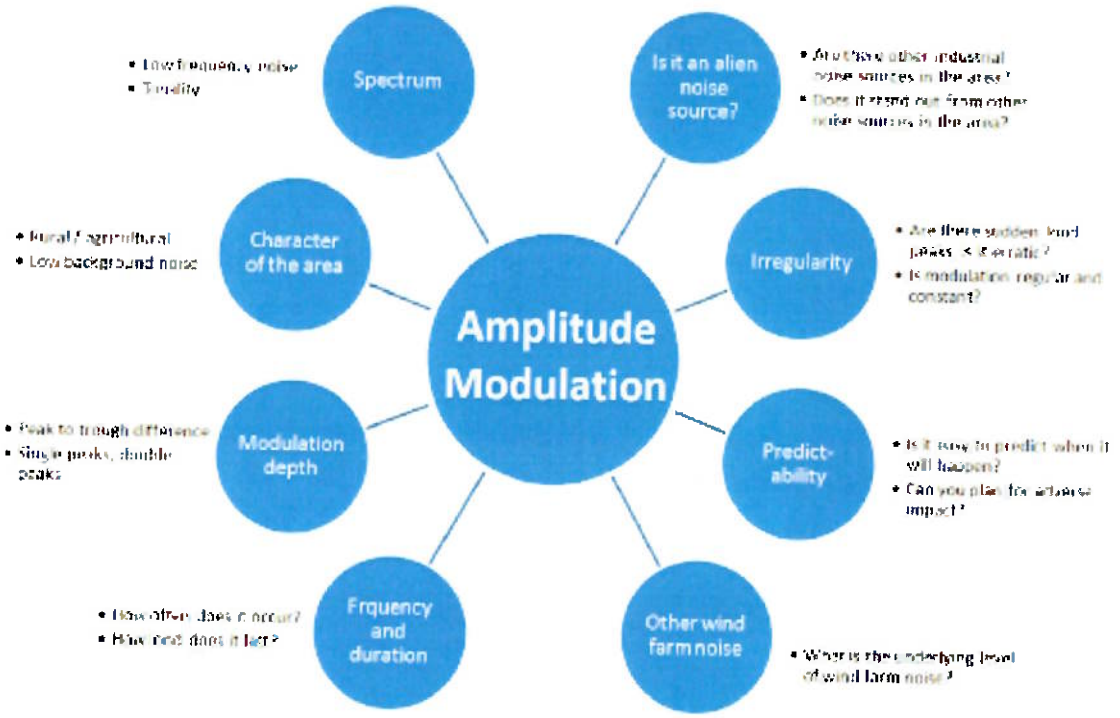


Figure 3: Aspects contributing to AM assessment

5.44 As already discussed, people react differently to sound and noise. Whereas some might not object to a certain level or type of wind farm noise, others clearly do find it intrusive. Why this is so and how it can be explained has been the subject of research but clear conclusions have not always been reached.

5.45 Several studies have found that annoyance is not necessarily related to sound level and that wind farm noise is more annoying at lower levels than other sources of noise.[30,31,32] Pedersen (2007) (2009) listed moderating factors as visual

[30] Yokoyama, S., Sakamoto, S., & Tachibana, H. (2013). Perception of low frequency components contained in wind turbine noise. 5th International Conference on Wind Turbine Noise. Denver.

[31] Pedersen E., & Waye, K. (2004). Perception and annoyance due to wind turbine noise - a dose response relationship. J. Acoust. Soc. Am. 116 (6) pp. 3460 -- 3470.

[32] Schäffer, B., Schlittmeier, S., Pieren, R., Heutschi, K., Brink, M., Graf, r., & Hellbrück, J. (2016). Short-term annoyance reactions to stationary and time-varying wind turbine and road traffic noise: A laboratory study. J Acoust. Soc. Am. 139(5) pp2949-2963.

impact, low background sound levels and lack of respite at night time. [33,34] Michaud et al (2016) found that response to wind turbine noise is related to the overall A weighted noise level but that communities are between 11dB and 26dB less tolerant of wind turbine noise than of transportation noise sources.[35]

5.46 Ioannidou et al (2016) focused on analysis of annoyance from AM and confirmed that for sources of AM of a fixed decibel level, modulation depth (peak to trough difference) was the primary determinant of annoyance.[36]

5.47 The research of my colleague Sarah Large at MAS found that differences between types of AM can clearly be heard and that differences in responses are largely a result of AM characteristics rather than sound energy levels.[37] Regularity, irregularity, constancy and repetitiveness were identified as both positive and negative features of AM whereas rhythmic features, low frequency sounds and drones / hums were all consistently identified as annoying. [37]

5.48 It is clear that there are many features of wind turbine noise and any one of these features might draw our attention, including changes within these features. The role that this has in wind farm noise disturbance is described by Gabriel et al (2013) [38]:

...he might wake up with the first peak of AM not knowing this was the reason, but half awake and listening if there might be some "danger". He might identify

[33] Pedersen, E. (2007) Human response to wind turbine noise - perception, annoyance and moderating factors. Göteborg: Göteborg University

[34] Pedersen, E., van den Berg, F., Bakker, R., & Bourma, J. (2009) Response to noise from modern wind farms in The Netherlands. J. Acoust. Soc. Am 126(2) pp. 634-643

[35] Michaud, S. et al (2016). Personal and situational variables associated with wind turbine noise annoyance. *J. Acoust. Soc. Am.* 139 (3) pp. 1455 -- 1466.

[36] Ioannidou, C., Santurette, S., & Jeong, C.H. (2016). Effect of modulation depth, frequency, and intermittence on wind turbine noise annoyance. J. Acoust. Soc. Am 139 (3) p.1241-1251.

[37] Large, S. (2016) A quantitative and qualitative review of amplitude modulation noise from wind energy development. Internoise 2016. Hamburg, Germany.

[38] Gabriel, J. et al. (2013). Amplitude Modulation and Complaints about Wind Turbine Noise. 5th International Conference on Wind Turbine Noise. Denver.

the wind farm as origin of noise with the next "peak" of AM and from now on it might be hard for him to rest or to fall asleep again.

5.49 Character of wind farm noise.

5.50 In contrast to a rural pastoral character, wind farms generate a mechanical and industrial source of noise that characterises the area as one in close proximity of and dominated by commercial / industrial activity. There is usually an overall increase in noise level that saturates the sound environment with broadband sound energy and masks many of the natural sources that would otherwise be heard.

5.51 In addition to the overall increase in sound energy there are additional characteristics associated with industry such as low frequency noise, hums, whines and AM that creates a cacophony of mechanical sound. It is a stark change to the otherwise quiet and tranquil soundscape devoid of such sources until a wind farm operates. It is an incongruous sound that can dominate and dictate the character of the area during day, evening and night and for sustained periods.

5.52 Spectral content of the noise.

5.53 The spectral content of the noise is usually variable and depends on the measurement location (indoors or outdoors) and the range of acoustic characteristics present. In turn these commonly depend on meteorological conditions, the make of turbine, distance and orientation. There are several key acoustic characteristics generated by a wind farm that have a specific spectral footprint. Lower frequency energy is commonly prevalent within the data. This can arise as an overall increase in low frequency energy (broad band) or with some tonality (specific third octave bands creating a humming sound) or with tonality and pulsing (a pulsing hum).

5.54 The presence of low frequency noise and hums / whines / tones is commonly associated with increased annoyance and is likely to make the noise more intrusive at lower levels than a sound of the same sound energy level but absent specific spectral content.

5.55 Regularity / predictability of the noise.

5.56 There is an element of predictability and regularly in wind farm noise impact from a wind farm. Whenever there is wind, there is likely to be impact and this will occur continuously until the wind farm is turned off or the wind drops. However, the level and type of impact is highly unpredictable. AM can arise for short periods or bursts within a longer period of sustained general wind farm noise impact or continuously for several hours at a time. Similarly, low frequency noise can arise briefly as a pulsing hum or for longer periods. No clear pattern to the type of noise impact that will arise is seen and the severity of noise impact is readily variable but apparent. The lack of predictability prevents residents from implementing effective coping mechanisms such as planning social events.

5.57 The impact of the noise on basic needs such as sleep and communication.

5.58 Wind farm noise level is never of a magnitude that would cause speech interference or would likely mask speech or other typical household sounds. However, it is of a level that is clearly audible and could cause annoyance or interference with other sounds and activities. The level and nature of impact is commonly of a type and magnitude that would be expected to result in sleep disturbance.

5.59 Levels of internal low frequency noise measured within bedrooms often exceed the Defra low frequency noise curve. Average internal noise levels also commonly exceed the threshold set for sleep preservation for steady continuous noises, such as road traffic noise. This is often the case as attenuation moving inside can be low. Attention is highly likely to be drawn to the noise of the wind farm due to acoustic features such as pulsing, tonality and AM and this is highly likely to interfere with the return to sleep once awoken.

5.60 Cumulative impact of noise intrusions

5.61 The noise impact from a wind farm can be treated as a whole (a single impact) and this is reasonable for many aspects of the noise. However, the location of different turbines relative to a dwelling can result in what appears to be multiple sound effects arising from different turbines. This particularly relates to AM. The effect of multiple characteristics arriving from different turbines and different

directions will have a cumulative impact on the sound environment and how the sound is perceived, creating an impression of being surrounded by the sound. Localisation of multiple sources also constitutes another aspect of the wind farm noise that will draw attention (making the noise harder to ignore).

5.62 In addition to cumulative noise impacts, there may also be the cumulative impact of shadow flicker and noise. It is not possible to quantify this cumulative effect.

5.63 Annoyance

5.64 Many of the factors discussed above are clear indicators of annoyance. Unlike other sources, for example transportation or industrial noise, the wind farm noise can occur 24/7/365 for as long as there is sufficient wind. Transportation sources would typically reduce at night time and strict controls are typically placed on industrial activity to either limit frequency and duration of intrusive sources or reduce the overall dominance of the noise if it is to occur regularly. Such controls and restrictions are not in place for the majority of wind energy developments. Thus, the wind farm noise is constant and therefore conflicts with day to day living far more so than many other sources of noise.

5.65 The lack of respite and lack of escape from wind farm noise is another factor readily associated with annoyance. A lack of control over an intruding noise or a lack of control over your environment is a common cause of annoyance. Residents have no control over the noise from a wind farm and there are no controls on its operation to the extent that there are no predictable or guaranteed periods of respite. For example, there is no ability to cope with a noise that occurs all night in the knowledge that the next night will not be affected.

5.66 There is commonly a lack of escape from the noise. External amenity areas at dwellings are commonly affected and it readily penetrates residential buildings leading to no where to escape it except leaving the area. When inside the wind farm noise remains clearly audible and dominant with windows open in most cases. In many cases aspects of wind farm noise are also audible indoors with the windows shut. As such, to escape entirely from the noise residents must leave the dwelling or generate a source of masking noise within the dwelling. The lack of control and extreme coping responses needed remove autonomy of

residents' actions and living within their own home. This is highly likely to lead to annoyance.

5.67 There are many other factors of annoyance discussed including common explanatory themes that arise throughout discussion papers on noise annoyance. If a sound attracts attention, if it is incongruous with the sound environment absent the specific sound, if the sound is much louder than other pre-existing sound sources then annoyance can be expected to arise. Such factors commonly arise in the case of wind farm noise. Multiple acoustic characteristics generated by a wind farm will attract attention for that reason alone.

5.68 A mechanical / industrial wind farm source of noise is an alien sound in an otherwise quiet, rural soundscape. Most wind farms generate substantial increases in sound energy above pre-existing background and ambient sound levels for significant periods but this is lost with averaging times when they do not.

5.69 Guski et al (1999) found that annoyance was mainly a result of "(1) immediate behavioural noise effects aspects like Disturbance and Interfering with intended activities, and (2) evaluative aspects like Nuisance, Unpleasantness and Getting on one's nerves".[27] The evaluative aspect of any wind farm noise commonly fits with annoyance, nuisance, unpleasantness and 'getting on one's nerves' responses.

5.70 Andringa and Lanser (2013) highlight the importance of 'quiet' in a sound environment. A level of quiet is needed to promote restorative behaviour. The presence of a quiet or restorative environment is marked by aural cues as to the safety of the environment. It would normally include aural cues such as wildlife sounds, birdsong.[39] These sounds are commonly masked or subsumed within wind farm noise and as such the wind farm noise works against aural cues that promote rest and relaxation.

[39] Natural sounds are typically considered with safety and lack of danger. For example, the sound of a forest or jungle will suddenly be silenced by the presence of a predator. This effect is commonly used in film scoring to indicate imminent danger or cause for concern.

5.71 There is a clear case for expected heightened annoyance with most wind farms for multiple reasons. Empirically there is a significant increase in noise and this is accompanied by acoustic character (multiple features) that attract attention and render the noise more annoying, harder to ignore. Qualitatively the noise conflicts with periods when residents would expect greater freedom from noise. It conflicts with and disrupts periods of sleep. There is a lack of control over the noise, lack of respite from the noise and limited escape from the noise. The combination of all of these factors commonly result in a state of affairs where it is expected residents to be highly annoyed. This arises at the levels which would comply with these draft guidelines.

5.72 This submission is by me based on my analysis of the draft guidelines but is extensively informed by much of the research and analysis of criteria, especially included in Part 2 that has previously been prepared by Sarah Large.

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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.

Main image: Sound waves that are disruptive, alien, unwanted, occurring in the wrong place, at the wrong time or otherwise in an unexpected way (context), are usually considered noise

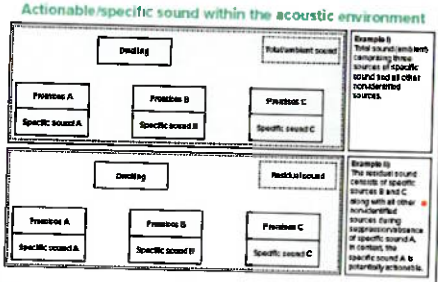
When is sound noise?

In air, sound is an aural sensation caused by pressure variations. The pressure variations are waves of energy. Sound is the human perception of those pressure waves via the hearing mechanisms located within the ear as interpreted by the brain. The pressure variations are transmitted via the middle ear (air), inner ear (fluid) and converted into nerve impulses mainly within the cochlea. The nerve impulses are detected and interpreted by the brain.

The perception of a sound, whether desired or unwanted will depend on a wide range of acoustic and non-acoustic factors, memories, associations, sensitivity and expectation. Sound can have positive psychological connotations such as a songbird reminding the

"The perception of a sound, whether desired or unwanted, depends on a range of acoustic and non-acoustic factors, memories, associations, sensitivity and expectation."

Actionable/specific sound within the acoustic environment



listener of nature. This provides a positive association with the acoustic environment. Where sound waves are disruptive, alien, unwanted, occur in the wrong place, at the wrong time or otherwise in an unexpected way (context), is usually considered noise.

Categories of noise and description of sound in context

In England, the Department for Environment, Food and Rural Affairs (DEFRA) within the Noise Policy Statement for England (NPSE) 2010 recognises noise as falling into three categories:

- 'environmental noise' which includes noise from transportation sources
- 'neighbour noise' which includes noise from inside and outside peoples 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[1]

Noise affecting sensitive locations such as dwellings can fall into any of the categories both externally and/or internally. The total (ambient) sound encompasses all categories of noise. Sources of actionable noise most commonly fall into the 'neighbour' and 'neighbourhood noise' category. The specific sound is emitted from a specific source and usually identifiable by the receiver within the acoustic environment as to where it emanates from and what it is caused by. The total, specific and residual sound is illustrated in Figure 1 above.[2]

In Figure 1, example i shows a dwelling juxtaposed with premises A, B and C. The premises operate independently, and each emit a specific sound respectively, also as A, B and C. The grey area represents the total sound comprising all sources near and far. In the context of example ii, premises A emits a specific sound of noticeably different character. Premises B and C along with all other non-identified sources of sound within this example acoustic environment contribute to the residual sound, as observed when the specific sound from premises A is suppressed. The occupants of the dwelling consider the specific sound emitted from premises A to be unwanted (noise) and intrusive within the context of a residential receiver. Depending on the context and different approaches to analysis in each of these two examples, the specific sound can be considered as part of the residual sound or as specific sound that is intrusive and unwanted at the residential receiver. 'Context' can therefore have widespread interpretation and application.

The term 'context' is increasingly used within environmental management and noise assessment. A wider definition suggests context is *"A set of physical (geographical, topographical, meteorological, and structural), social, psychological, cultural, situational conditions, relevant to determine a particular individual or collective behaviour, attitude, emotion toward an environmental stressor"*.[3] 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.[5,6]

Above: Figure 1

Situational factors and psychological reaction

Noise is commonly defined as unwanted sound or sound without value. Noise may arise in a variety of situations from a dripping tap, someone else's loud telephone conversation, an intruder alarm or sound including unusual or otherwise irritating features that disrupt thought processes. Conversely, the greater our mental effort or concentration on a task, the less attention we pay to other stimulants such as noise. As a result, noise disrupts activity such as relaxation and rest to a greater extent than activities requiring higher concentration. For example, undertaking manual work tasks, concentrating on an important telephone call or cutting a hedge.

The term 'noise' introduces a subjective (emotional) based response element to the individual's decision of whether a sound is wanted or unwanted. It is normally an unconscious response. It is important to note, whether a sound is noise and whether that noise is expected or annoying is dependent upon the circumstances (situational) factors in which sound is received. For example a relatively quiet dripping tap may be thought of as not too annoying but can prevent/disturb sleep if audible in a hotel bedroom at night when it is otherwise quiet. Likewise, an objectively loud audible intruder alarm sounding on the streets of towns and cities during the day may cause little annoyance to a transient listener but with the same sound energy level can become a serious annoyance when repeatedly malfunctioning at 2am in a residential neighbourhood. 'Noise annoyance' can be defined as negative feelings of dissatisfaction, displeasure, disturbance or irritation caused by a specific sound.[8]

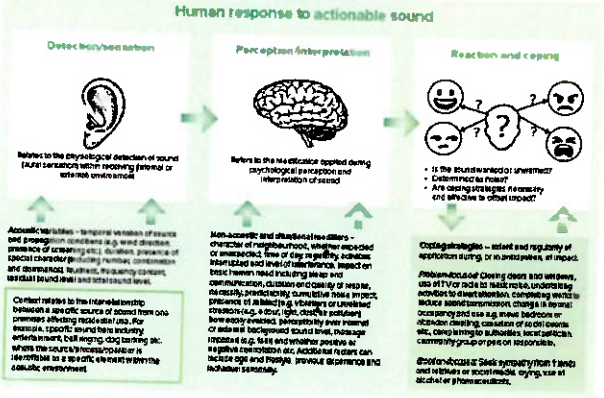
A loud telephone conversation of another passenger can be very annoying when trying to relax, read or concentrate on a long train journey. The speech content and use of language is likely to continuously trigger attention. However, the person making the call is less distracted by the noisy environment around them as they are concentrating on the call. These aspects of annoyance are far less determined by the decibel level other than in relation to audibility and possibly dominance, but by the constituents of the sound (character, message imparted to an inadvertent listener etc.) and how they are perceived (expectation, level of interruption etc.) in context.

The likelihood a sound is considered noise and will cause annoyance is multifactorial. The individual interpretation and reaction includes modifiers such as attitude/perception of the source and source operator, attitude to the message imparted, necessity to community, life, perception of control over the specific source, individual sensitivity and sensitivity to any specific characteristics present that grab attention i.e. disrupt rest, relaxation or activities requiring concentration. This is shown diagrammatically in Figure 2 below.

Figure 2 shows the detection/sensation, perception/interpretation and reaction/coping at the individual level.[9] Sensation relates to the physiological detection of sound and acoustic variables. Perception/interpretation refers to modification due to non-acoustic and situational factors applied during the psychological processing of sound within an internal or external environment. Non acoustic factors can arise from unconscious or conscious responses. Reaction follows psychological processing and modification to determine whether the sound is wanted or unwanted. Problem-focused or emotion-focused coping strategies may then be applied which are multidimensional and situation specific.[10] Coping strategies can be maladaptive, for example, the use of alcohol to sleep during repeat noise exposure. This form of maladaptive coping can lead to unintended adverse health outcomes. The aim of coping strategies is to counteract adverse impact arising from exposure to the noise stressor, usually in a way that disrupts desired lifestyle the least.

Interpretation also depends on related memories, for example if a particular activity (neighbour's party) led to disturbed sleep at an important point in lifetime then any related memories to noise from that neighbour could trigger emotive responses relating to the historical experience. One example would be a party affecting sleep the night before an exam and such recurrence is likely to more readily trigger negative response. The specific sound arising from industrial/commercial use is likely considered wanted by staff or those associated with the business as it informs on operations and imparts a positive (economic) message. However, it can be considered unwanted by residents when received in the context of a home environment where there is no equivalent positive message or perceived benefit.

Below: Figure 2



The aural experience will also depend on the condition of the ear and especially the inner ear which changes with age, exposure to excessive noise (sustained or sudden) and natural/genetic variation. Age introduces changes into this evaluation of noise both in terms of physiological and psychological changes where loss of hearing capacity due to presbycusis means generally there is less recognition of higher frequency intruding sounds.[11,12] Conversely the increased range of memory of different sounds, voices of individuals and exposure to societal experience introduces greater causes of distraction where attention is unconsciously drawn. Thus, a young child will recognise and be drawn by a parent's voice but not attracted by a wide range of sounds it has little experience of and therefore memory of. This has been demonstrated with smoke alarms where children who have not experienced the alarm may sleep through it but those trained to respond and treat the noise as a sign of danger (imparts a message) or is based on a known voice will more readily awaken.[12]

Cognition and habituation

Unlike other environmental stressors such as light, noise cannot be 'shut out' physiologically by the body.[14] However, habituation to some forms of noise does occur when the message interpreted by the brain is determined as not presenting a risk of the need for fight or flight (psychological and physiological stress response) such as road traffic noise. Humans typically habituate to noise that does not impart a message of concern. Similarly, a noise may not trigger psychological stress responses as there is no perceived threat but nevertheless draws attention because it triggers unconscious responses such as recognition of the noise and what it represents.

Humans are continuously and unconsciously listening. Humans aurally observe the environment for threat even when asleep which may trigger awakening in response to salient, sudden or loud sounds. This appears a natural response meaning it is difficult to prevent either awakening where the brain perceives a response may be needed, or attention when awake for example, triggering a memory such as from a known voice. Equally, alien and unrecognised sounds will trigger attention and awakening as the brain will be seeking input from all senses in a conscious state to determine its source and, whether it carries a threat or other message. These responses do not require loudness but sufficient recognition or degree of unconscious concern to trigger awakening. As a result, P14

14. For example, where eyes are exposed to high levels of light the eyelids can close and the iris constricts. There is no alternative or comparative mechanism for aural protection albeit it is understood there is a physiological mechanism of dampening to muscles connected to bone within the ear in response to sudden loud noises e.g. the middle-ear reflex/stapedius reflex.



Below: Sources of actionable noise most commonly fall into the 'neighbour' and 'neighbourhood noise' category

awakenings and distraction when awake arising from alien, unwanted or disliked sounds is not directly related to its loudness and more a factor of its detection, perception (audibility) and identification (interpretation) whether conscious or unconscious. An observer's auditory impression of the relative strength or intensity of the sound is less relevant once identified in a particular situation and humans do not normally relate its them in terms of their loudness in such cases. This is recognised in particular by the courts in nuisance cases.

Other effects include the 'irrelevant speech effect' which is an example of an effect that doesn't depend on the intensity of the noise. The irrelevant speech effect is the finding that performance on immediate serial recall tasks is impaired by the presence of background speech, even though the background speech is completely irrelevant to the task.[6]

In cases of continuous or constant noise exposure, for example distant road traffic noise, habituation occurs reducing adverse response at the individual level. However in cases of repeat exposure to actionable noise, sensitisation occurs where the message causes increasing alertness or alarm due to the absence of physical or emotional coping.[6,7] The determination of sound as noise, depends upon which type of response is triggered, whether we habituate to it and thus the negative response reduces and the consequence of the response such as awakening, disruption 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.



Above: Sound can have positive psychological connotations such as a song bird reminding the listener of nature

Noise impact on humans

There are generally two categories of sound source. The first are commonly classified as anonymous sources such as road, rail and aircraft. They are anonymous as we do not unconsciously associate them with a particular person or operator. Thus, when heard they less often draw our attention. They are normally present daily without exception and thus become embedded in memories that do not trigger the need for conscious response.

Sound from transportation is generally considered unwanted and defined "environmental noise" by national noise policy.[8] Impact is primarily related to energy dose and physiological effects of a high level of continuous sound energy causing sleep disturbance, annoyance and triggering hormone type responses. Adverse health effects from transportation noise (anonymous) arise primarily relative to their decibel level and transportation type causing impact (rail/road/air). It can be time specific such as where activity only arises at certain times, for example holiday traffic or operations of a port relating to ferry times. In most cases adverse impact follows a dose-response relationship and daily impact where an increasing decibel level of exposure increases the incidence of adverse health outcomes. A systematic review of evidence by the WHO (2018) identified different trigger levels for air, road and rail traffic.[9] Health effects including but not limited to annoyance and sleep disturbance are recognised to impact at certain trigger/onset levels of sound energy where a stepwise change occurs in the percentage of a population adversely affected.

Environmental noise affects everyone in society to varying degrees. Transportation noise can include special characteristics that require consideration (e.g. low frequency noise from aircraft) and reaction is influenced by non-acoustic and situational factors. One outcome is the development of different guideline levels for aircraft, road traffic and rail noise as provided in the WHO 2018 and the necessity for individual evaluation. There is a recognisable benefit of transportation sources, socially, for mobility and movement of goods. It is long recognised humans tend to habituate to low levels of distant or localised road traffic noise over time as it does not threaten safety (impart a message of danger) or trigger a 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 characteristics to the point it does not normally draw attention or directly relate to some other stressor. Such sources are not normally actionable in law and complaints do not result in direct regulatory action. Exceptions do occur such as a very noisy exhaust on a motorbike and military flying.

The second category is effectively actionable noise. This sound and its circumstances of impact typically contain acoustic and non-acoustic characteristics. Non-acoustic factors, generally are considered to be all factors other than sound level alone which contribute to noise annoyance and similar effects.[10] This can include a wide range of sources such as music or noise from an industrial site associated with a particular identifiable activity, process or operator. If the responsible person/individual or business) can be identified it is more likely the resulting impact will be perceived as noise by the receptor. Related memories will increasingly be set down as the noise is experienced and reinforce negative responses increasingly over time. Sound with this character unconsciously draws attention associating adverse response with the source process and person or organisation responsible. As a result, non-acoustic factors associated with the source add to impact (interpretation) and psychological stress caused by the noise (reaction) resulting in the application or coping strategies.

The source recognition and unconscious response, to the process or person responsible, become more readily identified in the brain resulting in increased sensitisation and drawing of attention. Over time, improved recognition develops in the same way a musician recognises faults with their instrument and a conductor recognises what part of the orchestra is at the wrong tempo or dominance. Heightened sensitivity is a normal human reaction following repeat exposure and should not be confused with individuals who may exhibit 'over-sensitivity', generally, to noise i.e. hyperacusis. This leads to a general principle that humans tend to habituate to environmental/transportation noise but sensitise to noise with attention drawing character or that imparts an adverse message. Important parameters include lack of controllability, unpredictability and where a noise is considered unnecessary. Intermittent (non-continuous) noise can have a greater effect on reaction due to the modification attributable to these non-acoustic and situational factors.

Impact from actionable noise with specific acoustic characteristics is determined more by non-acoustic factors such as regularity, times of occurrence, duration and quality of respite periods, message imparted and how individuals interpret it, character of the neighbourhood and what activities are affected. Audibility, dominance, attention grabbing, regularity, duration, times of occurrence and what is disturbed are important non-acoustic and psychoacoustic factors. One example is music bass beat from specific premises where music emissions are regularly audible. Regardless of decibel level, when observed inside the home they are widely recognised as unacceptable. Even when infrequently occurring at night it is recognised as unacceptable as it will disturb sleep, it does so not because of its decibel level but due to the detection and interpretation by the receiver and human responses which trigger awakening or impede mechanisms which lead to the onset of sleep. In the case of bass beat within music, there are two primary effect multipliers including the low frequency content and regular modulation. There are generally multiple reasons for increased human response including expectation and message imparted (speech). In such cases assessment is based on the acoustic characteristics, the mechanisms by which it intrudes, when it occurs and its frequency and duration along with other non-acoustic factors. Other acoustic factors are also important and can include the spectral distribution and changes in level along with the duration of such sound energy levels.

Relationship of noise character and loudness to 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, ➡

9. Exceptional 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 it convenient or financially beneficial to the operator however, it would likely be considered noise when received in a home environment to a resident living close by & annoying and many complaints arise.
10. For example, those at a late-night party enjoying themselves at the cost and disregard of others losing a night's sleep.
20. Determined through experience of both authors and feedback from the training of local authority officers responsible for the investigation of noise complaints and enforcement.

"It is generally recognised within planning policy and guidance, that once there is a high sound energy dose in an environment the tolerability of additional noise is reduced particularly where it has attention drawing character."

that once there is a high sound energy dose in an environment the tolerability of additional noise is reduced particularly where it has attention drawing character.[21]

It should be recognised quiet environments generally experience increased incongruity by intruding noise particularly where they are not expected. However, in a loud and cacophonic sound environment, low levels of additional noise may not increase attention disruption as there is already a wide range of ongoing attention-grabbing sounds triggering greater attention on tasks in order to avoid disruption. In that instance, the brain is flooded by such effects leading to more complex human responses including potentially a general increased unconscious avoidance of exposure.

Consider an evening environment impacted by a loud relatively steady roar of road traffic at levels of 55dB LAeq,T 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,[22] imposing the same music in this cacophony/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 discernability 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 dB(A) level is insufficient to determine whether a specific sound is considered acceptable particularly where certain acoustic and non-acoustic characteristics are present. Whilst pressure variations in the air are a form of energy that can be measured using scientific instruments the reaction to sound is predominantly psychological. This includes within both source noise and residual and background sound environments. The assessment of actionable noise requires more than an understanding of acoustics particularly as knowledge and research into noise with special or specific characteristics is limited.

It is possible complex noisy environments may exhibit a greater tolerability of additional characterful noise than less complex quieter environments and is an area for future research.

There are too many variables to provide precise levels or decibel ranges to such influencing factors, but we can draw reasonable conclusions. For example, where a noise is both loud and attention drawing, it does not become acceptable by simply reducing its loudness when still above the point it continues to draw attention. The latter element is less related to loudness and more related to the acoustic characteristics or message imparted by that noise which do not disappear until it is no longer discernible.

When undertaking noise impact assessments, it should be remembered noise falls into distinct categories and the resulting level of annoyance or stress increase can be dependent on a variety of acoustic, non-acoustic and situational factors independent of the decibel level. Dominance, audibility, noisiness and attention drawing elements needs to be analysed along with all the other factors discussed such as message imparted, frequency and duration but which can be further complicated by the constituents of the existing sound environment. Other factors such as additional environmental stressors within the receiving locale are also important.

21 For example, when considering context in BS4142:2014+A1:2019: Methods for rating and assessing industrial and commercial sound. London: BSI. Reference to 'absolute level' within online planning noise guidance. See https://www.gov.uk/guidance/noise--2 accessed 20/12/19.

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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 Selectaglaze office and factory.

Formerly known as the Rainalds Hatfield, the Comet's multimillion pound refurbishment, which began in 2017, is now complete. A new three storey extension block annexed to the rear of the hotel has added a further 52 rooms, which reflects and enhances the silhouette of the heritage building. This new extension is shared with a student residential development.

In addition, the hotel has also opened its own independent restaurant, 'Element Bar & Kitchen'. A replica of the Comet Racer mounted on a 20ft high pylon stands tall outside the hotel.

The hotel had retained the building's original Crittal sash windows, but this did not provide the required level of noise insulation to a number of the guest rooms, restaurant and function spaces.

To remedy this, St Albans-based Selectaglaze installed 104 secondary glazed units. The secondary windows were made bespoke to ensure the best fit and included four different systems, specific to the project's needs. All units were finished in white to match the original external windows.

The new secondary glazing to this Hatfield landmark will help lower energy bills and afford the guests a good night's sleep, and those visiting the hotel will be guaranteed a pleasant experience.

Hotel refurbishments are often fast-track projects requiring close cooperation between client, contractor and specialists. Selectaglaze has wide experience of working in buildings up to Grade I listed and offers a technical advisory service and specification advice to ensure correct interface with other trades.

Established in 1966, Regal Warrant Holder Selectaglaze is the leading specialist in the design, manufacture and installation of secondary glazing and will be exhibiting at Future Build 2020 from 3rd – 5th March 2020.

For further information, please contact Selectaglaze on 01727 837271
Email: enquiries@selectaglaze.co.uk
Visit: www.selectaglaze.co.uk

Appendix 2 : 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.

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Executive Summary

While ongoing for decades, more recently recorded consecutive years of rising oceans and mean global temperatures with increasing patterns of intensifying storms and fires have only heightened Man's resolve to fundamentally change worldwide dependence on fossil fuels. We are now responding with a sense of urgency. "Renewable" energies, particularly wind and solar, among other renewable sources, have been promoted as"winning solutions". Photovoltaic (solar) energy has become more affordable and is utilized more in sunnier locales. Commercially, beginning in northern Europe, Industrial wind turbines have, over three decades, spread rapidly across the globe. With increases in size to achieve increased power generation capacity, they appeared in the U.S. initially as a novelty but have been rapidly proliferated without a "proper introduction". Seemingly simple and intuitively harmless in design and implementation, when placed too close to human habitation, serious problems have occurred. It is as though we "leaped before we looked".

I am a Cardiologist who specialized in heart rhythm problems and I am providing a personal statement primarily focused on the adverse health effects (AHEs) arising from industrial wind turbines (IWTs).

A bit of history ties my interest to this concern:

Over two years ago, the "legitimacy" of industrial wind turbines as a source of SAFE and sustainable electricity was suddenly thrust into my life. This appeared as a "benign letter" from a local energy provider. Proposed, was a 52 turbine farm to be erected close to my property… a place protected by a conservation easement for having a few remnant prairie hillsides. In the surrounding miles, grazing and row-crop agriculture was the focused livelihood. These communities are the definition of an extremely quiet "rural residential" landscape. I knew almost nothing about wind turbines and, like nearly everyone, thought they were quiet, good for the world and assumed they were safe. In the ensuing weeks, public meetings were held where interested citizens had a chance to voice their opinions and concerns. Despite very time-limited presentations, it became obvious that opinions had rapidly polarized, shifting the debate from county vs an outside faceless large corporation to neighbor vs neighbor. Mid-American Energy (MAE), the Wind contractor, was there to answer questions but provided no hand-outs nor substantial didactic information. They sat in a group being largely silent, they only returned brief, limited answers when questioned. There was an industry physician-consultant from Boston who presented his opinions but no facts or data, and directly dismissed that noise related complaints were "real". Instead, (he implied) that those complaints were mostly imaginary physical or mental consequences from the presence of the IWTs. Any reasonable person present walked away after the meetings having no idea what health ramifications from IWTs might occur. The word "obfuscation" (the action of making something obscure, unclear or unintelligible) appeared in my mind.

Wind Energy's Position about Adverse Health Effects:

In these initial Board of Adjustment, and then later Board of Health meetings, **Wind Energy maintained their "position":**

1) **that** Industrial Wind Turbines are safe - yet without qualifications of how that self-designation of "SAFE" was given" – no studies, records and evaluations of structure failures, etc. They almost always follow the "safe statement" with boasting of the number of IWTs they have placed in Iowa and the revenue to the state, jobs created, and on and on, but never have provided evidence that scientifically proves "they are safe". Wind energy has limited "original" investigative research. Often a panel judges whether existing data supports the assertions by scientists that IWTs do cause AHEs. The subsequent peer review become akin to judging "opinions with opinions". Importantly, "indirect" impacts, which Wind Energy routinely ignores, are just as significant to the people who are impacted as are "direct" impacts. In fact, there is an enormous amount of data linking IWTs noise emissions to direct and indirect AHEs. Thorough and objective reviews of Wind energy's claims have been challenged and previously "debunked" (Punch and James, 2016). When challenging Wind Energy's representatives with the assertion that "industrial wind turbines have never been proven or shown to be safe", the don't respond – almost as a "taught response". Yet, after a Board of Health meeting, even one of the "pro-wind" Iowa Environmental Council academic speakers did agree with me that IWTs have **not** been proven to be safe.

2) **that** they (MAE) receive very few complaints… eventually they resolve. They contend that the "nocebo effect" accounts for most resident complaints. In this context, the nocebo effect is the association of symptoms and complaints "brought-on" by existing negative attitudes toward IWTs.

3) **that** there is no credible evidence that IWTs cause cardiovascular disease or metabolic disease.

4) **that** they reluctantly admit that some of "their studies" show that IWTs cause "annoyance" but reflect that it has no substantial health impact. Wind Energy, never comments about IWT-associated "severe annoyance" that causes resident evacuations of their home (which is also considered an adverse health effect).

5) **that** they will not admit that IWT noise causes sleep disruption. Strongly connected to this is their assertion that infrasound and low-frequency noise (ILFN) as a product of IWTs, accounts for a small part of the IWT noise and that infrasound cannot be heard and therefore cannot cause harm. Indeed, they firmly contend that ILFN is of no concern and strongly insist it should not be regulated.

I have carefully reviewed Wind Energy's position on all these adverse health effects. I have searched for definitions, textbooks, articles, and the presence and quality of reported peer-review. When defending their assertion that IWTs are safe, Wind Energy speaks both slowly, and definitively then "hides" behind the spoken words "no credible evidence". A reasonable person would ask "What would Wind Energy consider as credible evidence" and, as a concerned resident, what "credible evidence" have you produced that proves that IWTs are safe?

Purpose of this Manual

In this manual, I have collected information – first for myself - to clarify and resolve my questions and concerns. As the answers became evident (though admittedly difficult to find, clarify and integrate), the story of how this "intrusion" happened became clear and I share it with you. This manual will hopefully later serve as a resource for all who will question what health risks (as known in 2020) may be associated with living close to industrial wind turbines. This information took several years to collect. The process by which Wind Industry acquires county permitting is "rushed through" in literally only several weeks making this information, given that inconsiderate timeline, virtually unobtainable.

In this manual, I present evidence supporting my opinion that Industrial Wind Turbines (IWTs) will cause adverse health effects when located near residential properties in formerly quiet rural residential communities.

Beyond the potential serious health implications… we all need to fully understand and reflect carefully on the full implication of what these behemoth oscillating blades mounted high on towers will do to our personal and social and environmental communities.

I present relevant aspects of IWT-generated noise - including noise classification and its quantitative labelling through frequency and decibels measures and types of weighting through various filter types and how accurate noise exposure quantification is affected by filtering choices. The unique characteristics of IWT noise are reviewed and compared with other environmental noises. I will review the categories of noise frequencies across the entire range of emission of IWTs and important aspects of noise propagation and attenuation.

Please view the table of contents for contained subjects; ALL of these subjects are relevant. The reader **must NOT stop** at the simple debate of "he said vs she said" about health impacts. I found the answers largely in what "wasn't said" and past "acoustical history" and current corporate behavior.

I will highlight important historical events that add to the context of today's IWT regulation. For example, we need to be fully aware that VERY in-depth evaluations were done in the mid-1980s by NASA and the Dept of Energy-funded research. Scientists (N.D. Kelley, et. al.), in their thorough (basic science-level) investigations, were asked to evaluate the potential possible implementation of IWTs for adverse impacts. Their focus was on understanding the physics of

wind turbine operation and energy production. They also studied noise types produced by IWTs and observed and reported on the first confirmed cases of adverse health effects that developed with IWT prototypes up to 4 MW in generating capacity. Their initial determinations of ILFN and associated serious AHEs were first raised then and remain relevant to this day, although ignored by Wind Energy and its proponents. Also revealing is the history of acoustical evaluation of health-impacted occupants of some newly erected buildings from the 1970s to 1990s that was characterized as "sick-building syndrome".

Recognized in affected subjects, were similar symptoms connected to working near gas-fired turbines. Careful evaluations confirmed that ILFN from indoor HVAC (heating/cooling units) produced the symptoms.

Fortunately, buildings can be re-designed, defects in air ducts fixed, and additional sound insulation placed, but the only way to eliminate ILFN from IWTs is to turn them off or distance them from residents and their property far enough away that the ILFN can no longer be heard nor "perceived".

There are other issues besides adverse health effects:

It is important to ask questions and demand that they be answered; DO NOT assume that what Wind Energy is telling you is correct. Questions, such as "where did these setbacks come from? How, based on what we know, can we have setback distances that are so close and still be considered 'safe'? Whose responsibility is it to review these setbacks and decide if they are safe? How did Wind Energy's proclamation that ILFN 'is not a health concern' ever become "accepted?" Why is potentially harmful noise pollution allowed to trespass across the private land of non-participating neighbors – particularly when pollution regulation for other industries occurs up to/at the property line?" I still ask whether the MAE's land easements (for the entire host property) and the value of that land is used as collateral for the financing of the purchase and erection of the wind farms? If it is, what happens to that land ownership in the event that America comes to: 1) reject the denial of Wind Energy's adverse health consequences, **and also** 2) see that Wind Energy is not "green" and requires concomitant availability of back-up natural gas-burning that essentially negates any "renewable" aspects **and** 3) realize that the real cost of that electricity is roughly 3 times the cost of conventional electric power/kw of energy produced once the subsidies are factored out. Shouldn't we be building energy power plants that work nearly all the time (instead only one-third) and have a productive life of at least 40-50 years **and** 4) understand the extraordinary expense not only to maintain a functioning turbine but also related to eventual turbine/site decommissioning and non-recyclable blade disposal costs.

Where does all that money come from? Fifty-eight-year leases are a long time – generations come and go, political party majorities and Presential decrees that control the narratives keep flipping and MUCH better power production sources will become available. We need to think more about this before "leaping further."

I include in "Part 9" important findings while searching for an explanation of why inflicting harm on people living in host communities is "acceptable". To understand why things don't make sense you often have to explore the motives of – (in this case, including, but not limited to) Wind Energy. Beyond the motives, are the real actions and developed agendas that allow an industry to secure, maintain and perpetuate "their narrative." I have included several examples of what some would call "blatant" deception. For example, there is a formal presentation made by a Danish healthcare practitioner (Dr. Johansson) to Vestas' executives where "the truth was told" but his warnings were ignored. I will leave the reader to draw his own conclusions. Sadly, the whole process continues largely unchanged. Wind Energy apparently deems their current approach as a successful business plan and continues their practices largely unchanged. We, as the users who consume electricity, have a right to know the truth behind the industry's talking points.

It would be unfair to criticize wind energy production as an answer to global warming without offering other solutions. That said, one might assume that if an obvious better choice was available without all the problems and negative health impacts as I have reviewed, it would've been pursued. However, there are alternatives that are ignored. My comments are listed in part 10, "Carbon Management".

Stay Focused on the "Broad" Definition of Health

When the public or politicians are asked if wind turbines are dangerous or cause health problems, they sometimes "mentally imagine" the worst – post-apocalyptic or post-wartime images or even human suffering with death and hospitalization of the order we now see with the Covid-19 pandemic. Even "captured" politicians, proponents, and/or Wind Energy trade organizations couldn't sell that when subjected to any scientific scrutiny. Instead, we need to remain "broad-minded" to what health actually is - which is NOT limited to a defined set of continuously disabling symptoms that evolve in everyone over the short term and likely affects everyone the same. It is also not limited to a health effect that is progressive until death develops or when eventual disease syndromes become established with an established diagnosis. Adverse health consequences of environmental noise can be the asymptomatic (unrecognized) development of hypertension or vascular atherosclerosis or insulin resistance or can be much simply defined as the "the loss of wellbeing".

Indeed, some of the most common and impactful adverse health effects may come "as" headaches, tinnitus, dizziness, subtle confusion, unexplained loss of ambition or productivity, emotional lability or obvious or subtle depressive symptoms. Noise adverse health effects may initiate and accelerate disease progression, that **may,** when combined with genetic or known "accelerators" of disease (smoking, alcohol abuse, etc.) over a life-time, manifest as a recognized cardiovascular disease event – stroke, fatal or nor-fatal heart attacks.

The World Health Organization (WHO) defines "health" as a state of complete physical, mental and social wellbeing… The WHO definition links health explicitly with wellbeing and conceptualizes health as a human right requiring physical and social resources to achieve and maintain. Mental and physical health are inextricably connected, thus highlighting that "annoyance" – at almost any level – can contribute to adverse health effects (AHEs). As described by DeFrock (Australian), "Annoyance is a non-quantitative word that implies mildness in common use. A more accurate general descriptor would be mild, serious or 'intolerable' impacts." In the context of this report, "annoyance" generally means "High Annoyance" where it can result in indirect adverse health impacts. But even "mild" annoyance can create a negative or disagreeable reaction (which is NOT the nocebo effect) that can create a loss of wellbeing. Wellbeing refers to a positive rather than neutral state, framing health as a positive aspiration. Wellbeing is defined as "the state of being comfortable, healthy or happy". Shouldn't we protect an individual right to health and happiness – that defines wellbeing - by limiting intrusive noise pollution at one's private property line?

Cardiovascular Disease Explained (simplified)

In the Cardiology world, "atherosclerosis" is a term describing the development of (lipid (fats)-filled plaques) that get sequestered within the superficial inner layer of arteries that is contained by a "thin fibrous cap".

These are initiated and develop through a complex process simply characterized as "inflammation". Standard cardiac "risk factors, e.g. smoking, diabetes and others) facilitate atherosclerosis development. As plaque evolves, there is a complex action via cellular and neurohumoral processes that appear to be quite similar to those seen originating from other triggering sources. Some of those sources include small-sized air pollution particulates, PTSD, and of particular importance, environmental noise. In my medical practice I treat atrial fibrillation. Nearly half of those patients also have obstructive sleep apnea (OSA) which is thought to have significant adverse inflammatory triggering that may promote concomitant ischemic heart disease, hypertension and insulin resistance. Although likely less intense as a "stressor" than OSA, I believe IWTs act similarly through a stress related inflammatory pathway to promote cardiovascular disease.

With noise as the trigger, it is thought cardiovascular disease is promoted from "from an increased physiologic stress response" from noise levels "in excess of defined intensities". It appears there are noise thresholds (which the WHO has attempted to define). Similar to OSA, it may also occur indirectly through noise-associated sleep disturbance which then produces a "stress response" via the sympathetic limb ("fight or flight") of the autonomic nervous system. The autonomic nervous system can trigger vessel inflammation which then can promote atherosclerosis. In general, the more and longer the stress continues, the older the individual (with more time to develop larger and more "unstable" plaques), the more the likelihood that disease will become evident or "expressed". With often unpredictable sudden "stress response triggers and/or anatomical plaque instability," the plaque ruptures, exposing the lipid-rich core that initiates "local clotting" that may enlarge and propagate causing potential artery closure that quickly produces a state of deprived "down-stream" oxygen delivery. In the heart, when this happens, it causes a heart attack – termed "myocardial infarction". Health means living a life where such consequences become less likely through avoiding or mitigating "unconscious inflammatory bodily responses" that promote the genesis of disease states. Atherosclerosis development should never, minimally, suddenly or eventually be allowed to continue so as to produce cardiovascular disease "endpoints".

World Health Organization Comments on Wind Turbines (2018 Report)

Acceptable environmental noise exposure levels are defined in the Oct. 2018 WHO report for aircraft, rail, general industry, and road traffic sources, with "strong recommendations". That rating reflects the quality and the amount of the scientific data relevant to those studied noise sources. Also, in that publication - for the first time - a suggested "conditional" exposure level for wind turbine noise exposure being expressed as "Lden" was published. Lden means average sound Level: day, evening, and night of AUDIBLE noise as "averaged" over a 24-hour period with penalties of 5 dBA for evening periods, and 10 dBA for nighttime periods. It is measured using an sound meter set to use the "dBA" filter and weighted by time of day for the penalties. That filter is the most common one promoted by Wind Energy in turbine acoustics and is "centered" around 1000 hertz. The problem with this is that it does not accurately reflect the acoustic energy of ILFN. The conditional wind turbine noise level exposure was a limit of 45 dBA Lden, equal to that of aircraft noise but substantially lower (more restrictive) than railway or road traffic. Assuming wind turbines operate 24 hours a day this limit is equivalent to a 38 dBA Leq 24-hour average sound level. The data review

committee of the WHO document recommended "policymakers implement suitable measures to reduce exposure from wind turbines in that population exposure to levels above the guideline values". The "conditional" recommendation reflected that the data was not "robust enough (statistically, due to small numbers of subjects)" to support a "strong" recommendation. Importantly, they commented that there was no data suggesting that there was no risk. It is worth noting that the WHO's 38 dBA Leq 24 hour average is what would be calculated using the American National Standards Institute (ANSI) and Acoustical Society of America (ASA) Standard S12.9 Part 4 for assessing Land Use Compatibility. It is important to consider that the pre-specified health outcome evidence used was mostly limited to more serious adverse health consequences such as ischemic heart disease (atherosclerotic disease related), hypertension (elevated sympathetic tone and acquired loss of normal vessel relaxation related) as well as the prevalence of highly-annoyed populations (outdoors). Because wind turbine sound fluctuates as much as 11 dBA above the average this level would not eliminate stress from moderate annoyance or sleep disturbance.

I have also included "noise response curves" for severe annoyance in the appendix of part 6 (Adverse Health Effects) from the Wind Farm Noise Textbook (Hansen, Doolan, Hansen, 2017) that show published data (2001, 2008, 2016) from several studies. These two graphs IMPORTANTLY reflect an even greater annoyance from IWTs (which is dominated by low frequency noise) than what is reflected by dBA measurements (measuring only audible noise) as was used in the WHO report. This highlights that IWT noise is commonly described as "distinctly annoying" and is composed of noise from nearly all portions of the noise spectrum, rumble, roar and whoosh type sound. Indeed, the omnipresent component of ILFN is a real and prominent contributor to increased annoyance from IWT noise. IWT noise can be even heard when below background noises like leaf rustle, comprised of mainly mid and high frequency sound in communities at night likely due our perception of that low frequency noise component. Annoyance derived across the "wide-range" of frequency components of IWT noise NEEDS be accounted for when enacting "protective wind ordinances."

It is remarkable (to my knowledge) that Wind Energy has not commented on these incredibly high-level scientific assessments of potential concerns of environmental noise. The WHO virtually echoes that IWTs have never been shown to be safe. The WHO also clearly moves **toward** the level of declaration I make in this manual: that IWTs have AHEs including possibly serious cardiovascular effects. In fact, **there is strong credible evidence** that IWTs produce serious AHEs

I would suggest separate regulatory noise limits for both audible and ILFN noise exposures with both 40 dBA (for audible) and 60 dBC (for ILFN) noise limits – each expressed as "shall-not-exceed" dBA or dBC (Lmax(fast)). Compliance with these limits shall be measured by Class 1 sound level meters set to use the "fast" measurement circuits. Other circuits incorporate averaging which will understate the fluctuating character of wind turbines that is the likely cause of annoyance, sleep disturbance, and other AHEs. Despite that MAE would like to suggest otherwise, dBC measuring tools are "standard" on professional grade sound measuring equipment which can measure both at the same time. Noise levels can be easily obtained at the property line.

Prior regulatory parameters of setback distances (e.g. 1500 feet) or 45 to 50 dBA as Leq averaged sound levels) will NOT be protective of human adverse health effects. They do NOT account for fluctuating audible and ILFN acoustic energy – that have been correlated to AHEs, or the location of non-participating residences on their properties. When any wind contractor sites a turbine, they should include a design safety factor to be certain that during periods of fluctuating sound emissions the project will not exceed either of those noise limits or it will be "out of compliance". If they are uncertain about audible and ILFN propagation/attenuation or the accuracy of computer modeling, then a greater distance-separation or use of a quieter wind turbine make and model should be used so as to completely eliminate the potential of harming residents". Sound limits are carefully defined to protect residents and should not reflect a compromise to facilitate industrial development.

Non-compliance or less restrictive noise limits that result in resident harm is NOT acceptable as reasonable "collateral damage". Of note, George Hessler published a 2004 article that proposed dBC criteria in residential communities for low-frequency noise emissions from industrial sources that do not have fluctuating sound as a primary characteristic.

What are the Noises that IWT make?

IWT noise includes regular, dominant "pulsing" sensations perceived as either audible fluctuations in the sound or as bodily "pressures" due to air compression of the flowing air mass. These pressure waves are caused by changes in the lift of each of the 3 blades as they pass in front of the huge supporting tower. Also, as the blades rotate through the frequently vertically-stratified moving air mass, they may, under heavy "loading" conditions, lose lift (or stall) producing perceptible rhythmic swishing/thumping sound to which residents can become sensitized. Residents can often perceive these fluctuations as "whooshes" or "thumps" at considerable distances, well over a half mile - which is quite disagreeable and difficult to block from one's awareness and may occur at a distance where the IWT cannot yet

be seen, especially during the night when people are sleeping in quiet bedrooms. There is a rhythmic pulsation generated at the trailing-edge blade noise by the steady rotation speed that produces "blade-swish whooshes and thumps" and irregular, low-frequency "roar" from the blades due to in-flow turbulence. Collectively, there is a continuum of frequencies stretching from pressure pulsations at infrasonic frequencies 0.5 Hz (cycles per second) up through the normal hearing range of 1000 to 2000 Hz that are generated by each turbine. The sound immissions from each wind turbine also interact with nearby turbines to produce a constantly changing and distracting medley of fluctuating sound called amplitude modulation. Depending on the frequency amplitude modulation of IWTs. ILFN is both heard and perceived and easily evokes mental and physical stress. Unlike "less complex" daily noises, IWT noise does not become "accepted" by our perception processes and then unconsciously ignored. The subtle but constant changes make it difficult to impossible to ignore. Further, residential construction of residential homes for sound insulation does not effectively block the lower frequency noises. Further, people have a right to sleep with open windows which effectively eliminate any protection offered by walls and roofs. Trying to mask IWT noise by producing bland artificial "background" noise inside a home can only mitigate some portions - but not all of "stress-creating" wind turbine noise. As coping residents engage in their daily tasks, while the turbines operate above, only a momentary lapse of that focus will remind them of the enveloping dome that separates them from the peaceful world they once enjoyed.

Included Important Historical Insights into Wind Energy Claims

I have included in Part #9 a number of related events, letters and a copy of a speech that unveil what Wind Energy (Vestas – largest worldwide producer of IWTs) has done to advance their "narrative" centered around the promotion of IWTs.

When the state of New South Wales (NSW) in southeastern Australia approached Vestas about implementing IWT power, the state government presented to Vestas an initial draft of guidelines that contained low frequency noise regulation that outlined that state's proposed future "recognition, acceptance and treatment" of ILFN. In the beginning of that March, 2012 letter, Vestas in their "Executive Summary" response letter, immediately made clear their opinions about careful, science-based, health-protective regulations that would govern implementation of a new energy technology in NSW. They bluntly summarized: "*Vestas opposes the Draft Guidelines, primarily because of the sheer number of additional requirements and barriers that would be placed in front of the wind energy industry without any clear evidence, justification or demonstrated need for this additional regulation*". By that time (2012), there had been several years of rigorous publications by scientific investigators and acousticians as well as likely thousands of reports of adverse effects including forced home evacuations. In general, NSW concerns were raised that mostly involved human health – in all forms.

These included setbacks (proposed at 2 km), visual amenity, noise, health, decommissioning, auditing and compliance, environmental impact statements, property values, blade throw, conditions of consent and compliance as well as others. Vestas' extraordinarily self-serving retorts to each of these concerns were "abrupt and terse" (and without basis) – other than they are viewed as too restrictive to advance IWT introduction – which they admit was **the** primary issue. Comments about noise from NSW in the draft were recommended to "*be deleted in their entirety*" so as "*not to give the impression that the NSW Government places any credibility in the false claims of the anti-wind activist groups on the topic of health impacts*".

Decommissioning concerns were raised by NSW. Vestas did support a decommissioning and rehabilitation plan in the **environmental assessment** report, however, did not support the requirement to provide a decommissioning bond, nor have periodic updates in anticipated costs and implied that wind farm operators would maintain their assets for as long as possible since wind is "free." Vestas did not support the adoption of the noise guidelines as they claimed they were: unnecessary, discriminatory, and unclear. Again, the word "obfuscation" comes to mind. It should remain absolutely clear to any entity regulating IWTs into their jurisdiction that all these topics (and more) raised here ARE relevant and need to be addressed in writing in any Wind Ordinance; if it is not clarified, then compliance cannot be enforced.

ILFN: Convenient Flip-Flopping by Wind Energy for their Agendas

Further, to have health protective IWT noise regulation, as noted many times, recognition and regulation of ILFN is "critical". It is also my opinion when reviewing several "lines of historical action and commentary by Wind Energy" that Wind Energy recognized (certainly no later than the mid-1990s) the "threat" of ILFN to their business. As mentioned earlier, N.D. Kelley clearly identified the existence and the health threat from ILFN in the mid-1980s. In the same letter (above) and then in another one just a year before, Vestas reveals that they knew "true implications of ILFN and its health concerns". In the response to NSW suggested guidelines, Vestas denied that ILFN was a cause of AHEs and proclaimed: 1) it is therefore unnecessary to require the prediction and monitoring of low frequency noise

emission from wind turbines, 2) the existing and well- validated industry standard models for acoustic propagation are not designed to deal with frequencies at the low end of the audible spectrum, specifically because noise emissions in this band are not considered to pose issues likely to affect the surrounding environment, 3) "accordingly" Vestas suggests the removal of the requirements to measure low frequency noise from the Draft Guidelines. Yet, less than a year **earlier**, Vestas AU had written a letter to the Danish EPA claiming that a new low frequency noise limit for wind turbines could not be met because there were no design changes to modern utility scale wind turbines that could further reduce wind turbine noise to meet the new low frequency limits. On the one hand they claim there is no problem, and on the other hand they claim that there is no solution to a problem that they admit is a characteristic of wind turbines. (My comment: There is something rotten in Denmark). It is clear to me that Vestas recognized that ILFN would be a defining concern for IWTs – particularly as power generating capacity increased (which Vestas was rapidly designing and implementing for future designs). The newer larger MW models use longer the blades and slower hub rpm. This results in more ILFN than for earlier lower MW models with shorter blades and faster rotation speeds. The Wind Industry has adopted Vestas' stance about ILFN importance. We, as the potential residents to be affected and possibly suffer harm, need to clarify for ourselves the true existence of and potential harm from ILFN and react responsibly by regulating these harmful emissions generated by IWTs – especially with increasingly larger models that are more often being "clumped" together.

The Need for Informed Consent when KNOWN Unknown-Risks Exist.

The proposed affected residents, by a super-majority, opposes the plan (for Arbor Hills Wind Facility, Madison County) based on concerns of adverse health risks. At the same time, only a small-minority of easement owners (22%) actually live on the property and would have to endure the same health consequences. Reportedly they are not allowed, by contract, to raise health-related concerns that might arise while residing at the property. How this affects people living on that property to farm the land is not known. Having spoken to residents about their "signing experience" with a wind industry, they didn't recall that the representative declared the turbines "safe". They did, however, clearly remember that there was no listing or mentioning of possible adverse events, reports of serious or mild annoyance nor potential longer-term cardiovascular consequences. This failure to disclose potential risks to the participating landowner OR the non-participating (but still noise-affected neighboring resident) is bothersome and reflects a lack of due-diligence, oversight, and protective jurisprudence. With decades of ongoing concern and innumerable science-supported reports of occurring harm and well-researched plausible serious adverse health effects being published, one could reasonably describe the omission of informed consent as a failure of duty of the party seeking the easement to properly notify the lease of known risks. (Writer comment: While I not an attorney, very similar scenarios occur in human research where volunteers are asked to participate in a "condition" where there are unknown (or let alone known) potential health risks in return for financial compensation. To a reasonable person, such easement contracts demand greater transparency and much higher levels of subject protection. While it is true that Wind Industry contractors are not involved in a "medical study" per se, they are entering into a contract with potential known and unknown health consequences for which a consideration of payment is given in exchange for accepting the potential harmful consequences of exposure to that added risk, (IWT noise emissions).

This "Manual" is to Promote a Clearer and Accurate Description of Industrial Wind Turbines

I have written this personal statement for myself to collect, consider and organize the mass of information and misinformation present on IWTS. I personally have known the feelings of surprise, bewilderment, confusion, and hopeless frustration upon learning that a large industrial complex could be permitted into quiet rural residential locales that is zoned for agriculture. At county meetings where citizens voiced their concerns "on both sides" of the argument, there were some that mentioned it was their "right" to be able to earn income from the leasing of their property. Of those relatively few, there was no one that I can recall that said that it was acceptable that wind turbines could then produce noise that would actually harm their neighbors. None mentioned that their neighbors also have a "right" to enjoy the peaceful use of their properties. The authors of a comprehensive textbook "Wind Farm Noise" distilled all the conflicting pro- or anti-wind rhetoric in a simple declaration: "**it is time to stop debating whether or not a problem exists. It is well known that wind farm noise does result in sleep disturbance and health effects for some people and the time has come to decide what to do about it. The fact remains that some people are so affected by wind farm noise that their health suffers and some are forced to leave their home in order to achieve an acceptable quality of life.**" We need to respect each other and look for energy solutions that make sense and most residents agree about. I have desperately sought for the truth as minimal information or, (upon fact-checking), frequently incorrect information was given by a power company who planned to produce a "secure profit". I hope this

"true" version of truth is useful to those who need to make important decisions, protect themselves and their property and assist for clarification of concepts regarding Industrial wind turbine implementation and regulation. When finally understood in "all in its convoluted and conflicting enormity", it will hopefully be clear where the real questions remain.

Points to Remember: Returning to my initial assumptions upon hearing that IWTs might be placed closely to my property, I mentioned that "I thought they were quiet, good for the world and assumed they were safe".

Exploring much further, I now know that NONE of those are true. IWTs make a lot of distressing noise, when examined as a "possible solution for climate change" they don't make sense given cost, limited life, intermittency, dependence on CO2-producing energy back-up and affordable and adequate battery technology is possibly "beyond reach" and, they are clearly NOT safe for myriad number of reasons which I tried to describe in detail. IWTs cause adverse health effects with that definition being consistent with WHO definitions and currently practiced health care.

We are now in an era in science where we know that environmental factors – particular noise – can and does cause adverse health effects which can include serious cardiovascular consequences. Advances in understanding the consequences of disturbed sleep raise concern for contributing to the development of Alzheimer's disease. Shortened sleep duration has been highly correlated with cardiovascular disease development and endpoints of hypertension and ischemic heart disease.

We know the brain while "sleeping" can still be "aware" of noise (when it reaches a certain intensity (loudness) threshold and responds to it through body motility, even full awakening or "regressing" in its process of reaching various stages where vital restorative recovery of normal brain function occurs. Sleep disruption occurs with audible and, likely more importantly with IWTs, with lower frequency noise. The WHO has recently listed wind turbines as a potentially important source of environmental noise. While "high-level correlative data" does not exist yet, the WHO lists noise thresholds for potential disease development at levels lower than road traffic. Other analyses using severe annoyance metrics that include ILFN exposure drive the threshold noise levels much lower yet. Observing current, more inclusive definitions of health, IWTS do produce AHEs as annoyance (from mild to severe), and have been shown to disrupt normal sleep stage progression.

Utilizing metrics of biologic plausibility, as described by Sir Austin Bradford Hill, if met, can establish a "causal link" between WTN and AHEs for epidemiological purposes. As examined by Jerry Punch and Rick James in their 2016 comprehensive review (ref. in text), all 9 of The Bradford Hill criteria have been identified in the scientific literature as pertinent to the relationship between IWT noise and AHEs. Dr. Hill states, *"None of my nine viewpoints can bring indisputable evidence for or against the cause-and-effect hypothesis and none can be required as a sine qua non. What they can do, with greater or less strength, is to help us to make up our minds on the fundamental question – is there any other way of explaining the set of facts before us, is there any other answer equally, or more likely than cause and effect?"* In his final address observation, he asserts: *"All scientific work is incomplete – whether it be observational or experimental. All scientific work is liable to be upset or modified by advancing knowledge. That does not confer upon us a freedom to ignore the knowledge we already have, or to postpone the action that it appears to demand at a given time."*

Finally, included at the end of part #15, Mathias Basner, MD, PhD – who is considered a world leader on health effects from environmental noise, produced an editorial (2019) where he reviewed the potential impacts of noise on our health. He acknowledged the problem of smaller populations in currently available studies which make statistical powering of conclusion difficult. He has stressed that NONE of the wind noise guidelines data from the 2018 WHO report found an "absence of risk". He finished his comments with *"the fact that more studies are needed should not lead us to postpone the urgently needed protection of the population from noise." The knowledge we have acquired so far IS SUFFICIENT to take preventive actions and substantiate them with respective legal noise regulation.*

We have all learned that all people suffer to some extent– it is part of being human. But to intentionally force suffering upon affected citizens for the financial benefit of others is immoral. To "mentally take refuge away from guilt" by assuming huge "pinwheels spinning in a neighbor's field are ***silent*** *" and believing Wind Energy's mantra of 'no credible evidence' that IWTs cause human harm is patently disrespectful, unprofessional, immoral, and grossly irresponsible. We can and must do better.*

Needed Declarations:

1) I am a Cardiologist who specializes in heart arrhythmias (Electrophysiologist) who focuses on abnormal fast and slow heart rates/patterns, implantable device (pacemakers, defibrillators) therapy, and have participated (investigated, published and presented) clinical research for decades. I also have been privileged to be involved with human research and served as the Chairman of the City-Wide Investigative Review Board overseeing the ethical conduct of ongoing local clinical trials. In those patient trials, high standards of participant protection and adverse event evaluation was

paramount. I am drawn to understand the societal (local and international) impacts of IWTs – particularly health. I also felt compelled, through my years of human research experience, to protect the health, safety and welfare of myself and my fellow citizens.

2) I am not an Acoustician. An Acoustician is defined as an expert in the branch of physics concerned with the properties of sound. I have, however, corresponded at length with several Acousticians who have "specialized" their acoustical practice into the understanding, measurement and regulation of industrial wind turbine noise. They have shared with me their acquired in-depth understanding of IWT noise and its impact on people – from the details of measuring and interpreting noise to the impacts of that noise on people's lives. They have directly talked and worked with the victims of IWT noise exposure. They have been invited into these unfortunate people's homes and first-hand have measured, experienced and, on several occasions, have themselves suffered serious adverse health events from those noise exposures. They, through their professional lives, have seen the unfolding of IWT introduction around the world, interacted with key both pro- and anti-wind experts, and from their unique vantage point, provided a clearer understanding of the "real issues" and the history behind those issues. They have presented at national societal meetings, offered insightful theories and clarifications to their worldwide colleagues, published peer reviewed papers, testified in court trials, and at the request of governments. They are members of the Institute of Noise Control Engineering (INCE) and/or the Acoustical Society of America (ASA). The INCE/ASA Member has experience in noise impact assessment, the effects of noise on people, and control (complaints, annoyance, noise specifications) and is committed to their Canon of Ethics for unbiased professional services whose first mission is to protect the public's health and welfare. They are motivated to move forward into the "headwinds of greed and misinformation" because as professional experts, "they care about people".

3) The origins of the information I have presented and summarized, I believe to be reliable, verifiable and accurate. I, in no way, have manufactured history, slandered nor created (recently popularized) "alternative facts". I have expressed personal opinions based on collected information that I believe to be factual. My "physician opinions" come from four decades of interviewing, examining patients and applying basic human physiology and medical science in the effort to protect and improve their lives. I have read and re-read reviews and individual papers from both sides of the argument. In the enormous "confusion" of pro- and anti- Wind information, I have tried to focus on the quality of data being mindful of bias and full disclosure of and composition of reported "peer review" entities. I have looked specifically for the origins of noise regulation and the process by which current IWT siting practices became established.

July 1, 2020: Board of Zoning Madison County, Iowa

Re: Wind Turbine Ordinance for Madison County, Iowa

Dear Madison County Board of Zoning Members,

I have submitted his letter to support the process of obtaining a Wind Ordinance that best reflects the health, welfare and safety of our county. I am a board-certified Adult Cardiologist and Cardiac Electrophysiologist who lives in Madison County. As you very well know, the choice of having industrial wind turbines (IWTs) placed in our county is extraordinarily contentious. They are advertised as "green, less expensive and sustainable". The last several decades have seen a worldwide surge in the placement of these industrial-dimensioned turbines - beginning mostly in Europe and eventually coming to the U.S. where onshore implementation has been pursued aggressively. Studied very extensively in the mid-1980s, IWTs were rejected (seemingly) by the federal government, due to concerns of potential serious health hazards. The merits of those intensive studies finding harmful noise production by large-scale industrial wind turbines remain to this day and have never been discredited by Wind Energy. Industrial Wind Turbine approval and regulation have now been passed to states, and in some cases (as in Iowa), local municipalities and counties. Understanding all the complex issues of health concerns related to IWTs has taken, to date, nearly 2 years of my focused inquiry. New health concerns are raised continuously as independent research around the world continues. The Macksburg wind farm was placed several years ago. Currently, the Arbor Hills wind farm extension from Adair into Madison County is on hold pending the Iowa Supreme Court review of the procedural compliance by Madison county's Board of Adjustment in July, 2018 in a 3:2 vote to proceed with IWT placement.

As you know, the Madison County Board of Health (BOH) solicited and obtained information from local citizens, health professionals as well as Mid-American Energy. They were given enormous amounts of information to review and carefully consider in their consideration of the health impact that IWTs would have on the health of the county. They considered scientific information that was current at the time of their public hearings with a considerable amount of new information becoming available since the time of the initial Mid-American Energy proposal presentation. Concern revolved not only around "annoyance" which has been deemed a health risk by the World Health

Organization but also included more important concerns of sleep disturbance and chronic autonomic nervous system "hyper"- activation that, over significant time, may pose a risk to chronic cardiovascular disease and other adverse health events.
The BOH voted 2:1 declaring a potential adverse health risk exists with exposure to industrial wind turbines. They recommended, based on extensive data and peer-reviewed summaries (mostly the Punch/James article) that IWT setback should be 1.5 miles from property lines.
Of note, Madison County is NOT alone in their country governance process that includes a required opinion from the County of Health. In Chautaqua County, New York, the Board of Health Meeting on November 21, 2019 that called for a 1.5- mile setback and 35 dB(A). They requested that other municipalities in New York state to do the same. They are supported not just by their BOH but also the Western New York Health Alliance and the New York State Association of County Health Officials.
The 2016 review by Jerry L. Punch and Richard R. James "Wind turbine Noise and Human Health: A Four Decade History of Evidence that Wind Turbines Pose Risks" is, in my estimation, the most complete and fair review of this highly contentious topic.
You may find this Link extremely informing:
https://hearinghealthmatters.org/journalresearchposters/files/2016/09/16-10-21-Wind- Turbine-Noise-Post-Publication-Manuscript-HHTM-Punch-James.pdf
Their science-based review is organized by summarizing the past and present literature that addresses each of 12 selected statements that encapsulate specific claims or positions commonly taken by advocates for the Wind Industry. On page 5, Table 2 on page 28 in this publication are listed recommended minimum siting distances and maximum noise levels of industrial wind turbines based on the protection of human health. Seven referenced setback distances were listed with four recommending 1.25 miles or 2 km setbacks. The greatest distance listed was 4 km to protect against enhance amplitude modulated turbine noise which originates from the ILFN (infrasound, low-frequency noise) spectrum which Wind Energy denies poses any risk to humans. The shortest distance was 0.5 miles but with concomitant sound level requirements which would be impossible to achieve with the very large MAE proposed 2 MW IWT for Madison County.
Those concerns were felt to be reasonable and probable given the October, 2018 World Health Organization position document on Environmental Noise and Health as it concerned exposure to other (analogous) forms of noise from traffic, railway and aircraft noise. The key contentious point was that data was currently not "robust" enough nor "specific to" IWT noise to prove that IWT exposure caused sleep disturbance disabilities and, long-term, directly caused cardiovascular disease such as hypertension and facilitated atherosclerotic disease manifested as fatal and non-fatal myocardial infarctions. There was no disputing data but the quality of the data was deemed "conditional" by the WHO. Yet, importantly, the WHO for the first time, issued average exposure noise levels for IWT emitted noise (unwanted sound) as it did for the other 3 prior-tracked environmental noise sources.
Concerns were raised about IWT noise in previous 1999, 2009 as well as the 2018 statements. All statements primarily revolved around the adverse health consequence of sleep disturbance.
It is important to recognize that MAE representatives during the public hearing in our courthouse and quoted by Wind Energy over the last 35 years used the phrase: "if you can't hear it, it won't hurt you" when referring to potential adverse health effects arising from IWT production of "infrasound" noise. I very strongly disagree with MidAmerican Energy's glib statement having dealt with health consequences of "provoked" autonomic nervous systems in over 35 years of practice of subspecialty cardiovascular care. Like carbon monoxide, methane, radon gas from basements, radioactive fallout, inhaled asbestos - among many examples - what you can't hear (and in those cases, also can't see) **can** hurt and even kill you. Although long suspected that chronic noise exposure - including infrasound - was harmful, the objective nature of those risks is now being quantified.
I would agree that connecting minimal, let alone loud levels noise to hard endpoints of disability and even death is not intuitive. The vast majority of people think that IWTs are **"silent"** as their blades turn. That is what the general, unexposed public have come to imagine as they pass them on the interstate at 70 miles an hour with their windows closed or even open given all they could hear would be "background noise" of the turbulent air flowing through the window opening. One must drive to operating IWT sites in the country, park in the "midst" of the operating turbine forest, get out of the car and simply listen, and focus and think about what that complex "clawing/scraping" noise that you can hear and infrasound that you can't "hear" but could "perceive" during sleep - especially if you become unlucky enough to become sensitized (hyperaware) to those sound emissions. Even more informational to understanding the true impact of IWT noise is listening to the turbines operating in the late evening at a time someone would be trying to fall asleep.

Fortunately, as you live your life - in your home or at school or work - if you live far enough away from that noise source, the immediate consequences of annoyance and the much later potentially serious health consequence of audible, infrasound and low-frequency noise can be largely avoided. I wish the citizens of Madison County to have both the rights to rent their land to Mid-American energy for electricity production AND to enjoy the right to live in a truly healthy environment where they safely raise their children and grow old and enjoy their chosen rural lifestyle and where Nature is not threatened by oscillating blades. The only problem is that MAE has offered some of our citizens the chance to lease land for monetary gain but with turbines so big and powerful and of such a design that they pose serious health risks to others if placed too close to their neighbor's property line which is almost always within the range of harmful IWT noise travel. Indeed only 22% of landowners having easements in The Madison County portion of the Arbor Hills proposal would be exposed to the noise exposure they accepted in return for money while nearly 75% of actively polled nearby resident **do not want them** principally because of what they have learned about the health risks.

I launched into this in-depth learning experience because I care about how these will affect our countryside - health, wildlife, property values, view scape among many other reasons. I immediately suspected motives and perceived lies and later learned of "captured" behavior and "conflicted" elected officials who have been given the privilege and responsibility of voting for us and our health and quality of life. The mere elimination of an easement contract to allow a supervisor to very actively promote the preferred language of Wind Energy's requested ordinance does not eliminate their current conflict or future conflict. My motive of speaking up is for transparency and accuracy of data in areas with which I am familiar.

I would ask that you read what you can in the time that you have.

Suggestions for Manual Use:

This information has been structured to allow focus on different aspects of IWT consideration.

Part 1 is the introduction.

Parts 2 through 13 cover basics of sleep, wind basics and types of IWT emissions. The history of our understanding of IWT noise emissions and the extremely important "evolution" of the current sound level limits as proposed by the World Health Organization (WHO) that are completely ignored by MAE.

I spent a lot of time describing adverse health effects (AHEs) with particularly concern about Wind Energy's denial of infrasound contributions to adverse health effects - modern, science-supported data is provided in stark contrast to their "non-response". I also included a variety of other topics - ALL of which are relevant in considering IWT intrusion into our county. I reviewed peer review and included critiques of Wind Energy's favorite ACWEA report. Although I will be the first to say that I don't actively "dig up dirt", becoming familiar with an organization's agenda is important and some extraordinary past actions by Vestas are included for your review and thoughtful integration into the manner of their proposals and starkly limited amount of information that their product is safe for our fellow citizen. Again, these are my opinions. I discuss my views on carbon management and what Iowa should be focusing on. Critical points about noise regulation is covered in part 11 with important concepts of ordinance examples and regulation then finally recommendations are given. I would very strongly request your consideration of requesting more accountability and oversight for MAE or other Wind Industry firms. Remember, they don't live here, we do.

Part 14 is the Summary which is much shorter than the accumulation of information in parts 2-13 and would serve as the quickest way to begin to be conversational about this complicated topic.

Part 15 is my Conclusion which focuses on adverse health effects. There I provide statements from the best sources I can find with their opinions and suggestions. We all agree.

I have included various graphs and statements provided in the various "parts". Please review them. I would very strongly ask you read a speech given to Vestas in Denmark by a Danish national health care spokesperson, Dr. Johansson. In three page he exposes what we now are witnessing in Iowa.

We need to see this Wind Ordinance crafting as an opportunity and a need to protect ourselves. It should not promote reckless development with short-sighted gains - with most of those gains not going to this county. One should fairly request provisions that ensure compliance and safety. If Supervisors say that "if you make it too complicated and restrictive, they won't come". That is industry's problem.

We only are asking for respect and concern for our health and way of life. Our Wind Ordinance should reflect our stated responsibility to protect the Health, Safety and Welfare of Madison County, Iowa.

Thank you for your Commitment to our County's future.

W. Ben Johnson, M.D.

Part 2 Sleep:

Importance:

The majority of the industrialized world struggles to obtain adequate and restorative sleep. We constantly weigh exhaustion with the need to accomplish more. Work schedules vary and are consuming and pressurized. We balance our needs with the needs of our families finding little time for ourselves. Inadequate sleep begets mental and physical stress which begets chronic mental and physical disease.

Disturbed sleep is the most concerning adverse health effect from industrial wind turbines. It is the key to a cascade of adverse physiologic consequences that may, in the extreme, be associated with a host of potentially serious cardiovascular outcomes. While it is clear that such a relationship exists from exposure to automobile and train and aircraft noises, the data is not robust enough to confirm the same concerns with industrial wind turbines although there is rapidly accumulating data to support that association.

It has, however, reached scientific support to invoke a "Precautionary Principle" as adverse health consequences may be serious consequences and proposed wind farm development is extraordinarily expensive, multiple decades long in proposal and is highly unlikely to achieve the goal of being clean or renewable. The "precautionary" principle has been defined as a broad, epistemological, philosophical and legal approach to innovations with the potential for causing harm when extensive scientific knowledge on the matter is lacking. Epistemological relates to the theory of knowledge, especially with regard to its methods, validity and scope and the distinction between justified belief and opinion. I believe that current science does provide a "justified belief" and NOT mere opinion even in the matter of IWT noise and triggering cardiovascular disease. This principle emphasizes caution, pausing and review before leaping into new innovations that may prove disastrous.

It is worthwhile reviewing the process and importance of sleep thus recognizing the profound implications of appropriate siting of turbines to lessen the consequences of sleep disruption in their homes. Increasing "setback" distance from residence to IWT is the ONLY way to lessen wind turbine adverse health impacts.

Non-REM sleep typically occupies 75-80% of total sleep each night. This period provides time for essential brain function recovery - tissue growth and repair, energy is stored and hormones that are essential for growth and development are released. REM sleep typically occupies 20-25% of total sleep each night. This phase is when dreaming occurs, is essential for processing and consolidating emotions, stress and memories. It is reportedly vital for learning and stimulating the brain regions used in learning and new skill development.

Non-REM sleep transitions through 3 successively "deeper" sleep levels during the night with increasingly longer, deeper REM periods occurring toward morning. If the REM or non-REM cycles are interrupted multiple times through the night (either as brief, non-conscious arousals or as periods - however brief - of awakening) then we may fail to reach the "deeper" periods of sleep where these "recharging events" can occur. Consequences of interrupted, non-restorative sleep include feeling drowsy, irritable or depressed. Task efficiency decreases particularly with learning, remembering or making decisions. One can crave more unhealthy foods, which could cause weight gain. It has been described that quality sleep is as essential to survival "as food and water". As stated by the National Institutes of Health, "Sleep affects almost every type of tissue and system in the body - from the brain, heart and lungs to metabolism, immune function, mood and disease resistance. Research shows that a chronic lack of sleep, or getting poor quality sleep increases the risk of disorders including high blood pressure, cardiovascular disease, diabetes, depression and obesity".

The importance of reaching the "deeper" phases of sleep were highlighted with 10/31/2019 article published in the journal "Science" studying humans in deeper, non-REM sleep (confirmed with brain wave (EEG) recordings) while undergoing MRI imaging that measured the blood oxygen levels in the brain and how much cerebrospinal fluid (brain "crankcase oil") was flowing in and out over the surface of the brain. They discovered that in this portion of non-REM sleep, neurons start to synchronize (turning off and on at the same time). During the momentary periods when cells were "off", they didn't require as much oxygen, so less blood (flow amount determined by vessel reactivity to need) would flow into the brain that effectively created a larger residual space within the skull surrounding the brain. At that time, cerebrospinal fluid would then "rush in", filling in the space left behind from the decreased blood volume in the vessels thus facilitating "waves" of cerebrospinal fluid to circulate around the brain effectively removing metabolic by-products that accumulated during the prior day. Your need for sleep and your sleep patterns change as you age, but this varies significantly. Babies initially sleep as much as 16 to 18 hours per day which may boost growth and development (especially of the brain). School age children and teens need about 9.5 hours of sleep per night. Generally, adults need between at least 6-7 hours. After age 60, nighttime sleep tends to be shorted, lighter and interrupted by multiple awakenings. Elderly people are also more likely to take medications that interfere with sleep. For these reasons, our younger and older county residents are considered more vulnerable in their age-related

obstacles to achieve restorative sleep. In general, people are getting less sleep than they need due to longer work hours and the availability of round-the-clock entertainment and other activities. The idea of "catching up" on weekends actually never can be fully achieved.... although one may try...."sleeping-in on weekends" has been recently associated with heightened degrees of insulin resistances measures than simply returning to a normal sleep pattern.

I Have Seen the "Face" of IWT Harm

Three years ago, while inquiring about used farm machinery, I sought out a farmer who lived nearby in Guthrie county. Arriving at his farm perched along the "Mo-Miss Divide", I was fascinated at the distracting "surging" of spinning IWTs "for miles". Greeted by the farmer, I asked him about how "he and the turbines" got along. He noted that " a lot of people had moved away, and over half of those who agreed with their easement signing now regret having done so." Looking into his face, I could see the likely signature of chronic sleep deprivation (a distinctive appearance that I can easily recognize in those sent to me for atrial fibrillation consultations who have concomitant obstructive sleep apnea). His speech was a bit halting and searching.... I asked how his sleep was and whether he thought the turbines had created a problem sleeping. Looking inward, he paused, then scanned the ongoing turbine "wind chopping" and looked down then back up at me. "I don't think so... maybe you get used to it. A year ago, I built a new bedroom addition to my house putting in the best materials I could find with 2x6 construction, thicker insulation and heavier sheathing. It made it better.....(he paused) ...but on those windy nights I can still hear and feel that pounding...."I sensed an exhausted man who had resigned himself to "deal with it". He was imprisoned on his own farm with his entire livelihood around him.

Disturbed Sleep - A Worsening Modern Health Epidemic

We are a society plagued by increasing obesity (now about 40% of Americans are considered as obese with 7.7% being severely obese). The American Heart Association has now included obesity and severe obesity in children as cardiovascular risk factors. With the recent redefinition of hypertension going from 140/90 to 130/80, now >46% of American are considered hypertensive. The incidence of type II diabetes (the type related to "high" insulin levels due to acquired resistance of insulin action at the cellular level) continues to increase in incidence. Somewhere in this "modern health epidemic" is the problem of sleep quality and quantity. The 2019 annual statistical update from the American Heart Association included a new section on sleep and cardiovascular health cited data from the Centers for disease Control and Prevention that only 65% of Americans have a healthy sleep duration (at least 7 hours).

Recent Absolutely "Key" Large Scale Studies Linking Inadequate Sleep to Cardiovascular Events

Recent recognition that restorative sleep - quantified as total duration of sleep that is "effective" – if less than 6 hours per night has been associated with objective "end-points" of disease progression. Dr. Dominguez noted a "graded response" evident in the PESA (Progression of Early Subclinical Atherosclerosis) trial. This large trial (3974 middle-aged Madrid bank employees free of known clinical cardiovascular disease or history of stroke), wore a waist band activity monitor (actigraphy) for a week to record sleep quantity and quality. Movement during attempted sleep reflects often unconscious "brain awakening" that if brief (<15 seconds), may not remembered as having occurred. They also underwent 3-D vascular ultrasound and measurements of coronary artery calcium (via CAT scanning). The actigraphy confirmed common under-reporting of sleep duration (patients reported 10.7% had < 6 hours via questionnaire vs 27.1% via actigraphy. Multivariate analysis was performed adjusting for smoking, hypertension, physical activity, depression, OSA, daily calories, alcohol intake and other confounding variables. The investigators noted that subjects who slept < 6 hours/night had a 27% greater volume of non-coronary plaque than those who slept 7-8 hours. They also had a 21% more vascular territories (seen on CAT Scans identified with dense calcium imaging integrated in arterial cholesterol plaque formation) laden with subclinical atherosclerosis - women>men in measured effect.

The presenter also stated that the more times an individual typically awoke per night, the greater the number of atherosclerotic carotid or femoral artery territories were documented on 3D vascular ultrasound. The statistical power of this study was extremely high (extraordinarily unlikely by chance to be incorrect).

In another study, cardiovascular investigator Fountas (in Athens) reviewed 11 prospective studies correlating daily sleep duration (self-reported) and cardiovascular morbidity and mortality. Collectively 1,000,541 patients (assembled from many similar, but smaller studies where available data could be combined for better statistical power for subsequent larger population analysis - termed "metaanalysis") without baseline clinical CV disease were followed an average of 9.3 years. Data were adjusted for confounding features. He found that if average sleep was < 6 hours, they had a statistically significant and clinically meaningful 11% increase in the risk of a diagnosis of fatal or nonfatal

cardiovascular disease as compared with those sleeping 6-8 hrs. Moreover, those sleeping > 8 hours had a 32 % increase in those endpoints compared to 6-8 hours. (Longer sleep duration possibly related to morning exhaustion prompting additional sleep hours to "catch-up").
Both investigators highlighted the pathophysiologic changes related to sleep deprivation that likely increased the pathophysiology of the risk - sympathetic activation, increased inflammation and disrupted glucose metabolism. Again, inadequate or disrupted sleep was very highly statistically correlated to greater cardiovascular disease and their clinical events.

A YouTube Documentary worth seeing

https://urldefense.com/v3/__https://www.youtube.com/watch?v=vRpsO9qAX_A&t=1708s__;!!CqLityr3mSQ!ReCVeyUsTjv4BMmYx88rScisOuiYIMMwbnL4GAtN8Zj_1kLP8YXO-Z8zJaMCjv1rGRY$

The documentary reviews that absolute disconnect of "city-folk" with the realities of IWTs. A community assaulted with IWTs is interviewed... revealing the exhaustion in their lives and chronic nonspecific illnesses - nausea, headaches, etc. and importantly, a lot of dog/pet as well as livestock deaths. Particularly ocular problems were noted with blindness. One of the men interviewed had a lot of eye blinking and trouble focusing - all reflective of eye fatigue not uncommonly experienced by residents. I raise the concern of resonance vibration of fluid filled ocular structures near 5 Hz (infrasound) that could create the symptoms. Although a potentially serious problem, but because IWTs have never been evaluated for safety, it was never (with no current plans to) formally evaluated.
The finding of the "enlarged organs" found with necropsied pets has also been seen and commented upon by other physicians - again, we allow these processes to continue unevaluated.... apparently unconcerned about finding out the truth.

Disrupted Sleep Due to IWT Noise Emissions

Inadequate or disrupted sleep is the most common complaint from residents living near IWTs. It is extremely important to realize that not only does excessive audible noise cause, but with amplitude modulation from the ILFN noise spectrum occurring up to 3-4 km from a household, sleep disturbance can continue even with "reasonable distance, e.g. one-half mile" separation to avoid (usual) higher frequency audible noise. Sleep is "disrupted" through both unconscious arousals and with frank awakenings - both disrupting the healthy progressions through both non-REM and REM sleep periods.
At the 1500-foot setback proposed by Mr. Clifton (Madison County Supervisor), **average** sound levels (expressed as Leq) will be 45 dBA as measured outside the house as predicted by computer modeling. 45 dBA Leq means that there may be recorded peak/nadir or high/low values as another 6-11 dBA above/or below the 45 dBA Leq average. Albeit much less frequent that the average value, audible sound levels of 56 dbA are possible. Testimony under oath by Wind Energy representatives have confirmed these possible noise ranges that are expected from IWT sources. It also means to achieve bedroom levels of 30 dBA your windows will need to be closed tightly with all exterior audible sound not exceeding 45 dBA. Opening the bedroom window even a little (cracked 6 inches) for cooling or fresh air circulation will marked increase noise entry into the bedroom - enough to necessitate IWT separation another approximately 2000 feet farther to achieve the same interior audible levels as when the windows were closed.
ILFN poses an **even greater** threat to sleep disruption. ILFN generally attenuates at half the rate as does audible sound. This means that (roughly) to achieve the same reduction in noise levels for audible sound, you have to go twice as far to achieve the same noise level with infrasound. Infrasound travels to some extent by resonating in the ground that can then easily resonate a house foundation and structures within the house - being insignificantly lessened by wall/roof insulation. ILFN "sound travel" is frequently described as "amplifying" in the house. Low-frequency noise is audible being 40-60 dBs in the 20-200 Hz range. This would be hard to ignore without sound protection equipment (ear plugs).
The sounds in that frequency range are heard/perceived by people in their beds at night when the house is otherwise quiet as "vibrations", rumble and roar. While not particularly "loud", they are perceived because there are no other noises in the community to provide masking of these low frequencies.
The details of sleep are important; the implications of chronic sleep disturbance are profound. Most adults know very little about the what happens during sleep. Sleep Medicine is one of the most recent additions to an ever-increasing range of medical specialties. It should NOT be viewed as esoteric and beyond understanding…in fact, some of the most recent science is available at newsstands, on-line and delivered to your home. In a recent "double issue" of TIME magazine (August 17/24th, 2020), the editors dedicated 14 pages of the issue to the topic "How to sleep better – the changing science, business and culture of a good night's rest". One subsection was entitled "What exactly is your brain doing while you sleep?" and was highlighted with the words: "New Research on its physiology shows why we need to take slumber seriously".

In the third paragraph they write, "In the past five years, brain researchers have begun to expose a hidden world of chemical reactions, fluid flowing into and out of the brain, and the busy work of neurons that reveal the sleeping brain is as industrious as the waking one. Without good-quality sleep, those critical activities don't take place, and as a consequence, we don't just feel tired and cranky, but the processes that lead to certain disease may even get seeded. One of the reasons we sleep, it now seems, might be to keep a range of illnesses – including cognitive disease like Alzheimer's and other dementias – at bay". They then described the association of "build-up" brain amyloid and another protein call "tau" associated with patients suffering from Alzheimer's disease. In mice, they confirmed those protein levels "dropped dramatically – especially during the deeper stages of non-REM sleep". In mice chronically deprived of non-REM sleep, more amyloid built up in their brains over time than in mice who got regular nightly rest. Similarly, (Holtzman, the researcher) saw similar changes when he compared amyloid in the spinal fluid of people who were well rested vs. sleep deprived. The article continues describing even more promising confirmatory data and ongoing longitudinal studies.

In that same TIME "sleep-focus" set of articles, another writer wrote: "There are many scientific reasons to desire good sleep. Poor sleep quality is associated with a whole host of unhealthy side effects. Getting bad sleep puts people at a higher risk for diabetes, cardiovascular disease, Alzheimer's, impaired memory, problem-solving issues, fatigue, anxiety, mood disturbances and poor performance at work."

Another comment included "The keys to good sleep, I'm told, are simple: exercise; eating well; not drinking too much; a dark, quiet space; creating a wind-down routine; no "screens" two hours before bed; and a comfortable bed. The greatest enemy of sleep is "stress." In my opinion, speaking to the last listed point, the presence of inescapable, non-ignorable large, intermittently rotating massive structures – creating noise while adversely affecting the environment and property values - creates a "lingering" stress that is consciously and unconsciously "recognized and felt". Humans are continually trying (often unsuccessfully), to "resolve or normalize" such intrusions. That strife resolution is ongoing and likely contributes to sleep disruption and annoyance suffering.

In another section, comments from Dr. Louis Ptacek, a neurology professor at the UCSF, commented "human sleep is largely a mystery; getting too little is linked to heightened risk for metabolic disorders,

Type 2 diabetes, psychiatric disorders, autoimmune disease, neurodegeneration and many types of cancer. It is probably true that bad sleep leads to increased risks of virtually every disorder".

I ask, "Why should we not protect ourselves (not only our health but also including our well-being, our families, our properties) through the active protection of our ability to have quality sleep?"

Appendix:

The following table appeared in the World Health Organization Executive summary in 2009 although it had also been published in 1999. Current experimental Sleep Research continues to support the listed sleep disturbance threshold values.

Effect		Indicator	Threshold, dB
Biological effects	Change in cardiovascular activity	*	*
	EEG awakening	[illegible]	35
	Motility, onset of motility	[illegible]	32
	Changes in duration of various stages of sleep, in sleep structure and fragmentation of sleep	[illegible]	35
Sleep quality	Waking up in the night and/or too early in the morning	[illegible]	42
	Prolongation of the sleep inception period, difficulty getting to sleep	*	*
	Sleep fragmentation, reduced sleeping time	*	*
	Increased average motility when sleeping	[illegible]	42
Well-being	Self-reported sleep disturbance	[illegible]	42
	Use of somnifacient drugs and sedatives	[illegible]	40
Medical conditions	Environmental insomnia**	[illegible]	42

Table 1
Summary of effects and threshold levels for effects where *sufficient* evidence is available

* *Although the effect has been shown to occur or a plausible biological pathway could be constructed, indicators or threshold levels could not be determined.*

***Note that "environmental insomnia" is the result of diagnosis by a medical professional whilst "self-reported sleep disturbance" is essentially the same, but reported in the context of a social survey. Number of questions and exact wording may differ.*

Taken from W.H.O. 2009 EXECUTIVE SUMMARY

Part – 3: Wind Noise "Basics"

Wind Turbine Noise:

Sound Spectrum Defined by Frequency

Audible noise 20-approx 15,000 Hz (adult)

Infrasound 0.1-20 Hz

Low-frequency sound 20 to 160-200 Hz

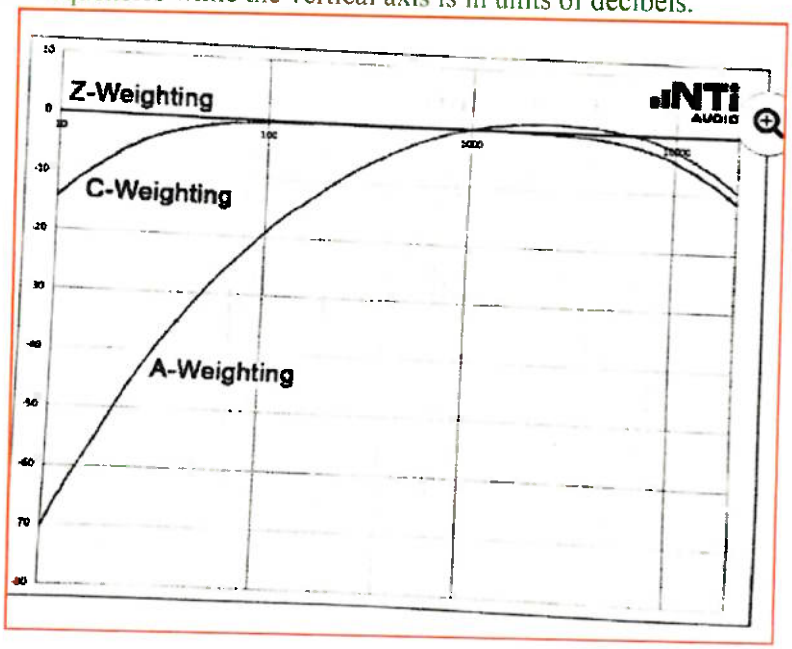
the term "ILFN" combines infrasound and low-frequency noise together.

Note: That "loudness" (or sound pressure) is measured in decibels (dB) and is quantified on a logarithmic scale meaning, e.g., that increasing the measured loudness of a sound from 30 dB to 40 dB (at 1000 Hz) is approximately 2 times louder (not 25%). The relationship of dB change to loudness varies with frequency where change occurs. (See below)

Sound Measurement and "Filter Effects" – Use with IWTs and What it Does and Doesn't Measure

Standards for describing sound levels or limits are set in decibels. Use of "dB(A)" with A, C, G, L, Z classification reflects the filter used during measurement. "A" has been used as the standard descriptor filter around the world but excludes accurate measurements of frequencies below 200 Hz, including both infrasound (0-20 Hz) and low frequency noise (20-200 Hz). This glaring "undermeasurement" of the true "quantity of infrasound using only "A weighting" to describe the whole noise spectrum was a product of the ETSU-R-97 wind turbine siting guideline by the BWEA and the British Department of Trade and Industry. This guideline was developed specifically to circumvent more science-based UK regulations that were more restrictive to IWT placement. As such, it is important to recognize that A-weighted loudness measurements will generally only reflect audible noise content which could also contain potentially harmful inaudible sound content - particularly when used with IWTs. National "standards" in Australia do not require infrasound (either within or outside homes) to be predicted in planning submissions nor to be measured in the required compliance testing to the planning permit noise conditions. Most jurisdictions do not require wind turbine-generated low frequency noise to be predicted or measured (unlike other sources of industrial noise). In fact, most noise measuring instruments and microphones are unable to measure accurately in the infrasound range, especially below 8 Hz., and some standards explicitly specify the use of equipment which cannot measure infrasound. Having said that, "C-weighting" is available on standard acoustical equipment and is clinically useful to measure environmental low-frequency noise sound pressure levels.

The image below shows the differences of Z- (unweighted) vs both A- and C-weighting. C-weighting will more accurately reflect intensities at various frequencies when applied in the low-frequency noise spectrum: The horizontal axis shows the log scale of frequencies while the vertical axis is in units of decibels.



Shadow Flicker

This is the effect of the sun (low on the horizon) shining through the rotating blades of a wind turbine casting a "recurrent/pulsing" moving shadow; it will be perceived as a "flicker" due to the rotating blades repeatedly casting the shadow.

Source of IWT Noise:

Machinery noise in the nacelle (horizontal containment for machinery - behind hub)
Rhythmic/pulsating, trailing-edge noise from the blades ("blade swish") as they slice through the air at up to 200 mph
Irregular, low frequency noise (LFN) and infrasound from the blades due to in-flow air turbulence
LFN and infrasound at the blade-tower-passage frequency and its harmonics.

Primer on Sound: What it is, Measurement (Adopted from Waubra foundation):

Operating turbines create electrical energy inside the nacelle through the rotation of a central axle that is turned by the force of wind pushing on large canted perpendicular blades connected to that axle.
Besides the desired generated electrical power, "waste energy" in the form of airborne pressure waves (sound) and ground-borne pressure waves (vibration) are released into the environment.
Noise is that part of the sound frequency spectrum which is audible or can be perceived. "Noise" is defined as unwanted sound.
The strength (sometimes expressed (vaguely similar) as "loudness" in the case of noise) of the sound is measure in decibels ("dB").
The wavelength of individual sound waves is a measure of the distance between the peaks of pressure waves. The speed of sound divided by the wavelength gives the frequency of the sound and is expressed in hertz (Hz)
Where the frequency of the sound waves is below 20 Hz, the distance between the waves becomes relatively longer, and the general term for this portion of the frequency spectrum is known as infrasound. Infrasound is only audible (heard) at sound high levels (dB). However, it can be "perceived" at lower sound levels and be damaging to the human body at levels well below audibility.
Impulsive infrasound from a variety of industrial sources (industrial turbines, HVAC installations) has long been known to have the potential to be harmful to humans, especially with chronic exposure.
Terrain and weather conditions influence noise. The wind speeds and directions upstream of a turbine vary due to:
Terrain effects, such as hilliness and ridge lines
Objects on the surface of the terrain, such as buildings and trees
Daytime thermal effects, temperature inversions
The following contribute to sound levels heard or perceived at residences:
meteorological conditions
wind turbine spacing and associated wake and turbulence effects
vortex effects
wind shear
turbine synchronicity (adjacent IWTs with blades turning with perceived passing of the tower at the same moment - generally is more intense with IWTs lined up parallel to wind direction
tower height, blade length
turbine power settings
During daytime, as the 3-bladed rotor turns, it encounters air at various speeds and directions which produces a combination of sound effects, i.e. rhythmic/pulsing blade swish about 3 dBA above the steady aerodynamic noise and a steady rhythm of low frequency noise and infrasound. During nighttime, air speeds and directions, not influenced by daytime thermal effects, become more varied, the atmosphere becomes more stratified and background noise is less, causing the various sound effects (aerodynamic noise, rhythmic/pulsating noise, rhythmic LFN and infrasound) to be noticeably more intense than during the daytime. The daytime swish noise often becomes a night-time clapping, beating or thumping noise. (Wilhem Post (On Wind Turbine Noise and Air Pressure pulses))
The so-called upwind vs downwind design of wind turbines can definitely influence turbine sound production. "Upwind" (referring to turbine blade positioning into the wind with blade positioning in front of supporting tower) is almost exclusively used as it produces less turbulence and hence less noise.
This was first described in detail by N.D. Kelley in the late 1980s.
People who are not exposed to the sounds of a wind farm find it very difficult to understand the problems of people who do live near to wind farms. Some people who live near wind farms are disturbed by the sounds of the farms, while others are not. As the sound levels increase, a greater percentage of exposed people suffer annoyance. In some

cases, adverse health effects are reported, in other cases, such effects do not appear evident. As sound levels increase, the reported incidence of health effects also increase and become increasingly severe. This lack of similar effects to every resident reflects individual noise sensitivities and complex effects on the physical health is confusing to outside observers (at first) but is well known in epidemiological data and normal variations of reactions at a given stimulus strength in populations.

Amplitude Modulation (Audible Blade Swish)

Although there remain differences in opinions about what causes the amplitude modulation of audible wind turbine noise most of the explanations involve air turbulence around the turbine blades. There are a number of explanations and more than one may apply at any specific wind farm site. For example, eddies in the wind, wind shear (different wind speeds at the higher reach of the blades compared to the lower reach), slightly different wind directions across the plane of the blades and interaction among turbines, have each been identified as causes of modulating wind turbine noise from modern upwind turbines.

The importance of the presence of audible amplitude modulation for wind turbines relates to the subjective annoyance of the audible signal that may warrant an adjustment for that subjective/annoying characteristic. In the frequency domain the fluctuation for a turbine occurs across the entire spectrum. At distances removed from the turbine, the high frequency components are reduced and can alter the audible fluctuations to more of a low frequency noise. At a given site of noise analysis within a field of emitting IWTs, a summation of noise described as "rumble to roar" is appreciated due to the collisions of sound waves - both amplifying and cancelling noise levels. These continuous "modulating noises" can be perceived as extremely annoying.

Variable Noise related to Blade Angle

The blade can be rotated at the point of attachment at the hub thus changing the canted blade angle with respect to inflow air. The steeper the angle, the more noise. Dr. Van den Berg summarized this in a table in his 2006 thesis. He described the increase of trailing edge sound level as a function of angle of attack. The most efficient power production is when the inflow air allows the turbine to reach full power with a blade angle of 1 degree or less. Thus, in real world operation where conditions are not so perfect, the sounds can exceed the "rated" sound power level used in a model by 11dBA or more (with the angle of attack at 9 degrees).

Wind Turbine Noise is "Distinctly Annoying"

Wind turbine noise has been described as having a character that makes it far more annoying and stressful than other sources of noise at the same A-weighted level, including airport, truck traffic, railroad or industrial noise. Thorne (acoustician) has pointed out that human perception of noise is based primarily on sound character rather than sound level, and that wind turbines are unique sound sources that exhibit special audible and inaudible modulated and tonal characteristics. He states that sound levels of 32 dBA Leq **OUTSIDE** a residence and/or above an individual's threshold of hearing inside the home are markers for serious AHEs, especially among susceptible individuals. Thorne described IWTs and wind farms as a unique source of sound and noise - like no other noise source. The sounds are often of low amplitude and shifting in character, making it difficult for people who have never been exposed to such sounds to understand the problems of those who complain about the sound. IWT noise is "distinct and annoying enough" to commonly be heard 10 dBA below background noise. It is this annoying property unique to IWT noise that likely causes more "stress" which can occur at "lower sound levels" than other environmental noise sources. This relative "more annoying effect" is reflected in the average Lden (sound level "average" over day-evening-night) ratings assigned by the WHO that are lower for IWT than rail or highway noise.

"Worst-Case Conditions" Sound Propagation Models

It is noted that consultants for wind utility developers often claim that wind turbine sound emissions inside and adjacent to the project footprint estimated by the sound propagation model's represent worst-case conditions. Models are representations and simplifications of complex interactions between noise emitters and their surrounding environment. For specific situations of modeling noise levels emitted by wind turbines, e.g. in complex terrain, such as sited along ridges and in valleys, understanding interacting factors and creating assumptions that will accurately allow predicted sound levels, can be quite challenging. The ability of the model to accurately replicate how the sounds are blocked by terrain or reflected by terrain is especially weak. **Errors in models of wind turbine noise propagation located on flat terrain have been shown to have errors of 5-10 dB or more** when studied by independent acoustical engineers.

However, it is only true that the input data (power sound level) used for the turbine's acoustic energy represents the turbine's sound emissions at or above its nominal operating wind speeds under standardized weather and wind

conditions. That designated power sound level will then permit a prospective buyer of turbines to compare the sound emissions from various makes and models. **The IEC (International Electrotechnical Commission) test data does not account for the increased noise from turbulence or other weather conditions that may cause higher sound emissions.** Indeed, in the IEC test data, it specifically reports that it is **not** "worst case" for real-world operations. Independent of the effect of weather and wind on the turbine's noise emissions, ANSI (American National Standards Institute) standards for outdoor noise caution that **turbulence in the air can increase the downwind sound levels by 6-7 dB or more.**

Impulsive sound was considered inherent only with older downwind turbine designs but was found only to be reduced with modern turbine upwind designs. In a landmark 2006 study by G.P. Van den Berg, it was shown that the impulsive swishing sound increases with size because larger modern turbines have blades located at higher elevations where they are subject to higher levels of "wind shear" during times of ground level "atmospheric instability". **This results in sound fluctuating 3-5 dBA between beats under-rate moderate conditions and vary up to 10 dBA or more during periods of higher turbulence.**

To compensate for the added annoyance of fluctuating or impulsive sound, the convention is to add a penalty of 5 dBA to computer model estimates of average sound levels to account for the increased annoyance from short term fluctuations in sound levels. In the Kamperman/James criteria, this penalty is already included in its recommendations for the maximum allowable sound level at the receiving property of 35 dBA.

The only information regarding sound levels to be expected during projected wind farm operation proposed for Madison County, Iowa Arbor Hills Project was "right at 45 dBA" as stated by Matt Ott given during the initial hearings for variance. I saw nothing in the application, that I as a citizen, was allowed to review that referred to produced sound levels.

Regardless of these complicated factors, objective noise limits, need to stand as the "limit" for any IWT noise production. IWT platting contractors must do their best (and likely remain conservative) as any emission levels about the limits are "not excusable" and should be consider as not being in compliance and thus requiring mitigation/correctional action.

Winds Speeds at Night: Contrary to Common Perception

Popular notion is that wind picks up (increases speed) after sunrise and abates after sundown. This is what is most often seen as experienced at ground level; the opposite occurs above 80 meters. After sunrise low altitude winds are coupled to high altitude winds due to the vertical air movements cause by the developing thermal turbulence. As a result, the low altitude winds are accelerated by the high winds, which through the air mass coupling, in turn slows the high-altitude winds. At sunset this process is reversed. As described by Rick James, "when ground-level wind speed calms after sunset, wind speed at typical hub height for large wind turbines commonly increases. As a result, turbines can be expected to operate, generating noise, while there is no masking effect from wind-related noise where people live (near the ground). The contrast between wind turbine and ambient sound levels is therefore at night more pronounced. As the turbine's blades sweep from top to bottom under such conditions, the blade encounters slightly different wind velocities creating unexpected turbulence that results in rhythmic swishing noise". Such calm or stable atmosphere at near-ground altitude accompanied by wind shear near turbine hub height occurred in the Van den Berg measurements **47% of the time** over the course of a year on average - and most often at night.

This is a key concept to understand when protecting the conditions for sleep during the night. This concept is the key "deception" propagated in the ETSUR- 97 guidelines pushed by the majority-authoring Wind Energy sympathetic factions in their attempts to evade more restrictive sound regulation based on sound annoyance/tolerance regulations present in the British Standard 4142 regulatory document. The resultant pseudoscience-based "high night-time" (and thus the short set-backs) permitted IWT-generated sound levels have been promulgated by both Wind Energy groups and turbine manufacturers in IWT adoption and spread throughout Europe, Australia, New Zealand and the United States. Wind Energy never talks about it.

Part – 4: IWT Sound Emissions - Types

As described in Part-3 "Wind Basics", sound emissions are first categorized by their frequencies.

Infrasound

Wind Turbines produce infrasound along with audible noise. The more powerful the wind turbine, the greater the proportion of infrasound and low frequency noise is emitted.

Sound with frequencies below 20 Hz is labeled as infrasound. It is usually cannot be heard, but actually can be heard at the higher end of the 20 Hz zone while "perceived" at the lower portions provided the sound pressure level is sufficiently high. The sound is perceived with the ears usually giving a feeling of pressure at the eardrums. Infrasound at an audible level is usually found on the car deck of a ferry and when driving a car with an open window. Infrasound is most often associated with sound at other frequencies, so the experience of listening to "pure" infrasound is uncommon.

"Perception" Thresholds, Serious Consequences with Larger IWTs Power Generating Capacity The rapid introduction into rural residential locations at close siting from resident of increasingly larger IWT for the purposes of larger energy production per turbine has been without ANY efforts by Wind Energy to ensure public safety with the new levels of sound production profiles - particularly in the infrasound range. George Kamperman (Acoustician) believes that the amount of low-frequency noise generated by IWTs increases by 3-5 dB for every megawatt of electrical power generated. This is particularly important as MAE has recently placed (in adjacent counties) many 4.8 MW IWTs (nearly 2.5 times greater output then the 2 MW planned for Madison County). Wind Energy disputes that IWTs produce little, if any, infrasound. Furthermore, they believe that within the infrasound range, the sound levels produced are less than the human thresholds for perception. Those referenced thresholds, however, were derived from assessment of "pure tones" which are not type of sounds produced by IWTs. ILFN is more characterized as impulsive and varied. As the human ear "reaches" to embrace detection, when sound is not pure-tonal, noise recognition can extend another 10 to perhaps 15 dB lower (Swinbanks).

Many Acousticians have commented about an easily discernable difference among people to hear sound. The distinct range of hearing capabilities in normal people is the primary basis of the observation that only a smaller percentage of an affected population suffers with noise annoyance which then becomes a larger percentage as the IWT sound levels increase (get louder). It is true that some can hear "better" (quieter levels) than others. AT the "townhall" resident testimonies held throughout Madison County (leading up to the efforts to formulate a Wind Ordinance) approximately 25% of residents voiced a desire to allow IWTs into the county while a passionate 75% did not want them forced into their lives. Several "pro-Wind" comments were from farmers who stated they "could run their tractors all day long under the turbine and never notice them". Such individuals, if wearing hearing protection or riding in a protective enclosed tractor cab, would probably be protected against appreciable audible emissions being generated by the IWTs. If such individuals worked without sound protection, the immediate background noise levels, e.g. tractor engine (and the domination of the sound source in the immediate vicinity) from farm machinery, would normally be high enough to exclude a separate, recognizable IWT noise. Even if machinery was not immediately operating, human sound perception "adapts" to the usual background noise level - thus making their "unfocused" listening experience less aware of ongoing IWT sound. Such adaptation may take several days to recover in the absence of background noise associated with mechanized farming.

Clear Lessons from N.D. Kelley Pioneering Studies

Evidence that IWTs produce perceptible levels of infrasound in addition to audible low-frequency noise above 20 Hz has been available since the 1980s (Taken from Punch/James - 2016). Kelley, et al, in response to noise complaints, measured noise levels emitted by the Mod-1 IWT during their seminal multi-year evaluation concluded:

"... one of the major causal agents responsible for the annoyance of nearby residents by IWT noise is the excitation of highly resonant structural and air volume modes by the coherent, low frequency sound radiated by large wind turbines. Further, there is evidence that the strong resonances found in the acoustic pressure field within rooms actually measured indicates a coupling of subaudible energy to human body resonances at 5,12, and 17-25 Hz, resulting in a sensation of whole-body vibrations".

Most importantly, Kelley found that the turbines radiated their peak sound power (loudest in terms of decibels) in the infrasonic range - typically between 1 and 10 Hz. Annoyance was the result of coupling of the turbine's impulsive low-frequency acoustic energy into the structures of some of the surrounding home - frequently confined to within the home itself. Despite these early findings that IWTs generate infrasonic levels that produce acoustic energy, vibrations and resonances that affect people in their homes, the Wind Industry has chosen to regard them as insignificant...

Infrasound Emissions from IWTs DO exist

There has been an intense effort by Wind Energy to "downplay" the existence (if possible) and the potential adverse health effects of infrasound.

The overall mechanisms by which jet engines, aerodynamic structures and wind turbines generate sound was first placed on a rigorous mathematical foundation by M.J. Lighthill in 1952 - nearly 70 years ago. Swinbanks (Acoustician) noted that his analysis has since stood the test of time. The principal process which generates very low frequency infrasound is the effect of the aerodynamic lift force of the blade acting upon the air. Even if a steady, unchanging lift force rotates in a circle, the periodic changes in its position give rise to sound generation. For an ideal wind turbine blade generating power in a completely uniform, steady oncoming airflow, the resultant sound consists primarily of the lowest blade-rate harmonic, plus to a lesser extent the immediate second and third harmonics. Swinbanks describes the infrasound-generating process as "unavoidable". (The following paragraphs are from his testimony at the Australian Select Committee on Wind Turbines - Submission 189). "If a wind turbine is to provide useful power, it must satisfy two requirements. First, it must slow down the oncoming wind in order to extract its energy. Secondly, it must convert this energy into a rotational torque to drive its generator. Thus, the blades of the turbine must exert a forward-acting force on the oncoming wind to slow it down, while exerting additional tangential forces in the circumferential direction to give the required torque. These simultaneous objectives are achieved by the twist and alignment of the blades relative to the oncoming wind, so that both components of force can be generated by the aerodynamic "lift" from the blades. For any wind turbine that is generating power, these two rotating force components have to be present. In turn, a specific amount of infrasound is inevitably generated, regardless of how precisely and accurately the blades are profiled, polished and streamlined".

These basic underlying effects were accurately modeled by NASA in their late 1980's investigation of upstream-rotor turbines (type in use today). However, real circumstances introduce additional effects. The existence of the support tower downstream of the blades still requires the airflow to separate around the tower, which gives rise to some degree of upstream modification of the flow directly in front of the tower. NASA initially modeled these effects using the assumptions of a comparatively smooth flow change, but in practice trailing vortices from the tips of the turbine blades can also impact the tower and lead to an increase in infrasonic noise generation. At the same time, slower moving air closer to the ground at the bottom of the blade rotation can give rise to additional recurring transient variation in lift force on the turbine blades. This effect becomes more significant as the diameters of wind turbine rotors increase in size, since the blades then rotate through a much greater vertical distance and the change in windspeed from the top to bottom of the rotation can then be much greater.

Finally, any large-scale turbulence present in the incident airflow results in additional fluctuating lift forces which can also interact with and modify the infrasound that is generated.

Long Range Propagation of Infrasound

Infrasound persists for much greater distances than audible sound and, unlike audible sound, penetrates well into insulated building structures with ease; and often increases the impact by resonating within the house, like a drum. This occurs, regardless of the source of sound and vibration energy.

Penetration of buildings and amplification via resonance can also occur from sound and vibration from natural sources such as earthquakes and thunder but is of such a temporal nature that, unlike wind turbines, produces no adverse health effects.

Sound propagation varies depending on the frequency of the sound being propagated. Audible sound attenuates (decays) at roughly 6 dB/distance doubling from the source. Infrasound attenuation is roughly half of that because of the longer wavelength being "absorbed and carried" in the "denser" medium of the ground. Infrasonic pulsations from a single 4 MW wind turbine were measured 10 km from their source in 1985 by NASA researcher William Willshire - the presence and recognition of associated adverse health consequences of this low frequency energy component of noise being noted

WELL BEFORE commercial IWTs were later pursued. Recent data collected by Acoustician Les Huson in Australia and the United Kingdom at onshore and offshore wind developments has shown that attenuation (reduction in sound level with increasing distance from the source) can be much less than the 3dB per doubling distance found by Willshire in 1985. This means that infrasound noise, in certain situations, can even propagate further than what is commonly described.

Under normal atmospheric conditions, the temperature of the air progressively gets colder as altitude increases. Under such conditions, the propagation of both audible sound and infrasound spreads out and attenuates at a similar rate of - 6dB per doubling of distance. There is also progressively greater attenuation of the higher audible frequencies, as a result of atmospheric sound absorption. Under

certain atmospheric conditions, however, there may be a temperature "inversion". This can occur particularly at night or the early morning, when the ground and the air immediately above it lose heat faster than the air at higher altitude. Consequently, for several hundred feet or more, the air may actually get warmer with increasing altitude, before ultimately reverting, at higher altitude, to its more usual cooling profile. A similar situation can occur when the wind changes from a cold wind blowing over cold ground, to a warmer wind from a different direction blowing over the same initially colder ground. A well-known consequence of this inversion temperature profile is that low frequency sound can be trapped and reflected by the inversion layer, so that it spreads out more slowly. Its rate of attenuation then reduces to more typically -3 dB per doubling of distance, so that at large distances, although the higher frequencies may be imperceptible, the ILFN can still be clearly detected.

Radiation inversions are probably the most common type of temperature inversions. This forms near the earth's surface during the night. After sunset, especially on a clear night, the earth's surface cools because energy is radiated to space. The air which is just above the earth cools through contact with the cool surface. Many residents in Adair county became upset after the recently erected IWTs became operations with the thumping they experienced during the first winter. They were being kept awake by the readily perceptible modulated low frequency noise and infrasonic "silent thumps" of IWTs at a distance of even 3 miles.

In considering IWT distancing from property lines and resident homes, it is first important to protect humans with audible sound limits - particularly at night - to eliminate disruption of sleep and thereby mitigate that core determinant of AHEs from wind turbines. That established limit of audible sound (expressed in dBA) will have some influence on the omnipresent lower frequencies of IWT emissions, but NOT complete "control". One MUST recognize that infrasound causes health effects and that those effects extend a much greater distance than audible sound. This is a sad reality, if audible sound limits are set high - e.g. >40 dBA at night - there is a marked increase in ill-effects of infrasound at the receptor structure. Distancing is the only way to lessen the harmful adverse effects of IWT noise. Initially defined are lower audible sound limits AND, ideally, secondly defined setback distances (to protect from longer-ranging infrasound) are needed to protect human health. The distance of 1.25-1.5 miles, as recommended by the Madison County Board of Health from their comprehensive review of available independent scientific information, would be appropriate for IWTs of 2 MW or less (although there would be some annoyance suffering, at times, even with that physical separation). Recently it has become apparently that separate ILFN noise regulation limits are needed – typically expressed with C-weighted values

IWT Separation and Infrasound

These following observations are particularly true of wind turbines which are positioned too closely together in a wind farm: The wakes from turbines positioned upstream are convected downstream by the wind and may compromise the lift forces generated by turbines located further downstream, with resultant adverse consequences for both the fatigue life of the blades and the generation of excess infrasound. The more the "wake deficit" that is brought about by the extraction of energy upstream, the more the reduction of the amount of power that the downstream turbine can generate in a given wind strength. This effect was first intentionally investigated in the design of the 1981 MOD-2 upwind rotor turbines. Yet despite this early research, more recent examples of wind farms have been constructed with separation in the downwind direction as little as 3 turbine blade-diameters, which not surprisingly have resulted in complaints from nearby residents of excessive noise and infrasound.

Historically it was accepted that wind turbines should be no less than 5-8 rotor diameters apart, depending on the direction and consistency of the prevailing wind, with the larger separation being for turbines in line with the major wind direction. This was accepted industry practice and, as an example, was explicitly specified in the 2002 NEW SEDA handbook. The purpose of this specification is to minimize turbulent air entering the blades on an adjacent turbine. As noted, turbulent air is associated with increased sound levels and infrasonic pulsations.

If a significant proportion of the wind blows at a right angle (90 degrees) from the major direction used for turbine layout it follows that turbine spacing should be 7 or 8 rotor diameters in both directions. It should be noted that the 7-8 rotor diameters number is a compromise between ensuring smooth air inflow to all turbines (and hence less noise and vibration) and packing as many turbines as possible into the project area. Research conducted at John Hopkins University in 2012 showed that the best design for efficient energy extraction suggests wind turbines should be 15 rotor diameters apart. It is increasingly evident that some projects are not laid out in accordance with accepted specifications to reduce turbulence, which in turn significantly increases acoustic emissions including audible noise and infrasonic pressure pulses. It is very important that such "variations of aggressive IWT placements" be recognized as likely and that residence audible sound levels (expressed as Lmax) be clarified precisely such that sound limits enforcement can be made. Additionally, with MAE's practice of turbine "clumping" and close in-line spacing, listing a maximal permissible sound level within the infrasound spectrum would also be protective.

Sound Propagation Computer Modeling

As just noted, it is increasingly evident that some projects are not laid out in accordance with accepted specifications to reduce turbulence, which in turn significantly increases acoustic emissions including audible noise and infrasonic pressure pulses.

There are commercial quality wind turbine computer modeling programs available but are limited to only spherical but not line propagation that could grossly underestimate the true impact of the sounds on adjacent properties located along the rows. These programs also did not follow the advice of the NASA studies about propagation of the infra and low-frequency sounds. Rick James, (Acoustician) commented that it was not uncommon for acoustical consultants hired by property owners to measure sound levels on their properties frequently found levels that exceed the modeled sound levels by 5-8 dBA. He was concerned that models/designs did not reflect "worse case conditions", failed to fully disclose assumptions, limitations and tolerances. Finally, they need to consistently provide confidence limits to account for the inherent inaccuracies in any model representing a complex set of conditions.

Recent Mid-American Energy promotional ads have extolled the "advanced quality of the computers they use in siting turbines. Although I do not know exactly what capabilities they have, the pattern of IWT placement in "clumping/groups" and placed in "lines" often congruent with prevailing wind directions suggests computer modeling may not be ideal based on the physics of IWT sound propagation. I would suggest that industry's "dense siting" practice may likely be "inconsistent" with the paramount **primary health concern** of limiting sound exposure to residents.

For these reasons, among others, an independent sound impact assessment by a qualified member of INCE (Institute of Noise Control Engineering) acoustician is needed and such a requirement should be in the requirements of a County Wind Ordinance. Although there is time and cost required for such a review, future monies saved will be enormous compared to the monies spent (legal fees) over decades by individuals and groups to eliminate or mitigate IWT annoyance produced from a poorly designed, industry-submitted plan. This independent audit should be made available to anticipated residents impacted by IWT placements near their residences BEFORE construction. This essential Wind Ordinance component is mentioned in the recommendations part.

Low Frequency Sound

The range for this category of sound is usually defined as 20-200 Hz but has also been defined, by some acousticians as 10-160 Hz. Low-frequency wind turbine noise is usually described in its modulating state as a rumbling, as humming or as a roar. It may have a more or less "tonal" character – described as fluctuating and varying in level and/or pitch. It may also be described as having tone-like pulses excited with regular or random intervals. It is often reported as having a feeling of eardrum pressure.

It is characteristic that the noise varies a lot in time with varying wind and other atmospheric conditions.

A beautiful representation of "on-going" low-frequency noise modulation was presented at the 2017 ICBEN (International Commission of Biological Effects of Noise) by Dr. Steven Cooper, Acoustician, The one minute visual recording of vacillating low-frequency sound levels (seen as snap-shots of colored lines along with summated averages along the recording duration represented in black) is available at

https://1drv.ms/v/s!AjF3hssMsBNBg5Rs1lRebR87OkWyQQ?e=gDptEi

You will note that the displayed frequency range extends from 0 to 1000 Hz. "Rumble" characterizes the sound from 20 to 100 Hz, "roar" from 100 to 200 Hz and "whoosh from 200 Hz and higher. These varying peaks within the noise spectrum, (generally high enough in dBA loudness) will generate audible sound - from which people suffer annoyance.

What you see is a "real-time" FFT analysis (Fast Fourier Transform converts a signal from its original domain (often time or space) to a representation in the frequency domain or vice versa). The black trace is "time-averaged" to slow it down enough to make it easy to see. As "averaged", the true peaks are not seen. The range of peaks are shown as the colored lines. The "beat" is relatively steady but the amplitudes at any frequency change a bit from one time to the next. This is because there are multiple wind turbines contributing to the acoustic data used to do the FFT analysis. While all turbines may be spinning at the same rpm, they are not perfectly in sync with each other and the sound from each turbine take a slightly different amount of time to reach the microphone. Thus, the black line trace is showing the blending of these similar pulses and tones, sometime adding together to create a maximum, sometimes cancelling each other out creating a minimum.

Leventhal (primary Acoustician for Wind energy) has identified (in his more recent opinion) that infrasound is not an acoustic issue of annoyance associated with turbines, but the emphasis should be on low frequency noise. In Leventhall's DEFRA report, in 2004, he referenced work undertaken by Bradley in 1994 that changed the modulation

rate of low frequency noise and obtained a subjective assessment of the annoyance factor for different rates of modulation. Bradley indicated for the critical region of between 2 and 4 Hz (being the rate of modulation of low-frequency noise) could require an adjustment for annoyance of up to 17 dB, due to the subjective assessment of the severity of the annoyance when compared to no modulation. Leventhall reportedly "left" this mainstream of thought in 2005 as he became the primary Wind Energy acoustical spokesman.

The level of annoyance suffering increases substantially for low frequency sound - once perceived – than the more readily audible mid-frequency sounds. Low-frequency is in the 20-200 Hz range and is more appropriately measured with dBC filtering.

Annoyance:

A complex consequence of IWT... will focus on "audible" sources. (Taken from Rick James, 2009)

It is not clear which of the following IWT noises generate "annoyance suffering" that is specified by the WHO as an "adverse health effect". It could be:

1) the distinctive rhythmic, impulsive or modulating character of wind turbine noise (synonyms for "thump", "swoosh" or "beating" sounds.

2) its characteristic low frequency energy (both audible and inaudible and also impulsive),

3) health effects of chronic exposure to wind turbine noise (especially at night),

4) in-phase modulation among several turbines in a wind farm (this can triple the impulse sound level when impulses of three or more turbines become synchronized) or some combination of all these factors best explains the annoyance.

One or more of these characteristics are likely present depending on atmospheric and topographic conditions, (especially at night) as is the individual susceptibility of each person to them. Nevertheless, reports based on surveys of those living near wind farms consistently find that, compared to surveys of those living near other sources of industrial noise, annoyance (suffering) is significantly higher for comparable sound levels among wind utility footprint residents. In most cases, where relationships between sound level and annoyance have been determined, annoyance starts at sound levels **10 dBA or more below the sound level** that would cause equivalent annoyance from the other common community noise sources. Whereas one would expect that people would be annoyed by 45 dBA nighttime sound levels outside their homes in an urban area, rural residents are equally annoyed by wind turbines when the sound levels are 35 dBA independent of the time of day.

Annoyance is discussed later to a greater extent in the discussion of adverse health effects.

Appendix

(Taken from the "Wind farm Noise" textbook during the author's description of Outer Hair Cell Responses, Hearing Thresholds in the Infrasound and Lower-Frequency Sound Spectrums) Note significantly lower recognition of infrasound emissions as perceived by the "outer hair cell response".

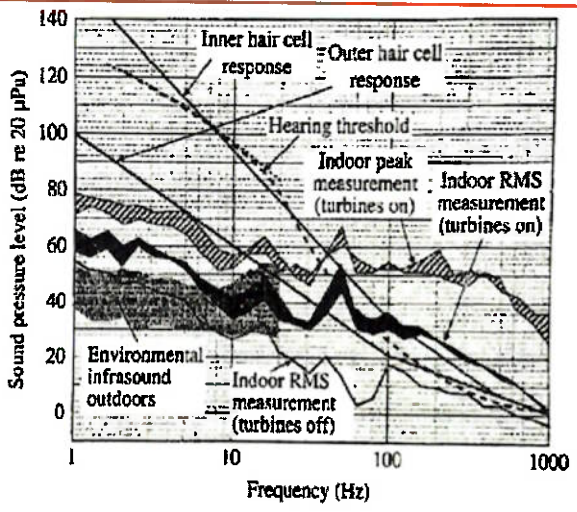


Figure 7.7 Inner and outer hair cell responses, hearing thresholds, environmental infrasound and wind farm infrasound.

Part – 5: History

Wind Energy's Wind Ordinance preferences: Where did they come from and will they protect human health?

In this section I will review first the early understanding of lower frequency noise and its impacts on humans and then focus on the development by Wind Energy of the ETSU-R-97 guideline document that has come to be the "basis and explanation" of current siting of IWTs at a typical distance of 1500 feet from residences despite a tremendous amount of recent science saying that adverse health effects are seen at that distance.

Early ILFN recognition in Industrial gas turbines and HVAC systems.

(Taken from Richard James review article: "Wind Turbine and Low-Frequency Sound: Warning Signs That Were Not Heart) - Bulletin of Science, Technology and Society 32(2) 108-127, 2012)

In the 1970s through the 1990s, acoustical consulting was often associated with occupational and community noise in the audible frequency range. Several projects involved industrial processes where high levels of infrasound were a significant factor contributing to an occupational hazard. Examples of locations where workers reported adverse audible and ILFN included foundries operations and combustion burners. In the early 1990s, there were concerns about pregnant women being exposed to noisy occupational environments.

James, in his article, pointed out that the ILFN was not the focus of the study but did prompt changes to the noise processes to allow greater worker safety and tolerance. This author importantly makes the distinction that unlike those industry responses, Wind Energy has not pursued any investigation of the sound types nor impacts of the noise made by IWTs. While some IWT design changes were made (use of up-wind design, blade shape/wind loading considerations, and blade edge "feathering" - that mostly affect audible noise emissions), ILFN cannot be appreciably lessened **except by** reduction in the sound power level ratings of the turbines and/or by increasing distancing to the receptor (resident).

By the early-mid 2000's, increasing numbers of reports of resident AHEs living near wind turbine utilities were appearing, which this author believes was related to:

1) intense ramp-up of on-shore IWT farms in this country - moving from remote locations into rural residential areas.

2) a substantial increase in the power generation capacity of individual turbines (correlated with "blade swept area" made possible by added turbine hub height to permit longer blade arm lengths and technologic improvements in turbine design and building materials, (all done without ANY acknowledgement nor study of potential subsequent heightened AHEs to humans).

3) implementation of turbine-siting guidance with "Outside U.S."- developed "turbine siting guidance" (mostly through the ETSU-R-97 document developed by Wind Energy interest in the United Kingdom in the absence federal oversight/verification in this country).

Over those early years, a number of acoustical engineer researchers collected an increasing body of knowledge focused on the similarity of machinery - produced and IWT - associated worker/resident complaints. James mentioned Charles Ebbing - head of Carrier Corp Acoustical Labs who investigated HVAC noise affecting some occupants of high-rise office buildings. Dr. Malcolm Swinbanks, who had many years of experience with machines that produce ILFN, was an early investigator. He also had personal experience with inaudible levels of modulated ILFN causing the type of symptoms associated with IWTs. Dr. Swinbanks became a major scientist raising the concern of AHEs caused by IWT noise emissions.

Of particular historical clarification, is that Dr. Swinbanks worked from 1975 to 1978 and then again from 1985 to 1989 with Dr. Geoff Leventhall on these investigations of noise production by gas turbines and industrial wind turbines. Indeed, clarification of the ILFN emissions from IWTs was made by Kelley, et al in the 1980s, with a decade-later reaffirmation of the relevance of that work in the understanding of adverse health effects from those lower frequency noises.

It is of absolute importance was that Dr. Geoff Leventhall did much of the research needed to resolve the problem. A report published in 1997 by some of the same researchers who have since published articles on wind turbine noise and other effects (Persson Waye, Rylander, Benton, and Leventhall) highlight some of the compelling parallels:

1) (From the background): Some of the symptoms that are related to exposure to low frequency noise such as mental tiredness, lack of concentration and headache related symptoms, could be associated with a reduced performance and work satisfaction.

2) (From the Conclusion): The results showed that low frequency noise was estimated to interfere more strongly with performance. The results also gave some indications that cognitive demands were less well coped with under the low frequency noise condition. .... The relation between reduced activity and response time, which was especially pronounced in the low frequency noise condition, may also indicate that increased fatigue was of importance for the results.

The adverse health effects reported by workers occurred with short-duration exposure (e.g. 8 hours a day or less). This is a much lower "dose" than what people living near IWTs experience. That 1997 study found that some of the symptoms related to exposure to modulated very low-frequency sound are similar to those reported by people experiencing exposure to IWTs.

Rick James went on to highlight other, earlier parallels in scientific evaluations of "noise-Induced sick building syndrome. This referred to buildings erected during the 1970s and 1980s that used large fans, centrally located, often on the top floor, to provide heating and air-conditioning for the building. In the affected buildings, complaints arose that people did not want to live or work there. Complaints of physical discomfort, productivity loss, effects on mood, lower social orientation, cognitive dysfunction, headaches were voiced by many (but not all). In these buildings, it was found that the HVAC system was the primary source of recorded infrasound and very low-frequency sound. Not all workers in the building complained of audible rumbles. When the problem was audible, one or more workers might hear a rumble or roar from the ventilation ducts. In those cases, there was little question about the problem. People who could hear it, demanded that it be fixed. But, if it was inaudible, people did not associate their symptoms with the sounds that made them less productive. It required special studies and tests developed by Dr. Leventhal and others to identify that the workers' sense of being uncomfortable or having other symptoms while in their offices was associated with the modulated ILFN.

These investigators convincingly showed that pulsations in the HVAC systems corresponded to times when the workers reported symptoms of mental tiredness, lack of concentration, headaches and reduced performance and work satisfaction. Rick James carefully and fairly clarified that many of those symptoms from the studied "sick buildings" were "couched" in the language of productivity and work performance. However, subsequent research revealed a host of closely-matched symptoms that are reported by those experiencing adverse health effects from IWTs.

Apparently, Dr. Leventhall, despite his early research and clarification of ILFN being responsible for symptoms closely mirroring those from IWTs, in the years to follow, uniquely and inexplicably chose to develop and support Wind Energy's stance on the "benign" character of ILFN produced by wind turbines. He became a champion and referenced leader in Wind Energy's promulgation of IWTs around the world.

Hearing vs Perceiving - Both can produce AHEs

Continued research supported the link between the complaints and aspects of wind turbine ILFN.

People who worked or lived near large rotating machines found that they felt uncomfortable or had symptoms that were not related to any known illness or pathology. A common denominator of all those machines is that they produce sounds in the ILFN range. A review of some studies conducted to determine why people reacted negatively to working near these machines revealed a "common thread" - inaudible ILFN was present and was associated with the physical symptoms reported by some of the workers.

Previous research had shown that at AUDIBLE levels, ILFN were able to produce physical responses.

However, many scientist and engineers assumed that inaudible levels could not cause any problems.

Indeed, Mid-American Energy (MAE) representatives in our Winterset Courthouse during the 2018 permitting process, repeated the saying "what you can't hear, can't hurt you". Many acoustical engineers were taught this as a part of their academic training regarding the perception of ILFN.

Subsequent studies by researchers such as Swinbanks, Ebbing and Ebbing's colleague Blazier, an independent acoustical consultant who worked in the HVAC industry, found evidence that SOME people responded to INAUDIBLE levels of ILFN produced by the machines.

Further, relevant comments by Swinbanks (2010) include "as a result of spending long hours working on sites in the presence of significant levels of very low frequency noise, I acquired considerable familiarity with its effects and consequences." In addition, and not unique to just Dr. Swinbanks, he became sensitized to ILFN his early work with those noise exposures, noting he could perceive or "feel" inaudible ILFN. This author has, as well, appreciated that ineffable sensation (best described as an extremely fine skin tingling) when emerging from a car in the setting of densely and closely sited large IWTs surround a home in central Adair County operating during "heavy winds," to attend a meeting.

Typically, when a resident complains of "perceiving" these "inaudible pulsations", an industry-paid acoustician may come to measure nearby IWT emissions. Their reports state that the levels of infrasound are below the threshold of perception for steady pure tones. Swinbanks (2010) stated "care must be taken when comparing broad-band measurements, having noise simultaneously present at all frequencies, against a threshold defined by individual, stand-alone pure tones". He offered a neuro-processing basis observation: When an ear is subjected to a steady pure tone in a laboratory environment, it will be less sensitive to low-frequency sound than when presented with sound consisting of a complex mix of tones (neither steady nor pure) in the same frequency range. They are a complex mix of tones whose

summed amplitude modulates in short, rapid bursts, sometimes lasting 10 milliseconds or less. These modulations, or pulsations have high crest factors and large dynamic ranges.
The peaks can be 30 to 40 dB higher than the SPL (sound pressure level) in the valleys between them". Dr. Malcolm A. Swinbanks produced a nice review of this topic when presenting to the Australian Senate Select Committee on Wind Turbines on March 20, 2015. Part 2 describes "The Perception of Low Frequency Sound and Infrasound". As noted in the previous paragraph, it is important to see IWT noise as "impulsive and complex".... meaning levels of sound fail to take into account either of the character of the sound or the relationship between adjacent frequency bands. He also referenced a number of reported cases in the literature where ILFN was clearly being perceived at significantly lower levels than would be assessed by such basic comparisons with the hearing threshold.
He summarized that "conventional hearing perception is considered to take place via response of the inner hair cells of the cochlea (the sensing structure of the inner ear), but it has been shown that the cochlea outer hair cells respond with greater sensitivity at very low frequency, and induce additional neurological signals. Hitherto, these outer hair cells have been considered to perform only the task of controlling the overall sensitivity of the hearing process, but it is possible that they can also contribute directly to very low frequency perception". He continued with "a further mechanism has been proposed, whereby sound pressures acting through the lymphatic fluid directly on the otolith components of the vestibular (balance) organs have been calculated to exert comparable forces to those induced by motion and acceleration. Any non-uniformity in the compliance of the structures supporting these otolith sensors may then result in a response which that of physical motion. Indeed, it has been argued that the correlation between persons who suffer from motion sickness and those who report adverse effects from wind turbines is sufficient to be more than a result of mere chance".
Of note is that a resident from NW Madison County, who turned west onto I-80 was faced by a horizon of revolving turbine blades. She soon thereafter felt sick, nauseated and vertiginous enough to be forced to stop her car on the side, attempted to recover, fortunately later then proceeded off the next exit.... eventually recovering upon exiting the turbine field. That same sensation has been noted by others.

Wind Energy Concedes "Annoyance" Exists but Offers Other Excuses

Over the past twenty years, the wind industry has presented "their" evidence implying that IWTs are "safe" near people's home. Yet the reports of nearby residents suffering annoyance, sleep disturbance and the consequences of chronic non-restorative sleep and body/vestibular responses have been received from people living within 2 or more kilometers of IWTs not only located in this country but in countries around the world (Hanning & Nissenbaum, 2011; Harry, 2007; Krogh, Gillis & Kouwen, 2011; Nissenbaum, 2009; Phipps, Amati, McCoard and Fisher, 2007; Shepherd, McBride, Welch, Dirks & Hill, 2011).
Some of the research has focused on the annoyance potential from audible sound produced by wind turbines. Wind Energy agrees that annoyance does exist but stops there to accept the impact of that adverse consequence. Annoyance suffering is real and is an adverse health effect in and of itself – as was recognized and stated clearly by the WHO in 2009. Symptoms of depression, anxiety, confusion, vertigo (among many, many others) are real spin-off manifestations of being in close proximity to these turbine towers. They are NOT reflective of psychosomatic or psychological illness of residents. The "nocebo effect" may have some minor role but as months to years of exposure pass, the symptoms frequently persist and may become debilitating making a psychosomatic etiology highly unlikely.
I would point out that the 2015 peer-reviewed publication by the Council of Canadian Academies that was given to the Madison County Board of Health by the Iowa Environmental Council (local representation of the Wind Energy faction) lists that current evidence is sufficient to establish a causal relationship between a person's exposure to wind turbine noise and feelings (suffering) of annoyance.
Beyond the audible and visible "triggers" of annoyance suffering there are less obvious causes of the adverse health effects from IWTs. While Wind Energy has repeatedly downplayed the concern of infrasound and that humans are biologically incapable of "hearing" infrasound so that it should represent no concern to human health, there is ample evidence that this is **not** the case.
1) There are examples of adverse health responses mediated through the vestibular system's response to modulated infra and low-frequency noise.
2) Salt and Lichtenhan (2011) and Salt and Kaltenback (2011) have confirmed that there is a physiologic response to modulated infrasound at levels below the threshold of perception (defined in laboratories using "pure tones" that may start at amplitudes as low as 60 dBG).
3) Swinbanks (2011) demonstrated that as a direct consequence of the dynamic time domain stimulation of the auditory system by the modulating wind turbine infrasound, the "typical IWT infrasonic and low-frequency noise can be readily perceptible and audible at very much lower levels than had been previously recognized" (noted above).

4) Even much more recently, (Max Planck Institute) data using f-MRI (functional magnetic resonance imaging of the brain), found that "subaudible" noise in the infrasound range directly "activates" specific brain centers or "nuclei" which are known to directly influence body autonomic responses. In my opinion, this may be the link with automobile and air traffic noise where autonomic stimulation is thought to trigger the development of cardiovascular disease. This is very likely the case with IWT noise but, because IWT noise is more "annoying", this autonomic triggering is likely beginning at lower sound thresholds (less loud) than the other studied environmental noises. These threshold comparisons are shown in the 2018 WHO report.

Despite these findings and clear impacts of adverse health effects on humans by IWTs, the Wind Energy Industry, through its experts and trade associations, has denied that IWTs can cause such AHEs.

Highly recognized experts, some well- known in the field of acoustics, have defended the wind industry position through white papers, reports and testimony in hearing and through committees that establish guidelines for siting industrial-scale wind turbines. That viewpoint has not been accepted by other experts.

NASA and Department of Energy Funded Research from the early 1980s to about 1991

The U.S. government has known about health effects of infrasound and low frequency noise from IWTs since 1987. It was concerned (then) enough to commission a study. The study was a research project funded by the U.S. Department of Health, Contract No. DE-AC02-83CH10093. Among many impressive scientific papers, was the following: Dr. N.D. Kelley, Solar Energy Research Institute, Golden, Colorado:

"A proposed Metric for Assessing the Potential of Community Annoyance from Wind Turbine Low- Frequency Noise Emissions" Note: "Community Annoyance" is now called Wind Turbine Syndrome; "Low Frequency" includes infrasound; "Emissions" includes noise and vibrations.

It should be noted that the Wind Energy faction still does not (implied refuses) to consider to measure ILFN exposure levels inside the home.

Between 1982 and 1988, Kelley and his colleagues published five important papers:

1. N. D. Kelley, R. R. Hemphill, M. E. McKenna. "A Methodology for Assessment of Wind Turbine Noise Generation", 1982. (First published in J. Solar Engineering, Vol. 21 (1981), pp.341-356).

2. E. W. Jacobs, N. D. Kelley, H. E. McKenna, N. J. Birkenheuer. "Wake Characteristics of the MOD-2 Wind Turbine at Medicine Bow, Wyoming". November 1984.

3. N. D. Kelley, H. E. McKenna, R. R. Hemphill, C. l. Etter, R. l. Garrelts, N. C. Linn. "Acoustic Noise Associated with the MOD-1 Wind Turbine: Its Source, Impact, and Control". February 1985. (First published by the Solar Energy Research Institute, February 1985). (262 pages)

4. N.D. Kelley. "A Proposed Metric for Assessing the Potential of Community Annoyance from Wind Turbine Low-Frequency Noise Emissions", November 1987.

5. N. D. Kelley, H. E. McKenna, E. W. Jacobs, R. R. Hemphill, J. Birkenheuer. "The MOD-2 Wind Turbine: Aeroacoustical Noise Sources, Emissions, and Potential Impact". Solar Energy Research Institute. Prepared for the U.S. Department of Energy, January 1988. His work was published in peer reviewed journals. He presented his paper "Acoustic Noise Associated with the MOD-1 Wind Turbine: Its Source, Impact, and Control" at the Fourth ASME (American Society of Mechanical Engineers) Wind Energy Symposium held in Dallas, Texas on 18-20 February 1985. In 1987 he presented his paper "A Proposed Metric for Assessing the **Potential of Community Annoyance from Wind Turbine Low-Frequency Noise Emissions", at the American Wind Energy Association "Windpower '87 Conference and Exposition", October 5-8, 1987 in San Francisco, California.**

Kelley et al. concluded: "...one of major causal agents responsible for the annoyance of nearby residents by wind turbine noise is the excitation of highly resonant structural and air volume modes by the coherent, low frequency sound radiated by large wind turbines. Further, there is evidence that the strong resonances found in the acoustic pressure field within rooms actually measured indicates a coupling of subaudible energy to human body resonances at 5,12 and 17-25 Hz, resulting in a sensation of whole-body vibration." A page from that publication graphically shows the display of measured frequencies and their sound pressures.

3) Additional investigation by Kelley, found that turbines radiated their **peak** sound power in the infrasound range, typically between 1 and 10 Hz (that is STILL the case as can be seen on Wind Industry produced displays of IWT-produced sound intensities along the entire noise spectrum). Annoyance was the result of a coupling of the turbine's impulsive low-frequency acoustic energy into the structures of the home and that the annoyance was frequently confined to "within the home itself". In Kelley's and in three other investigator`s work, the studies report similar findings, namely that perception, generally is non-auditory in character, begins when the rms ("average") SPLs (loudness) of the modulating tones that are as low as 35 dB rms with increasing impacts as the rms levels rise to 50, 60

and to 70 dB and higher. In all these studies the dynamic modulation of the blade-pass tones produces pressure peaks that are often 10 dB or more greater sometimes much more, than the rms values.
The following link tracks the work of Dr. Kelley and his findings which remain relevant for IWTs currently being placed for energy generation.
http://docs.wind-watch.org/Infrasound-wind-turbines-4-August-2015.pdf
I would strongly recommend that this link be opened and the history of the recognition of infrasound and its potential for adverse health effects was first described by N.D. Kelley and how it was "forgotten or intentionally overlooked". Despite the recognition of potential human harm, this information was discarded by Wind Energy and specifically by the turbine manufacturer, Vestas, the manufacturer of turbines proposed for installation in Madison County.
Two primary researchers, Hubbard and Shepherd (1990) **(30 years ago)**, reported the following:
1) Wind turbines primarily produce infrasound and low-frequency sound.
2) Sound propagates from IWTs at a decay rate half that of common (audible) "point" sources
3) IWT noise travels farther than other sounds.
4) IWT noise will be a significant indoor noise problem due to room resonance and a dominance of ILFN acoustic energy.

1500 Setback recommended by MAE:
Fifteen hundred (1500) feet was the distance (in the original Mid-American Energy (MAE) request for siting of IWT) from rural residences for the proposed Arbor Hills Wind Farm. At none of those initial and none of the subsequent follow-up meetings at any level was there a description of how that distance was proposed, how long it had been in use nor ANY description about the human health implications of that distance. In the written proposal, there was no listing of the anticipated noise exposure level to residents. Some of the presenting MAE representatives were not clear as to which model of IWT was planned for Arbor Hills. The only mention of noise levels incurred by the IWTs was the verbal (never written) comment (during the meeting) by Matt Ott (MAE) was that he anticipated no more than 45 decibels at the front door of an occupied residence. He claimed that it was a safe level.
Fifteen hundred feet setback was the only specification in not only Madison County's proposals but also that of Adair County and any proposal IWTs that I have seen for Iowa. So where did it come from?

The Origen of the 1500 Foot Setback
Industrial Wind Turbines function through transferring wind energy onto large rotating blades that turn a shaft that operates a generator that creates electrical energy. That entire string of energy transfer creates sound which is characterized as "noise" when it is characterized as disagreeable. Noise regulation from any source in the United Kingdom was via the British Standard BS4142 (described as method for rating industrial noise affecting mixed residential and industrial areas). A document described as the Planning Policy Guidance 24 (PPG24) was generated in the UK that outlines some of the main considerations which local planning authorities should take into account in drawing up development plan policies and when determining planning applications. PPG24 provides advice on how the planning system can be used to minimize the adverse impact of noise without placing unreasonable restrictions on development or adding unduly to the costs and administrative burdens of business. The document introduced the concept of noise exposure categories (NECs) ranging from A-D for residential development and recommends appropriate levels for exposure to different sources of noise. A proposal for residential development needed a determination of which NEC categories would be operative also taking into account both day and night-time noise levels. The PPG24 takes into account the recommendations of the Noise Review Working Party which reported in October 1990. PPG24 - 1994 recommended using the British Standard BS4142. This regulation was formulated to assess facility external noise (outside at a property) **based on the likelihood of complaints.**
Background noise levels (LA90) should be measured. Source-specific noise levels (rating level) are then obtained from manufacturer's data or measured in situ. The background noise level is then subtracted from the Rating Level. If there is likely to be a tonal content or "specific character" to the building services plant noise then a +5 dBA correction is applied to the Rating Level. This assessment method is only applicable to external areas. Assessment of excess value:
1) A difference of around +10 dBA or more indicates that complaints are likely
2) A difference of around +5 dBA indicates a marginal significance of complaint.
This is the same (but not for IWTs) formulation as used in the United States ... as in the ISO TC/43. ((ISO is the registered trademark for the International Organization for Standardization. TC/43 deals with acoustics under which there are three subcategories - noise, building acoustics and underwater acoustics. Under the "noise" category, there

are many further subcategories including ISO 1996-1:2016 which describes measurement and assessment of environmental noise. In the overview of subcategory, ISO 1996-1:2016 defines the basic quantities to be used for the description of noise in community environments and describes basic assessment procedures. It also specifies methods to assess environmental noise and gives guidance on predicting the potential annoyance response of a community to long-term exposure from various types of environmental noises. ISO 2016 is currently in the third edition, is 47 pages long, and can be purchased from the ISO website)).

In general, the LA90 (background) noise is going to be in the mid-upper 20s dBA range in the rural residential areas of Madison County.

This BS4142 regulatory limit is based on reasonable likelihood of complaint generations and was too restrictive for IWTs **as wind turbine have no noise control options except greater distancing**. Other industrial facilities don't have this problem, because they can enclose machinery in buildings, use mufflers, duct wrapping, etc. Thus, the Wind Industry had to come up with a "guideline" that raised background noise levels with the definition of 'LA90 -10 min' and convince U.K. regulators to use that guideline instead of BS4142. (Unfortunately, the LA90-10min measurement is effective for broadband noise such as traffic noise but not when measuring intermittent noise as produced by wind turbines).

That is exactly what they did as they developed ETSU-97. BS4142 continues to be used for industrial permitting and apparently remains a thorn in the side of consultants working to permit wind turbines and promote more noise in rural areas.

ETSU-R-97

ETSU-97 is a guideline and not a set of regulations. The acronym stands for "Energy Technology Support Unit". The ETSU working group was formed by the British Wind Energy Association for the purpose of preparing wind energy friendly guidelines and research. In that capacity, it worked on behalf of the Department of Trade and Industry (DTI); generally, with no independent oversight and no transparency. "The Assessment and Rating of Noise from Wind Farms" was published in 1997 and became and remains the UK government's preferred method of assessing wind farm noise for planning purposes. Rick James (in his article, Wind Turbine Infra and Low-Frequency Sound: Warning Signs that were not Heard) went on to describe the "inadequate" design of the ETSU-R-97 which was a "guideline only" for the UK that was developed specifically to circumvent more science-based UK regulations that were more restrictive to IWT placement. The guideline was developed by the Working Group on Noise from Wind Turbines which consisted of several acoustical consultants with ties to the wind industry in the UK, representative of companies or their attorneys involved in or with the wind industry, and several representatives of local governments and the chairman, who represented the government's Department of Trade and Industry (DTI).

The introductory comments about ETSU's purpose to "offer a reasonable degree of protection to wind farm neighbors without unreasonable restriction on wind farm development" has been met with near universal contempt (as also occurred in Madison County during a joint writing session with the Supervisors) as the guidelines should not provide the justification to impose greater levels of wind turbine noise intrusion than would be permitted by other forms of industrial development.

ETSU-97 compares the turbine noise with a level 5dB above background noise, but when background noise levels are low (particularly in rural areas), it sets a higher lower limit. The day time lower limit can be anywhere between 35 and 40 dBA and the night time lower limit is 43dBA. The most bizarre result is that night time background noise level can be "assigned" up to 8dBA more than the day time noise. No other standard anywhere in the world has a nighttime limit higher than a day time limit.

The ETSU-R-97 was specifically designed that way to harvest the greater wind resources that occur at night.

It appears that the ETSU-R-97 was produced to permit introduction of wind farms into inappropriate low background noise locations where they and other comparable industrial installations could not meet planning conditions derived from the long established BS4142. It could be reasonably supported that the Department of Trade and Industry (DTI) worked with the British Wind Energy Association that formed the ETSU to develop "fuzzy-science" based guidelines. I would view this as "pseudo-science to support policy, NOT policy to support science".

Further concerns:- ETSU-97 is a document that has remained unchanged over 23 years. Over the same period most everything else has changed:

1) The understanding into the effects of noise on people has advanced - particularly regarding adverse effects of noise on sleep and potential for cardiovascular disease promotion from environmental noise. The World Health Organization has weighed in with guidelines concerning not only other forms of environmental noise but also IWT noise. Sleep studies and actigraphy (movement) monitoring have now clarified sound pressure levels where there is 1) no sleep

disturbance, 2) non-conscious recognition of noise with subsequent disturbance of healthy sleep stage architecture and 3) awakening from sleep due to the uniquely disruptive quality of IWT noise.
2) The maximum size of IWTs has increased. With that, adverse health effects from sound emissions in the infrasound-low frequency noise (ILFN) range are now recognized in turbines >.5 MW thus creating new health considerations of turbine siting (that were not considered with the initial guideline).
3) The maximum size of wind farms has increased.
4) The possibility for closer adjacencies between neighboring wind farms has increased, leading to the need for greater consideration of cumulative noise effects.
5) The approach to wind turbine control has evolved from previously dominant 'stall regulated' technology to the now dominant 'variable speed' technology, thereby enabling much more control flexibility over the noise output characteristics of wind turbines.
6) Acoustic standards which were present in the early 1990s (which then formed the basis of discussions for ETSU-97) have been updated. This includes increased awareness of factors affecting 'derived prevailing background noise levels'.
Despite all these technologic and scientific advances in our understanding of IWT noise and its effects on human, the ETSU-97 has not changed since it has been accepted as non-regulatory guidance.
1) They initiated the "practice" of unreasonably "treading" inside the property rather than sticking to the property line.
2) ETSU-97 avoids "sound limits", rather, they set up the device of "relative to background noise: with which they were able to ramp the limit up assuming a low wind shear (gradient of wind speeds over the vertical height of the rotor sweep) factor. Noise intrusion is most likely during high wind shear conditions so mainly during the night time and evening when wind speeds at ground level are likely to be low but turbine noise at or close to maximum. Noise assessments by wind farm developers have either failed to consider wind shear or applied very low levels of corrections so underestimating the likely noise impact on nearby residents.
3) Additionally, when ETSU-97 was written, the tallest IWT was 32 meters to the hub, at which height wind shear effects could only lend to relatively small errors. Now total heights of tower/blade are >200 meters bring even greater adverse wind shear associated noise production. On average, high wind shear occurs at night about one-third of the time.
4) ETSU-R-97 allows night-time IWT levels to >20dBA above actual background noise in many quiet rural locations. (Greater than 10 dBA over background levels is associated with noise levels where complaints are likely. The additional 10 dBA represents noise levels that are 4 times louder and 100 times more intense)
5) They used a L90 (average over 90% of time tested) for the wind turbine noise, which is approximately 7-13 dB lower than the Lmax. Sleep disturbance, being biologic in origin is best characterized at given decibel threshold levels. ETSU-97, by characterizing noise essentially as an average (Leq), eliminated any possibility of assessing for sleep disturbance which is the most important of the many adverse health effects produced by IWTs. The "Leq" noise level designation of the IWT noise level (rather than Lmax) continues today and is present in the Wind Ordinance draft given (directly or indirectly) to county supervisors by industry.
6) There is no recognition of infrasound, low frequency (ILFN) or tonal noise character (see below).
7) Amplitude modulation is the most important noise characteristic of wind turbines. All comments about this are excluded in ETSU-R-97. Wind turbine excess amplitude modulation (EAM) is generally recognized as when the turbine blade 'swish' changes to thumping or banging. EAM is highly intrusive event at >1.5 km. The attenuation afforded by a closed window can be highly variable depending on the type of glazing system and frequency of the noise. In the event of low frequency noise as occurs with EAM, no window type, whether open or closed is effective at attenuating the noise. EAM is similar to helicopter "blade slap" - itself the result of blade vortex interaction. This aerodynamic interaction noise consequence has been well understood for decades... Why is a wind turbine's EAM such a technical mystery for Wind Energy? Simple: Wind Energy (including Mid-American Energy – as overtly stated by Matt Ott - one of their apparent technical experts) denies that ILFN can be perceived in any way by humans and therefore could not cause no adverse health effects. Vestas, the manufacturer of IWTs used by MAE in this region, formally requested and received permission from New South Wales, Australia 2012 to longer consider ILFN a relevant consideration in IWT siting. It appears that Wind energy has continued the same stance to completely ignore ILFN as a concern in this county (in the absence of federal/state oversight). A complete copy of that letter is in this part's appendix.
This description is NOT to suggest that the labeled ETSU guidelines are the ones specifically given to the Supervisors nor were incorporated into the initial MAE request for variance. The distance "1500 feet" is used throughout Iowa and the only precedence for this "extremely close setback and consequential excessive resident noise level exposures came

with the development and initial acceptance by the UK government. The "forced acceptance" by residents outside the U.S. has appeared to have worked well enough that WE development in this country has simply retained those original poorly conceived and now further outdated "guidelines". Peak noise levels appear arbitrary as well. At every location within the UK or where ETSU principles have been used internationally there has been resistance and public outcry in not all but among a significant proportion of affected residents.

Subsequent Adoption Worldwide

After being adopted (but not approved as regulation) by the British government, British Acousticians Hayes and later Leventhall were pivotal in the adoption of the ETSU-R-97 tenets - particularly to former British colonies (Australia. New Zealand) - with these Acousticians being presumably sent to establish control of the narrative and establish a template that the local firms could subsequently use for other wind energy projects. Leventhall formally started his pro-Wind energy work when he became a spokesperson for the British Wind Energy Association in the mid 2000's after Dr. Van den Berg published his thesis "The Sound of High Winds" and two other papers that observed wind turbine blades create pressure pulses as the blade passes the tower. For the next 15 years, reportedly at the request of industry trade groups, Leventhall and others organized "international" wind turbine noise conferences where research was promoted and reviewed that reflected the Wind Energy vision. Hayes (British Acoustician) apparently consulted on a project in New York state in the mid-late 2000's where working with US consultants reportedly "borrowed ETSU concepts" to get their projects approved in later projects. Those "templates" reportedly initiated by Hayes were "used around the world" being changed to accommodate regulations. It is highly likely that such "original" language perpetuates to this day; with the various "Wind Energy Associations" sharing the recipe to Wind Energy Industry (contractors)- a great many of whom sit at the Wind Energy boards. (Do a search for the Australian senate's hearings on wind turbine noise. Start at "Stopthesethings.com" and "the Waubra Foundation" searching for the names Hayes. Leventhal, Swinbanks, Thorne, Cooper to locate their work in Australia and New Zealand).

So Where is the Federal-Level Oversight to Protect the American People from IWT Adverse Health Effects?

Aaron Price (Madison County Supervisor – resigned as of early July, 2020) stated in a prior county meeting something to the effect that the Federal government would not have allowed IWTs to become so "widespread" if there was some inherent risk to human health. The unspoken fact is: There is **NO** regulation of IWT by the U.S. Federal government. This fact, in the course of my reading, remains completely unaddressed by Wind Energy; they get to define if IWTs are safe (seemingly in an arbitrary and capricious manner) or not and convince local counties in Iowa that they are OK. They have found that financial incentives seem to facilitate adoption of IWT placement - both for the landowners and the county tax rolls.

The U.S. Environmental Protection Agency (EPA) created the Office of Noise Abatement and Control (ONAC) following enactment of the Noise Control Act of 1972. In 1981 Congress agreed to the Reagan Administration's proposal to cease funding for ONAC. Congress, however, did not repeal the Noise Control Act when it eliminated ONAC's funding.

Before its elimination, ONAC engaged in a wide variety of activities to abate noise pollution under authority of the Noise Control Act and, after 1978, the Quiet Communities Act.

The Quiet Communities Act of 1978 amended portions of the 1972 Noise Control Act to require coordination between federal agencies on noise control. It was intended to speed up FAA response to noise regulations proposed by the EPA and requires the FAA to provide the public with a detailed analysis of EPA proposals. These included identifying sources of noise for regulation, promulgating noise emission standards, coordinating federal noise research and noise abatement, working with industry and international, state and local regulators to develop consensus standards, disseminating information and educational materials and sponsoring research concerning the effects of noise and the methods by which it can be abated. It also authorized the EPA to provide grants to state and local governments for noise abatement.

The EPA ceased most noise abatement activities after ONAC's funding was eliminated. There is still some minimal enforcement in the area of airport noise. Responsibility for the enforcement of EPA's railroad and motor carrier emission standards was shifted to the Department of Transportation.

Since defunding ONAC, federal noise emission and labeling standards have not been subjected (best I can find in the internet literature) to critical evaluations despite the evolution of relevant science and technology and a better understanding of the effects of noise on people. The EPA has been unable to provide technical assistance to state and local governments or to participate in private standard-setting efforts. State and local governments have been

preempted from adopting their own noise emission and labeling standards that differ from EPA standards for sources or products that EPA has regulated.

Apparently, there were **never** any EPA standards or regulations for industrial wind turbines. State and local governance has had to pick up that protective effort... but as said many times... without funding or other vital resources to do that. Specifically lacking are technical resources and highly trained engineering specialists to understand the science of industrial wind turbine sound emissions and interpret and stay current with the rapid explosion of our understanding of those sound emissions causing adverse health effects. Unfortunately, relying on Wind Energy and the Wind industry for objective knowledge and guidance in protecting human health has never happened. In my opinion, executing their agenda has, by necessity, eliminated their concerns of protecting human health.

Part 6: Adverse Health Effects from IWTs

A great review (essentially a textbook - 2014) was done by Bob Thorne, PhD (PhD in Public Health and Acoustician specializing in infra- and low frequency sound) - 158 pages "Wind Farm Noise and Human Perception - A Review". (May google the title; the entire text comes up). It starts with the Preamble: "There is a significant body of peer-reviewed research readily available in public forum to substantiate the potential for serious to moderate adverse health effects to individuals due to wind farm activity noise while living in their residencies and while working on their farms near large-scale wind farms or large turbines. Adverse health effects can arise from extreme psychological stress from environmental noise, particularly low frequency noise with symptoms of sleep disturbance, headache, tinnitus, ear pressure, dizziness, vertigo, nausea, visual blurring, tachycardia, irritability, problems with concentration and memory, and panic attack episodes associated with such sensations when awake or asleep".

The hypothesis from this Review is that serious harm to health occurs when a susceptible individual is so beset by the noise in question that he or she suffers recurring sleep disturbance, anxiety and stress.

Research for the Review suggests that 5% to 10% of the individuals living in the vicinity of a large wind farm will experience serious harm to their health. The observed markers for serious health effects are:

(a) wind farm noise levels of LAeq 32 dB or more **OUTSIDE** the residence and

(b) wind farm noise if heard or is perceptible (felt) at levels above the individual's threshold of hearing **inside the home**.

Previously, a study took place in Victoria, Australia (2012) that was led by Bob Thorne that was published and presented to the Australian Senate Hearing on 'Excessive Noise from Wind Farms'. The residents interviewed lived between 700 and 3500 meters with an average distance of 1400 meters. (This is almost three times farther than the distance proposed by Mr. Clifton in his Wind Ordinance draft submitted to the Board of Zoning for review and judgement). The study design is exploratory and observational, establishing the research required for the development of hypotheses. It is a scientific method- driven determination of health-related, perceptual and environmental variables, i.e. health related quality of life and noise exposure in a sample of adults exposed to wind farm generated noise.

The study used convenience sampling to obtain completed questionnaires. The survey included self report assessments on exposure to community noise and perceived intrusiveness of noise; annoyance and sleep interference due to noise exposure; psychological wellbeing, quality of life and general health; noise sensitivity and personality traits; attitudes to noise sources; and demographic information.

Questions were guided by pre-existing studies in the literature or by the use of pre-existing validated inventories, including:

- WHO Quality of Life ScaleQ
- Questions from Dr. Thorne on annoyance
- Noise Sensitivity Questionaire
- SF-36v2 Health Survey
- Sleep Disturbance from Epworth Sleepiness Scale, Pittsburgh Sleep Quality Index

Questions from Dr. Nissenbaum on Turbines and Health

The study sampled sound levels from wind farm locales and non-affected locales with full monitoring for low frequency sound and infrasound. The 23 residents sampled lived within 5 km of two wind farms while 2 were from locales without wind turbine activity.

In this comprehensive study, results of all the six categories were evaluated. As I have done in my research, the World Health Organization's Health and Noise criteria were central to the descriptions of harm. "Health" was defined as a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity. Quality of life is a multifaceted concept: "An individual's perception of their position in life in the context of the culture and value systems in which they live and in relation to their goals, expectations, standards and concerns. It is a broad ranging concept affected in a complex way by the person's physical health, psychological state, personal beliefs, social relationships and their relationship to salient features of their environment".

Further, the WHO Report of "burden of disease from environmental noise" - from 2011 and 2018 is a scientific evidence supported "exposure-response relationships" and case studies in calculating burden of disease. The report concludes ".... environmental noise should be considered not only as a cause for nuisance but also a concern for public health and environmental health". In the 2018 WHO report on environmental noise, beside automobile traffic, railway noise and aircraft noise, evaluations were done on industrial wind turbines and leisure noise.

The WHO report considers sleep disturbance and its potential for adverse health effects. I would agree that sleep disturbance is the MOST significant concern and is the pathway to a full range of serious adverse health effects.

Concordance that sleep disturbance produces major health endpoints accompanies most review of AHEs from IWTs. Most significant to myself, as a practicing Cardiologist for 30 years, is closed-linked data of sleep duration and serious cardiovascular outcomes (reviewed in Part - 2). Inherent with that association are important autonomically-mediated association with "chronic inflammation" that may trigger/promote the development of asymptomatic measurable (developing atherosclerotic obstructive vascular disease) and observable clinical cardiovascular endpoints such as hypertension and fatal and non-fatal heart attacks. ANYTHING a society can do to lessen cardiovascular disease development and its progression - including minimizing suffering annoyance from industrial wind turbines - should be considered paramount. This is particularly relevant when lease lengths of 58 years are being granted for projected continual operation of IWTs.

Comments on the Thorne's study results included:

1) The data suggests that the sample of individuals exposed to turbine noise, have, on average, substantially lower health-related quality of life compared to the community and clinical samples.

2) When exposed to wind farm noise and wind turbine generated air pressure variations, some will more likely than not to be so affected that there is serious harm (also termed 'significant adverse effect') to health.

3) 91% of the respondents stated that turbines annoyed them inside the home while 9% said no. For turbine noise heard outside the home 95% of the respondents said yes and 5% said no. All report that wind turbines affect sleep and the ability to work is dramatically affected.

4) Families have moved away to sleep, (but) must still work the land and will not sell.

5) Headaches, although not serious adverse health effects, clearly effects quality of life. In response to the question: "What health effects such as headaches have you experienced since the turbines went online that did not exist previously", 24% responded with daily or constant headaches, 56 % experienced headaches 2-4 times a week, 64% experienced a tight scalp or band-effect around the head, 52% experienced blurred vision, 40% stated dizziness was experienced, 4% experienced chest pains, 52% experienced nausea, 76% state ear-ringing was experienced, 12 % experienced pressure in the ears and 60% experienced vertigo/balance problems. Of the persons who responded citing headaches as a problem, 80% observe that headaches only occur when the turbines are operating. Most of the respondents noted that these effects are not experienced all the time but often enough to be debilitating.

6) In response to the question: 'How long did it take after the turbines started before you felt unwell', 35% of the respondents said fairly quickly (a month or less) and 56% said 6-8 months. Of those who responded "fairly quickly", there were some who became unwell almost immediately. These respondents now find it very difficult to return to the locale to work when the turbines are operating as they suffer from headaches and/or nausea almost immediately. In 56% of the responses the symptoms improve/abate fairly quickly when the person leaves the locality.

7) Dr. Thorne provided some insights into experiencing IWT noise. "Wind turbine sound has a unique nature that is variable over time and highly dependent on wind speed and directions, as well as locale. Some standards refer to "audible characteristics" such as amplitude modulation, tonality, impulsiveness and so on. Observations at the different locations near the wind farms under different weather conditions and measurement distances indicate the sound of turbines are individually observable (swish, rumbles, clunks, whines) at distances of 200-500 meters. (500 meters is the setback distance proposed by Mr. Clifton in his Wind Ordinance draft). At around 900 meters only clearly distinctive turbines are identifiable (swish, rumbles) and by 2000 to 3000 meters, the sound of turbines is "cumulative" and is heard as a general source of noise. At each wind farm, turbines could be "clearly " heard at dwellings approximately 2000 meters from the nearest turbine. The sound of turbines can be heard 2000 meters both upwind and 2000 meters downwind as well at an angle to the turbines. The sound, with turbines operating, can be described as a steady rumble with a mixture of rumble-thumps. The general character over a long time period of an hour or so is of a steady rumble".

8) In this study, at 2000 meters, IWT sound is perceptible outside or inside a dwelling. The sound of turbines is often "clearer" inside as higher frequencies are reduced through the building fabric.

In his "Discussion Summary" section from his 2012 study he commented that:

1) By necessity, the investigation was applied to residents who claim they are adversely affected

2) All those studied WERE adversely affected by wind farm activity, ...and there was evidence of serious harm to health.

3) The subjective experience of annoyance is a common reaction to noise. Different individuals can exhibit different annoyance reactions to the same noise, and these individual differences can be ascribed partly to differences in noise sensitivity.

4) The finding suggested that the individuals living near the wind farms of this study have a degraded Health-Related Quality of Life through annoyance and sleep disruption and that their health is significantly and seriously adversely affected (harmed) by noise.
5) Serious harm means more than "mere" annoyance and that it can be quantified in terms of reported illness, sleep disturbance or other physical effects.
6) Definitions of 'serious harm' were postulated:
a) an exposed individual is adversely affected to the extent that he or she is obliged to remove himself or herself from the exposure in order to mitigate the harm; and/or
b) if three or more serious adverse health effects are recorded for an individual. Three serious adverse health effects are established from this study as being:
i) Sleep disturbance with a global PSQI >5 (validated sleep study)
ii) a state of constant anxiety, anger and helplessness
iii) an SF36v2 mental health value of <40 (validated health survey)
I have researched and asked experts in IWT-related matters, what Wind Energy thought of this study and the conclusions Dr. Thorne produced that show "conclusively" that IWTs can cause serious AHEs.
Those experts reported: little, if any response was generated by Wind Energy. This appears to have become their "normal response" of Wind Energy, i.e. unless it can support their narrative, they don't talk about it.... hoping, like this study and the proceeding long list of studies and data and basic science supporting that IWTs do cause adverse health effects, will simply "go away".
Included in this manual is a fascinating sequence of verbatim comments made by residents who were severely harmed by IWT Noise and, as a result, felt to consider or proceed to achieve evacuation of their homes. We, as the public (unless we are close acquaintances with affected residents) do not directly hear these comments of distress. I am sure that participating resident granting easement have the same "scale of distressed comments, but are forbidden by contract to express those reactions. Please read the 6/28/2020 article included in this Part's Appendix, by Carmen Krough, et al, "Wind Turbines: Why Some Families Living in Proximity to Wind Energy Facilities Contemplate Vacating Their Homes: An Overview of Findings". The intensity and depth of their reactions is quite personal and revealing.
Later, Dr. Thorne in his 2014 textbook, reviewed "Wind Farms and Health Effects". In his chapter, he provided a very brief introduction to a small sample of experts who have published evidence of the topic of wind farm activity and its potential effect on human health. Up front, he highlighted **the ultimate connection: "If there were no ill effects before the wind farm started operating, and there are a lot of complaints about adverse health effects now that it is operating, what has changed"?**
1) Dr. Eja Pedersen in Human Response to Wind Turbine Noise: Perception, annoyance and moderating factors" present an understanding of how people who live in the vicinity of wind turbines are affected by wind turbine noise and how individual, situational and visual factors, as well as sound properties, moderate the response. She has written other works on IWT health effects.
2) Dr. Nina Pierpont, MD, PhD (Academic Pediatrician) presents work relating health effects of wind farm activity. Her work presents an important body of knowledge that has been extensively peer-reviewed. She states the following symptoms: "... sleep disturbance, headache, tinnitus, ear pressure, dizziness, vertigo, nausea, visual blurring, tachycardia, irritability, problems with concentration and memory and panic attack episodes associated with sensations of internal pulsation or quivering when awake or asleep". Insight into the understanding and threshold of defining adverse health effects by Wind Energy were exampled by their "acoustical science leader", Dr. G. H. Leventhall as he critiqued Dr. Pierpont's work. (As one reads the following quote in his review paper, keep in mind Dr. Leventhall's absolute rejection that wind turbine ILFN contributes to adverse health effects). "I am happy to accept these symptoms, as they have been known to me for many years **as symptoms of extreme psychological stress** from environmental noise, particular low frequency noise. The symptoms have been published before. The so called **"wind turbine syndrome" cannot be distinguished from the stress effects from a persistent and unwanted sound.** These are experienced by a small proportion of the population and have been well known for some time". In later correspondence, Dr. Leventhall confirms his belief that there is no such thing as wind turbine syndrome. This writer/reviewer believed Dr. Leventhall acknowledged (in his first comment) that the psychological and associated physical stress originated from industrial wind turbine noise. Symptoms reflect the underlying adverse health effects. Moreover, when IWTs are "forced onto an otherwise unaffected population" some of whom then develop these symptoms, it highlights the immoral and unethical behavior of the Wind Industry contractor who "causes" those

adverse health effects. It is NOT the resident's fault that he and many of his neighbors develop "ill-health consequences" that can go on to precipitate other health effects.
3) This central concept of Wind Energy's actions to deprive a resident of his health also extends to his well-being, quality of life, and amenity. Dr. Daniel Shepherd specializes in public health and psychoacoustical studies. He sees "primary health" as embracing the concept of health in all policies (e.g. labor, environment, education) and so includes not only the treatment of disease but its prevention. At the community level, good health can be facilitated not only by the pursuit of healthy lifestyles but also with the provision of restful and restorative living environments. A prominent factor determining the restfulness of a living space is the level of privacy and intrusion by community pollutants, including smell, air quality and noise. He finds that "there exists compelling evidence attesting to the impact that community noise can have on health. A number of interacting factors combine to determine an individual's response to noise. As such, noise level should not be used as the sole metric with which to judge the potential health effects of noise. Annoyance can lead to degraded health, quality of life and impaired sleep, while disrupted sleep can lead directly to severe health deficits. Noise sensitive individuals are more susceptible to the negative effects of community noise. Turbine noise is a type of community noise and likewise has the potential to impact health and wellbeing. Evidence to this effect now exists in the peer-reviewed literature. Dr. Shepherd has proposed a simple model demonstrating (in the rural context) feasible mechanisms exist by which wind turbine exposure can degrade health and wellbeing: turbine noise can lead directly to annoyance and sleep disturbance (i.e. primary health effects) or can induce annoyance (suffering) by degrading amenity. Additionally, the trait of noise sensitivity constitutes a major risk factor, with annoyance and sleep disturbance the likely mediators between noise sensitivity and health. In relation to secondary health effects, it would be expected that quality of life will be affected immediately, while stress-related disease emerges from chronic annoyance and sleep disturbance over time.
4) Clarifying the central risk of sleep disturbance (which I too, have seen in patients presenting with heart arrhythmias and obstructive sleep apnea), Physician Dr. Hanning, reports that "inadequate sleep has been associated not just with fatigue, sleepiness and cognitive impairment but also with an increased risk of obesity, impaired glucose tolerance, high blood pressure, heart disease, cancer and depression". Sleepy people have a substantially increased risk of traffic accidents.
5) Michael Nissenbaum, M.D., has conducted a study of the health effects of persons living within the Mars Hill Wind Turbine Project in Maine. He declared a "high probability" of significant AHEs for residents living within 1100 meters and a significant risk of AHEs in a significant subset of people living out to 2000 meters from an IWT. He listed:
1) Sleep disturbances/sleep deprivation and the multiple illnesses that cascade from chronic sleep disturbance
2) Psychological stress which can result in additional effects including cardiovascular disease, chronic depression, anger and other psychiatric symptomatology.
3) Increased headaches
4) Unintended adverse changes in weight
5) Auditory and vestibular system disturbances
6) Increased requirements for and use of prescription medications.
5) Dr. C. V. Phillips reviewed some epidemiologic principles in his testimony before the Wisconsin Public Services Commission. Based on his knowledge of epidemiology and scientific methods and his readings of the available studies, he summarized that:
1) **There is ample scientific evidence to conclude that wind turbines cause serious health problems** for some people living nearby. In addition, he commented on the observation of people vacating their home being an exposure-disease combination.
2) **Reported health effects, including insomnia, loss of concentration, anxiety and general psychological distress are as real as physical ailments, and are part of accepted modern definitions of individual and public health. While more difficult to study (less objective, presenting in "gradation"), they probably account for more of the total burden of morbidity in Western countries than do strictly physical diseases.** It is relevant and important to take the less intense versions of the problems more seriously in making policy decisions, while not ignoring the serious diseases.
3) **The reports that claim that there is no evidence of health effects (Writer's comment: commonly seen on Wind Energy websites and their "peer reviewed" papers) are based on a very simplistic understanding of epidemiology and self-serving definitions of what does not count as evidence. Though those reports probably seem convincing (on first appearances), they do not represent proper scientific reasoning, and in some cases the conclusions of those reports do not even match their own analysis.**

"Effects of Wind Farm Noise and Vibration on People" in the 39-page chapter of the "Wind Farm Noise" Textbook. They authors summarized: There are many well-documented cases of adverse health effects resulting from both short- and long-term exposure to wind turbine noise. These symptoms include nausea, dizziness, pressure (or fullness) in the ears and recurring sleep disturbance; in most cases medical professionals are unable to otherwise explain them. There are also a significant number of people who are so badly affected that they have had to leave their homes or have had to undergo medical treatment to address their (unexplained) symptoms. Sleep disturbance experienced by people living in the vicinity of wind farms manifests as prevention of the onset of sleep (insomnia) or the prevention of a return to sleep after being awakened. (Writer's comment: Sleep disturbance as either shortened time in sleep due to insomnia or recurrent awakening **or** normal-sleep stage progression disruption due to "brief, non-awakening" events that results in delay or prevention of reaching deep slow wave or REM sleep have also been shown in formal sleep study evaluation with EEG (brain wave) monitoring. This sleep architecture fragmentation has been known for more than 20 years and is recognized by the World Health Organization. The 1999 WHO statements list 32 dBA as the audible threshold for sleep disruption.)

Continuing from "Wind Farm Noise": Ten to twenty percent of the population are easily disturbed from their sleep and a higher percentage can be expected to be found in rural areas (Hanning and Nissenbaum, 2011). Of course, a smaller percentage of the population (generally 5-10%, according to Thorne, (2013)), report serious health effects, although a considerably greater percentage suffer from annoyance and recurring sleep disturbance. In some cases, some members of the same family suffer terrible effects while others suffer no ill effects at all. The actual percentages depend on how far the residents are from the nearest turbine. In cases where they are **within 500 meters of the nearest turbine** (MAE's request as pursued by Phil Clifton (Supervisor) for the Madison County Wind Ordinance), **up to 30% of people may be highly annoyed and suffer some form of adverse health effect in addition to sleep deprivation.** As distance from the nearest turbine increases, the percentages of affected people decrease. Thorne (2012, 2014 - from the literature mentioned at this part's beginning), found that adverse health effects occur in some people when wind farm noise levels exceed LAeq,10min levels of either:

32 dBA OUTSIDE the residence

22 dBA INDOORS, if wind farm noise is at a level that is perceptible inside the home.

Thorne also concluded that noise that exhibited excessive levels of "fluctuation" that could contribute to adverse effects. He defined fluctuation in terms of LAeq and LZeq levels in 1/3-octave bands averaged over 0.1-0.125 msec. The LZeq metric is used to determine if amplitude modulation (AM) exists for low frequency noise or infrasound, where LAeq metric is more likely to identify AM in the mid-frequency range. A difference of 2 dB or less between the peak and trough of the 1/3-octave band sound level was considered to acceptable, 4 dB was considered to be unreasonable and 6 dB or more was considered to be excessive.

In a recent study, McBride et al. (2014) found that some people living near wind farms had a lower quality of life than others due to increased levels of stress and poorer sleep. It also became apparent that the 'objective manifestations of health effects associated with noise-related annoyance may emerge after some years of exposure'.

The Cape Bridgewater wind farm has been the subject of studies by Thorne (2012) and Cooper (2015), who both found poor sleep quality and adverse health effects in residents. Cooper surveyed six occupants of three houses located between 650 and 1600 m from the nearest turbine. He found that these residents suffered from sleep disturbance, headache, ear pressure, tinnitus and an elevated pulse rate (an indirect finding associated with autonomic shifting toward more dominant sympathetic tone).

The onset of these later four 'sensations' was found to be well correlated with changes in the turbine output power, caused by the following operating scenarios: turbines starting up increase in power of 20% or more
decrease in power of 20% or more turbines operating at maximum power and wind increased above 12 m/s

Cooper also found that the infrasound environment with the wind farm operation was characterized by a mix of tonal noise and random noise and was very different to the natural environments, which is characterized by random noise only. He found that the total sound pressure level (denoted WTS - 'wind turbine signature') of the first 11 harmonics of the blade-passing frequency of the wind turbines was correlated with **unacceptable sensation perceived within infrasound spectrum**, such as those listed above. With (specific measuring tools), he recorded the peak levels of the first 11 harmonics. He then added them logarithmically to obtain what he referred to as the WTS (dB). He found that if the WTS (dB) exceeded 51 dB, an unacceptable sensation level would exist. He pointed out that all of the residents involved in his study have been exposed to wind farm noise for at least six years and had a heightened sensitivity to it. (Writer's comment: The WTS stands for "wind turbine signature" which is a characteristic "equally separated" discrete spikes (from 5-20 dB in size) above the time-based infrasound sound pressure recording. These spikes, consistent with the associated transient "strained" blade acoustic response

thought to be due to blade stalling/bending during rapid load fluctuations).
Leventhall, (the principal and historical "managing" Acoustician for Wind Energy), in his submission to the Australian Senate Inquiry, pointed out that the large changes in wind farm output power would produce a noticeable change in audible noise produced by the wind farm and this change would draw people's attention to it and attract the recorded responses. He also pointed out that people in the Cooper study recorded increases in audible noise at the same time as they recorded increases in sensations, leading Leventhall to conclude that the adverse health effects experienced by residences were a result of audible noise, not inaudible infrasound, and that 'residents are reacting in the typical manner of highly stressed persons who are affected by a noise which they do not wish to hear'. (Writer's comment: To my knowledge, actual audible-zone sound recordings (actual A-weighted rises in mean sound levels) correspond with the subjects' recognition of the 'increase in audible noise'. Why is this phenomenon only recognized after a considerable period of 'conditioning time' (years?). Why does this infrasound perception occur at long distances from the IWT - much farther than audible sound would travel? Has wind industry done anything to actively prove or disprove that speculation made by Leventhall? How would he explain the extremely discrete infrasound-origin spikes that correlated with the subjects' recognition? Has Wind Energy, in an effort to bring data supporting Dr. Leventhall's hypothesis, reproduced these findings themselves, then taken the recording of an infrasound-only spectrum that contained those "inaudible spikes" without accompanying audible sound content (filtered out) and verified that they were not the source of the reported sensation. Other Acousticians, report sensitized subjects when "coming into the visualized OR NON-VISUALIZED proximity of the windfarm (miles away), but too far away to "hear" (audible) but close enough to perceive more distantly-projected infrasound) report perceiving the disagreeable/disrupting sensations, and that they can recognize those tones during "heavy" wind farm operation. Residents frequently lament that they, as the suffering residents, "don't know why THEY have to prove these noise perceptions. They ask why the makers of the wind farm or the turbines themselves are not required to show they are safe and "free from harm"? Separately, if wind turbine noise doesn't produce adverse health effects as Leventhall wishes people to accept as true, then why would wind turbine exposure cause high stress in individuals and why would they recognize the noise (coming from the turbine) as disagreeable? In my opinion, Levanthall needs to 1) take professional responsibility for that statement and 2) prove his statement and produce data that is accepted by an independent (not from Wind Energy chosen reviewers) medical and acoustical sciences peer review.)
Doolan (2013) reviewed literature concerning wind turbine noise perception, annoyance and low frequency emission. He concluded the following:
1) There is a similarity between findings of studies on low-frequency noise annoyance and wind farm noise annoyance.
2) There may be a link between personal and social moderating factors and annoyance.
3) Noise levels that satisfy acceptable A-weighted criteria can still cause annoyance, suggesting that the A-weighted noise level is an inappropriate criterion for specifying allowable wind farm noise levels. (Writer comment: This is particularly a concern with IWTs> 2 MW which have the capability to radiate perceptible ILFN much farther than less powerful IWT models. A-weighting is mostly used to judge audible sound levels. This observation gives STRONG SUPPORT to require regulation of IWT ILFN emissions by an objective limit, e.g. "shall-not-exceed 55 or 60 dBC Lmax (fast)
4) Spectral balance and temporal qualities of the noise should be included in any criteria of acceptability.
5) It is possible that a person's susceptibility to wind farm noise may change as the length of exposure increases.
6) (Greater clarification of particular IWT noise features causing annoyance is needed).
There were many other studies listed and described to the extent reported above. Some were questionnaire driven, all reported symptoms in varying and usually distance-dependent fashion. Association with IWT noise exposure and disturbance of sleep, psychological effects and "distress" in humans were noted. Exact association of which type (frequency range) noise is responsible is not clear.
Of particular note was the comment semantics in the Schmidt (2014) study that summarized the findings: ...At present, it seems reasonable to conclude that noise from wind turbines increases the risk of annoyance and disturbed sleep in exposed subjects in a dose-response relationship. There seems to be a tolerable limit of around LAeq of 35 dB. This would equate up to 46 dBA Lmax. (Writer comment: Why is the resident required to "tolerate" a detectable noise level? Toleration implies ongoing annoyance which, in itself, is an adverse health effect). Audible noise thresholds avoid sleep disturbance is 30 dBA; 32 dBA and above disturbs sleep which cause adverse health effects).

Annoyance:

In 1999, the WHO defined annoyance as "a feeling of displeasure associated with any agent or condition known or believed by an individual or a group to be adversely affecting them". Later, the WHO in 2011 declared that "high

levels of annoyance caused by environmental noise should be considered as one of the environmental health burdens". Annoyance is considered to be an adverse health effect (AHE) by the WHO's definition of health.
Noise sensitivity is considered to be a stable, partly heritable personality trait. Noise sensitive individuals are more likely to have stress related disorders, anxiety, HAs and poorer sleep than the average. Several studies have concluded that **individuals do not "get used" to annoyance over time... they may become indifferent but not unaffected.**
There is no dispute that psychological factors play a part in any reaction to turbine noise, to suggest that they are the sole explanation is contrary to evidence.
Annoyance "burden" varies directly with the sound levels. The "extent" of annoyance varies from study to study and among differing standards and statements from health organizations.
The 2016 Health Canada Study found that 13.7% of residents reported a high (very or extreme) level of annoyance above 40dBA.
A noise criteria reference chart for rural areas compared EPA community reactions from 1974 case studies to normalize community reaction to intrusive noise in rural areas:
Sporadic resident complaints begin at 30 dBA (Ldn) (level combined with day-night differences)
Widespread complaints at 34 dBA
Strong appeals to stop at 44 dBA
Vigorous community action at 50 dBA
(The latter two sound levels represented 10 and 13% of the population as being very annoyed)
Noise in rural areas above 35 dBA are considered as "incompatible" by the American National Standards Institute
Above 40 dBA, the WHO has issued statements of concern (based on scientific sleep data that noise will produce sleep impacts - motility, sleep architecture disruption, arousals, chronic sleep deprivation).
Dr. Malcolm Swinbanks had a few comments about "annoyance"
1) Residents should not be described as "annoyed" by IWTs but rather "suffer annoyance". It is important to distinguish between an effect that has been externally imposed, rather than self-induced.
2) It has been suggested that blame lies with specific types of personality, implying that people are at fault who have sought a rural lifestyle because they value quiet and tranquility in preference to an urban environment. It is unlikely that many of those living in rural areas will have preselected personalities enabling them to be tolerant of unwelcome, external adverse intrusion.
3) Recently the argument has been advanced (please see Vestas request to the government of New South Wales, Australia to eliminate ILFN as a relevant consideration in placing IWTs) that "problems are created by activists raising alarm in advance of windfarm consent and installation and that the subsequent number of complaints can be directly correlated with the prior presence of such activists".
This argument is meaningless if it fails to take account of the actual sound levels, setbacks and geography of individual windfarms, or the fact that there are reportedly many more complaints in the USA than in Europe, given that the **permitted sound levels in the USA are clearly significantly higher than elsewhere.**
Landowners or neighbors may not respond with complaints as they have entered into agreements with Wind Energy to not complain in exchange for cash payments. Also, a very significant number of landowners who have signed the 58-year term property easement, no longer live (or ever lived) on the property. It is my opinion that it is unethical to prohibit, by contract and implied penalty, that residents relinquish their right to voice concerns about potential or real adverse health effects that they are experiencing or will experience as a result of accepting financial return in exchange for placement of an IWT on their property. Such "gag-rule" contracts have been described as to be severely deficient in informed consent (particularly since wind industry refuses to acknowledge the potential health impacts of infrasound). Resolution of such resident/patient health concerns (though requests for medical services are likely not prohibited) will occur but, in an era of exploding health costs, will lead to a "potentially preventable" economic burden to our strained healthcare system.
Annoyance is a health issue for many people living near IWTs. It is considered to be an adverse health effect (AHE) by the WHO's definition of health.
There is no dispute that psychological factors play a part in any reaction to turbine noise, to suggest that they are the sole explanation is contrary to evidence. Those "psychological factors" are far more likely to produce immediate complaints that frequently dissipate within weeks to months. Complaints that develop early and persist or develop more slowly (usually within 6 months) are most likely unrelated to any "negative emotional" response.

Low Frequency Noise

The WHO, in 1999 stated, "It should be noted that low frequency noise, for example from ventilation systems, can disturb rest and sleep even at low sound levels. In that same publication, the WHO identified the importance of measuring low-frequency components. "It should be noted that a large proportion of low-frequency components in a noise may increase considerably the adverse effects on health" and that "the evidence on low frequency noise is sufficiently strong to warrant immediate concern". This was stated over 2 decades ago without substantial recognition or response by protective governmental agencies. Apparently that information is not provided to County Supervisors.
Leventhall was one of the first Acousticians to describe how low-frequency noise is a special noise problem - particularly to sensitive people in their homes. He indicated that annoyance to lowfrequency noise increases rapidly with noise levels often starting just above the threshold of audibility.
He also noted that the WHO places a special emphasis on low-frequency noise as an environmental problem and source of sleep disturbance, even at low levels. (Leventhall, as noted elsewhere, since has become the principle "Acoustician mouthpiece" of Wind Energy mostly through his denial of IWT produced infrasound). The WHO acknowledges that a noise consisting of a large proportion of low frequency components may considerably increase AHEs and should be limited to <40 dBA. Cummings, another Acoustician, notes that sound levels of 40 dBA trigger high levels of community pushback.
Amplitude modulation (AM) of infrasound and low frequency noise has adverse effects on the body. It is a term often used to describe wind turbine noise - usually referring to low-frequency noise, it can include infrasound. It refers to a sound that varies in intensity over either a short or long time period - generally on the order of seconds or fractions of a second. Nearby residents to IWTs find measurable AM sounds as highly disturbing with symptoms varying person to person and in a significant portion of such residents. These symptoms include sleep disturbance, annoyance, headaches, ear pressure or pain, dizziness, nausea, anxiety and a general feeling of distress or discomfort. Some of the rarer symptoms are blurred vision and memory loss.
There is extraordinarily strong evidence that other forms of less "annoying" environmental noise can cause cardiovascular disease (hypertension, atherosclerotic vascular disease and fatal and non-fatal myocardial infarctions) as described elsewhere in this submission to the Madison County Board of Zoning. This is well documented in the 2018 WHO report on Environmental Noise. I have also made reference to two articles published in 2019 that appeared in world cardiovascular meetings and highly respected cardiovascular journals which link "impaired sleep (duration) to objective measures of vascular atherosclerosis and heightened rates of clinical events.
Nina Pierpont, M.D. (Pediatrician), PhD (Population biology) coined the term "Wind Turbine Syndrome" to describe a range of symptoms reported for 38 family members of 10 families who lived near IWTs.
Her work has been very extensively peer-reviewed. More recent laboratory research, suggest that a variety of health symptoms may be due to ILFN stimulation of both vestibular and cochlear components of the inner ear.

Infrasound Recognition and AHEs.
With most of the newer wind turbines (now 3 MW to 3.5 MW)- (as described in Australia)-increasing numbers of residents living within 10 km (6.2 miles) have suffered and are still suffering severe health impacts since the wind turbines started operating. Many have left their homes repeatedly and eventually permanently, to live in greatly diminished financial circumstances, as their homes are no longer habitable or saleable. Some resident become too "unwell" to work. Wind turbines are not the only source of impulsive infrasound and low frequency noise causing severe health damage. The same pattern of identical serious adverse health effects, sleep deprivation and home abandonments, sometimes out to similar distances are being report by neighbors to other known sources of infrasound and low frequency noise - at open cut coal mining, underground mines with large extractor fans, gas turbine power stations and other sites.
Berger (2015) noted three important aspects of wind turbine infrasound:
1) The sound is regular and pulsating in amplitude. The rhythmic thumping stimulates the inner ear sensory functions, causing a host of symptoms (nausea, chest pain, etc.)
2) Measurements of environmental infrasound are typically reported as average or RMS values.
However, the peak values of the signal are what are likely to determine the detection threshold. The peak to RMS ratio for wind turbine infrasound is greater than the peak-to-RMS ratio for tonal sound used in infrasound thresholds testing, so the RMS amplitude of wind turbine sound underestimates its ability to be detected. (This is visually displayed on Fig. 7.7 from "Wind Farm Noise" which was placed in the appendix of Part 4).
3) Some people may be far more sensitive that others due to differences in physiology: some may not be bothered at all but some may suffer severe symptoms when exposed to the same infrasound levels.

Inaudible sound pulsations occurring at infrasonic frequencies emitted by wind turbines have been shown to cause perceptible sensations in a laboratory experiment by research Steve Cooper, an acoustician from Australia. The results were presented at the December 2017 Acoustical Society of America Conference in New Orleans. There he showed that:

1) He can reproduce in his laboratory the acoustic characteristics of IWT sound pressure pulsations occurring at infrasonic rates found in homes of people living near utility scale wind turbines who have filed complaints of adverse sensation and health effects.

2) These inaudible acoustic conditions reliably trigger, in self-identified "sensitive people", sensations and adverse effects associated with the complaints by people who live in or near the footprint of utility scale wind turbines.

Conclusions included that:

1) Wind turbine sound emissions consisting of dynamically modulated pressure pulsations at infrasonic frequencies synchronized to the Blade Pass Frequency have been shown to cause sensations and other adverse effects under controlled laboratory conditions.

2) Alternative explanations, frequently offered by Wind Energy as the Nocebo Effect, are NO LONGER acceptable arguments, since direct cause and effect has been established.

Perception of Infrasound by a Deaf Woman

Separately, another "experiment" was done by Dr. Steven Cooper involving a functionally deaf woman with auditory nerve damage. She claimed (and constantly suffered annoyance from) she could perceive (inaudible to her and to others) "when the IWTs were turned on or off or when they gearedup".

During this witnessed demonstration (in the basement away from any visual clues of IWT operation, the utility operator agreed to (through phone interaction with Dr. Cooper) turn on/off and "gear-up" as Dr. Cooper requested. The deaf resident correctly (very shortly after initiation) recognized all the "test states" that were otherwise consider "inaudible" sound emissions. She explained the perceived signal as a sensation of pressure or movement in the air or structure of her home. She demonstrated this to Dr. Cooper by having him remove his shoes and socks and stand on a part of the floor of her home where the vibrations were most prominent for her. He was able to feel it. Dr. Cooper said that thresholds of sensation were experienced at narrow band sound pressure levels of 4-5 Hz at >50dB. Prior nominal (tonal) audible threshold for frequencies of 4-5 Hz is >100dB. He also did tests of ground vibration and structure response that showed the movement he felt was not from ground borne energy, but was from the home responding ("breathing") to the pulse pressure.

When that pulse goes through a structure (home or one's body) small resonance are evoked that can be felt as pressure changes or if affecting the vestibular sensory organs, as motion.

Finally, in Appendix 3 of the July 25, 2011 "Noise-Con 2011" submission by Bray and James, they included comments from Alex Salt, PhD (14 December 2010) as below:

Infrasound Perception from Wind Turbines and the Inner Ear? Dr. Salt's view:

There is controversy whether prolonged exposure to the sounds generated by wind turbines adversely affects human health. The unweighted spectrum of wind turbine noise slowly rises with decreasing frequency, with the greatest output in the 1-2 Hz range. As "conventionally understood" human hearing is insensitive to infrasound (needing over 120 dB SPL to detect 2 Hz), it is claimed that infrasound generated by wind turbines is below threshold and therefore cannot affect people. The inner hair cells (IHC) of the cochlea, through which hearing is mediated, are velocity-sensitive and insensitive to low frequency sounds. The outer hair cells (OHC), in contrast, are displacement sensitive and respond to infrasonic frequencies at levels up to **40 dB below those that are heard**. A review found the G-weighted (filter that will actually measure infrasound while A-weighting does not) noise levels generated by IWTs with upwind rotors to be approximately 70 dBG. This is substantially below the (tonal) threshold for hearing ultrasound which is 95 dBG but is above the calculated level for OHC stimulation of 60 dBG. This suggests that most wind turbines will be producing an unheard stimulation of the OHCs. Whether this is conveyed to the brain by type II (incoming, sensory) fibers or influences other aspects of sound perception is not known. Listeners find the so-called amplitude modulation of higher frequency sounds (described as "blade swish" or "thump") highly annoying. This could represent either a modulation of audible sounds (as detected by a sound level meter) or a biological modulation caused by variation of OHC gain as operating point is biased by the infrasound. Cochlear responses to infrasound also depend on audible input, with audible tones suppressing cochlear microphonic responses to infrasound in animals. These findings demonstrate that the response of the inner ear to infrasound is complex and needs to be understood in more detail **before** it can be concluded that the ear **cannot** be affected by wind turbine noise.

Measuring Infrasound

To fully assess all potential annoying or health-damaging sound components being emitted from IWTs, methods of measuring sound must:
1) utilize instruments able to monitor the whole spectrum of sound
2) be conducted inside as well as outside homes or at property lines if sound is regulated there.
3) produce results in narrow bands **not** one-third octaves or dB(A) as is currently standard
4) must continue over sufficient periods of time, to cover most if not all environmental conditions (wind speed and direction, etc.)

The Concern that IWTs Can Facilitate Development of Cardiovascular Disease:
The WHO data review boards (Principally Measuring **Environmental** Noise Data) measured 3 critical health outcomes: **(Taken directly from 2018 WHO statement)**
1) Cardiovascular Disease: ischemic heart disease (angina, myocardial infarction (heart attack), hypertension. **Noted that cardiovascular disease has important health consequences and can lead to more severe disease and/or mortality.**
2) Effects on sleep: Percentage who were highly sleep-disturbed (via data from):
A) self-reported and assessed with standardized scale
B) Formal sleep studies (PSGs) - probability of additional awakenings
C) Cardiac and BP measures during sleep
D) Motility measures of sleep outcomes in adults
E) Sleep disturbance in children
Noted that effects on **sleep may be in the causal pathway to cardiovascular disease.**
3) Annoyance: reflected by the percentage of the population that is highly annoyed assess with standardized scale
Noted that large proportions of the population are affected by noise annoyance, even at relatively low exposure levels. **Annoyance may be in the causal pathway to cardiovascular disease.**
***** Again, the three links (or causal pathways) to cardiovascular disease are from environmental noise (directly measured increased incidence, due to effects from sleep disruption and annoyance)**
****
The data directly from available IWT exposure studies is considered "conditional" with available studies not being of sufficient "power" to currently be consider the evidence to be "strong enough" to include IWT noise. NONE of the available data suggested otherwise. Notable is that wind turbine noise has been described as having a character that makes it far more annoying and stressful than other sources of noise at the same A-weighted level, including traffic and industrial noise. Additionally, Thorne, has pointed out that human perception of noise is based primarily on sound character rather than sound level, and that wind turbines are unique sound sources that exhibit special audible and inaudible modulated and tonal characteristics.
(Writer's comment: Like many "triggers or responses" in biological systems, thresholds for presumed autonomic shifting to heightened reactionary sympathetic tone is likely NOT a single feature…such as a discrete noise level…but include other features such as quality of the annoying stimulus or unique factors present in "vulnerable populations"). **Particularly noteworthy are the WHO recommendations to policy-makers to reduce exposure from wind turbines in the population exposed to levels of 45 db Lden. Other forms of environmental noise which also had recommended noise levels were:**
Aircraft: 45 dB Lden, 40 dB Lnight
Railway: 54 dB Lden, 44 dB Lnight
Road Traffic: 53 dB Lden, 45 dB Lnight
Industrial Wind Turbines: 45 dB Lden - nothing specified for night given inadequate data to allow a recommendation.
The review data committee conditionally recommended that policy-makers implement suitable measure to reduce exposure from wind turbines in the population exposed to levels above the guideline values.
The reported guidelines were published BY the WHO Regional Office for Europe. In terms of their health implications, the recommended exposure levels can be considered applicable in other regions and suitable for a global audience, as a large body of the evidence underpinning the recommendations was derived not only for European noise effect studies but also from research in other parts of the world - mainly America, Asia and Australia.
What is Going On: Deep Dive into a Much Deeper Pond
The human organism is thought to have evolved in a "natural" environment where survival was dependent upon unique capabilities of hearing and vision among other senses that were selected and honed over millions of years. The brain became the "central processor" of information from all the traditional senses and also received and responded

through the peripheral nervous system. Within the peripheral nervous system, there is the autonomic nervous system that influences the function of internal organs. Simplistically, it is a "control system" that acts largely unconsciously and regulates bodily functions such as heart rate, digestion, respiratory and many others. Within the autonomic nervous system, there are two major branches - the sympathetic and parasympathetic nervous systems.
The sympathetic nervous system is often considered the "fight or flight" system using "activating" chemicals such as norepinephrine as a neurotransmitter with epinephrine (adrenaline) being produced by the adrenal glands. The parasympathetic system is often considered the "sleep and eat" system and chiefly uses acetylcholine to act on two different receptors. In many cases, both of these systems have "opposite" actions where one system activates a physiologic response and the other inhibits it. In practicality, there is an "undulating balance" - or responsive "rheostat" that can both momentarily change an ongoing balance or can more persistently change (slightly) toward one side or the other depending on environmental or individual "body-regulating needs."
As a heart rhythm specialist, I am referred patients having the consequences of heart attacks presenting as palpitations representing "PVCs" or "non-sustained lower heart chamber (ventricular) abnormal rhythms" or, more serious, aborted sudden cardiac death. Genetics combined with environmental/behavioral factors can produce atherosclerosis which is a complex disease process facilitated by high cholesterol, hypertension, smoking, glucose intolerance among others. The development of the atherosclerotic "plaque" has been worked out showing a very complex genesis.
An over-riding factor in the disease background is our controlling nervous system. One system – the autonomic nervous system - plays a both protective and facilitative role for our body's survival and functioning in responding to the "outside environment" or regulation of normal day/night activities.
As just mentioned, this is achieved by both hormonal and neurotransmitter actions. It is truly remarkable how a perceived threat can almost instantly change the ease of individual atoms transferring through a single cell membrane on specific portions of our heart's "wiring system" or can subtly shift membrane thresholds that trigger contraction of individual heart cells. Long-term or "tonic" activation of the "fight-or-flight" limb of the autonomic system (sympathetic system) can have the effect of disrupting a "normal balance or "homeostasis" that has the potential consequence of causing "more rapid aging" - this being associated with body adaptation processes that turn out to be "destabilizing and disease producing".
Listed on a NIH (National Institutes of Health) web site (C Ayada, U Toru, Y Korkut: Hippokratia, 2015 Apr-June, 19(2):99-108 The Relationship of Stress and Blood pressure Effectors), the authors describe long-term stress physiological adaptation as different from acute stress and lay-out the chain of responses that are believed to occur. "Daily events cause chronic stress and have detrimental effects on the body (allostatic load) beyond the creation of "fight or flight" response to acute stress. In general, chronic stress has various effects, such as increased risk of cardiovascular disease, decreased baroreceptor reflex response, increased blood pressure and neuroendocrine response to new acute stress, decreased blood pressure and neuroendocrine response to repeated stress and increased basal blood pressure. These mechanisms work together harmoniously to help an organism survive under acute stress conditions and to prepare it for future threats. However, long-term activation of the stress circuit can cause many different health problems, including the increase of risk factors for cardiovascular disease. Although cardiovascular diseases progress in stress, especially in depression, the role of the RAAS (renin angiotensin aldosterone system) in the stress response is generally neglected. Indeed, the RAAS is one of the most important systems in the development of the pathogenesis of cardiovascular diseases." The authors describe the known effects of elevated norepinephrine from chronic stress that lead to increased hypoxia, cAMP levels, catecholamine metabolites and intracellular calcium. Through elevated renin from chronic stress, angiotensin II becomes elevated that leads to increased superoxide anions, ACTH levels, adrenal glucocorticoids, aldosterone and catecholamines. Together these two consequences may affect excitation-contraction matching, activated apoptotic ways, pathological hypertrophy, weakening of ventricular plasticity and left the ventricular ejection fraction, cardiovascular damage related to oxidative stress, increased ventricular hypertrophy, vasoconstriction, sodium retention, the development of myocardial fibrosis and facilitated cardiovascular remodeling. All these may promote the development of chronic heart failure.
They also describe the relationship of chronic stress and Endothelin-1. " ET-1 is found in most endothelial cells, and is the strongest vasoconstrictor agent (of ET-1,2 and 3). It is produced in the heart, kidneys, central nervous system and posterior lobe of the pituitary gland. ET-1 production is increased by many factors....and there is evidence that ET-1 production is increased in hypertension models". They continue with ET-1 effects on ET-A and ET-B receptors and resultant cardiovascular effects. Importantly, " in addition to its vasoactive characteristics, ET-1 stimulates smooth muscle cell proliferation through the same receptors. Thus, it contributes to vascular restructuring and leukocyte adhesion. ET-1 generally tends to increase blood pressure and venous tone. Additionally, it is reported that the mitogenic effect of ET-1 contributes to the development of atherosclerosis... it is likely to be a component in the

pathogenesis of cardiovascular diseases. ET-1 causes an increase in human vascular smooth cells which occur through platelet-derived growth factor, fibroblast growth factor and epidermal growth factor as a result of the response to ET-A receptor. That is why anti-endothelin treatment may not be only anti-hypertensive but also anti-atherosclerotic."
This above excerpt is not meant to confuse or overwhelm but to demonstrate that basic bench research and clinical trials leading to RAAS inhibitors and beta blockers have become quite sophisticated and that through this research, models of adverse health effects from chronic stress (producing sympathetic activation) are quite plausible and could be considered "causal".

Other Real-time Medical Examples of likely Autonomically-Mediated Cardiovascular Disease Obstructive Sleep Apnea - A Disease Model to Consider for IWT Health Effects

In my work I deal with arrhythmias - heart rates that are too fast, too slow or not "normal". Atrial fibrillation is fast becoming one of the abnormal rhythms that is consuming most of a "heart electrician's" time and an increasing amount of this country's medical resources. Atrial fibrillation likely has always been a part of the human condition but in the last 40 years - particularly after linking atrial fibrillation to embolic stroke - it has become a major health concern and threat. In this country, roughly half of the patients with atrial fibrillation have a disorder sleep - the majority of that labelled as obstructive sleep apnea (OSA). Briefly, it is the intermittent complete or partial interruption of airflow into or out of the lungs occurring as the patient transitions into deeper sleep with relaxing tonsillar soft tissue or the tongue creating obstruction to that airflow.

Patients with OSA are commonly overweight being frequently obese to morbidly obese. Their nights of sleep are characterized by multiple arousals triggered by intermittent surging adrenergic tone due to low oxygen in the blood caused by airway obstruction and resultant marked interruption of oxygen delivery to the lungs. They frequently snore loudly and characterize their nights of "sleep" as nonquenching and "never enough" They wake up tired and start the day exhausted and find themselves struggling at times with otherwise simple acts or mental calculations. They reluctantly admit and are told by others, that they "seem to be in a cloud". Treatment begins with confirming the diagnosis with a sleep study and usually the prescribing of a CPAP (continuous positive airway pressure) mask. These same patients often also have type II diabetes, and hypertension (often quite labile (varying)), and hyperlipidemias. There is also evidence of endothelial (lining of blood vessels) dysfunction and hypercoagulability. As mentioned, they are frequently obese.

How did this all start? An unhealthy lifestyle is, of course, the superficial answer. More likely it started with our stressful lives (vaguely stated because it is) and living in the "passing lane" where sleep is considered a more optional need or where for some, obtaining quality, restorative sleep is compromised by where we live. Unfortunately, disordered sleep creates the metabolic condition where sympathetic tone and stress hormones are higher thus affecting glucose metabolism and the triggers of hunger and satiety (1) which leads to obesity, insulin resistance, hypertension among many other things. Clearly, our genetics also have a role. Importantly, not everybody will react to "stress" the same, and, as a result, not everyone displays these later stages where discrete disease states are attained and then labeled.

From various cardiovascular studies some findings were presented: Patients suffering from OSA have >2.8 times increased likelihood of fatal cardiovascular (CV) events and nearly 3.2 times likelihood of nonfatal CV events. In a study of 182 men, ages 30-69 years followed for 7 years, 122 did not have OSA noting that their developed incidence of CVD as 6.6%. The remaining 60 with OSA had a CVD incidence of 36.7% - 5 times higher. Although long suspected, the incidence of heart failure (both with impaired and preserved systolic (contractile) function) has been correlated with sleep disturbance. In the Heart Health Study, mild-moderate OSA (AHI>10) was independently associated with a 2.38-times increased odds of having heart failure. Hypertension - however defined - is quite common in our industrialized society. Extensive reviews by multiple investigators show that 50% of OSA patients have hypertension and 30% of hypertensive patient have OSA. Indeed, OSA - one form of a sleep disorder, is strongly associated with the development of hypertension which then can progress into a myriad of various endorgan diseases (strokes, heart disease, vascular disease, kidney disease, etc.).

As seen with industrial wind turbines, suffering annoyance and tinnitus and sleep disturbance are adverse health effects that effect quality of life associated with dBAs of <40... but does not constitute the harder endpoints of cardiovascular disease which, when you look at the additional disease burden as a function of increasing sound levels, starts around 40 dBA. I would hypothesize that the transition from 30 to 40 dBA reflects autonomic shifting from likely intermittent to a more consistent "active/dominant" sympathetic tone that initiates the cascade of inflammatory response and adverse renin-angiotensin/aldosterone system (RAAS) activation that, over time, plays out the development of hypertension and atherosclerotic vascular disease leading to both subclinical and clinical ischemic (adverse organ blood flow) consequences.

WHO Comments about Environmental Noise Health Effects

With the escalating threat over climate change triggering rapid industrialization of wind energy generation, both factions: pro- or anti- wind are now coming to grips with realities of what these massive machines and their visual impacts, sound emissions and effects on property values and wildlife, etc., **NOW** mean to their future energy security balanced against quality of life. The visual impacts are complex as individuals and communities try to adapt to its alien presence. The effects of wind turbines on man are relatively new with one of the earliest papers in 1987 (Kelley) surprisingly identified what is likely the most important consideration of chronic exposure to IWTs - infrasound and low frequent noise
(16). It has only been in the last 15-20 years where we have seriously pursued defining IWT exposure and health impacts. Intensive discussion and data collection leading to publishing that generate acknowledged "experts" that are pulled to friendly factions into unfriendly judicial interactions continues for one reason – the entirety of the health impact from IWTs - psychologic and physical - remains incompletely described.

The "conflict" of the siting of these turbines is driven by financial rewards on one side and on the other side an imposition of enduring unnatural background noise and an honest concern for potential serious adverse health effects that most likely worsen through subliminally to significantly heightened stress.

Effects are hard to measure and they are seemingly wide-ranging in scope and variable among people.

In the long-term manner in which residents are exposed living close to IWTs, to clarify and quantify "the full extent" of their long-term health effects will take a long time with carefully designed studies with enough people in both the exposed and "control" groups where confounding variables are recognized and accounted for that will quantifiable and statistically validated conclusions that then can best forge public policy. Such a complete and long-term study will likely NOT be done. Having said that, there currently is an enormous amount of information about AHEs from IWT exposure – enough to implement protective "siting regulations".

In the 2018 WHO report, under the area of "additional contextual factors", they again state that "very little evidence is available about the adverse health effects of continuous exposure to wind turbine noise". They did comment that proper public involvement, communication and consultation of affected citizens living in the vicinity of wind turbines during the PLANNING state of future installations is expected to be beneficial as part of health and environmental impact assessments. That said, it should be noted that MAE's first notification to residents living in the targeted turbine zone (except for those approached up to two years earlier to obtain easements) was not done until a few weeks before the first of three public hearings - essentially not allowing any education or research on the potential impact on targeted residents of a decision which did not request/involve their input. That report also states that residents living in the potential areas selected for IWTs may have greater expectations of the quietness of their surrounds and therefore be more aware of the noise disturbances. They also pointed out, unlike for traffic, railways or aircraft noise that with wind turbines, noise reduction interventions are more complicated than for other noise sources due to the height of the source and because outdoor disturbance is a particularly large factor.

Furthermore, they comment that noise "emitted from wind turbines has other characteristics, including the repetitive nature of the sound of the rotating blades and atmospheric influence leading to a variability of amplitude modulation, which can be a source of above average annoyance. This differentiates it from noise from other sources and has not always been properly characterized". They acknowledge (which pro-wind factions refuse) that "standard methods of measuring sound, most commonly including A-weighting, may not capture the low-frequency sound and amplitude modulation characteristic of wind turbine noise". These last three points are central considerations to the production of disordered sleep and subsequently in the production of pleomorphic (many faceted) adverse health effects.

In a 2019 German medical publications, Mathias Basner, Associate Professor of Sleep and Chronobiology at the University of Pennsylvania wrote an editorial entitled "Noise: What is to be done?" Dr. Basner also was a lead writer of the 2018 WHO publication on the "Burden of Disease from Environmental Noise". He pointed out that "health effects of noise go far beyond hearing". The so-called nonauditory effects of noise include annoyance reaction of the exposed population, sleep disturbance, school children's learning impairment and cardiovascular disease" (increased risk for hypertension and myocardial infarction). He continued by clarifying that "noise is defined as unwanted sound" and that the circumstances of the noise exposure play a crucial role for the non-auditory noise effects. Sound is often perceived as noise if one has little control over it and feels at somebody else's mercy. He stated that the "number of studies on the health effects of noise has increased considerably over the past few years. Even if high-quality studies are still missing for many noise sources and disease endpoints, there is little doubt among researchers that noise is an important risk factor for cardiovascular disease. He commented that we habituate (get used to) to many things -

including noise. However, the habituation is rarely complete - **that is that the adverse health effects are still at work even if we no longer perceive noise as such.** Health impairments from noise exposure is the result of cumulative processes, i.e. health impairment is the result of relevant exposure over long periods of time.

Appendix:

Beyond the physics and physical harm, there is an undercurrent of mental anguish and reaction that leads to AHEs. Open link below for 17-page June, 2020 article overviewing reasons why some residents are forced to vacate their homes.

- **Wind Turbine Incident/Complaint Reports in Ontario, Canada: A Review—Why Are They Important?**

Carmen M. Krogh, E. Jane Wilson, Mary E. Harrington
Open Access Library Journal Vol.6 No.2, February 18, 2019
DOI: 10.4236/oalib.1105200 582 Downloads 2,331 Views Citations

- **Human Health, Rights and Wind Turbine Deployment in Canada**

Carmen Krogh, Brett Horner
Open Journal of Social Sciences Vol.5 No.5, May 17, 2017
DOI: 10.4236/jss.2017.55012 1,805 Downloads 3,509 Views Citations
This article belongs to the Special Issue on **Human Rights and Social Justice**

- **Preliminary Results: Exploring Why Some Families Living in Proximity to Wind Turbine Facilities Contemplate Vacating Their Homes—A Community-Based Study**

Carmen M. Krogh, Robert Y. McMurtry, Anne Dumbrille, Debra Hughes, Lorrie Gillis
Open Access Library Journal Vol.7 No.2, February 21, 2020
DOI: 10.4236/oalib.1106118 404 Downloads 1,265 Views Citations

- **Déja vu and Wind Turbines: A Review of Lived Experiences after Appeals of Ontario Industrial-Scale Wind Power Facilities**

Jane Wilson, Carmen Krogh, Paula C. Peel
Open Access Library Journal Vol.7 No.5, May 15, 2020
DOI: 10.4236/oalib.1106276 775 Downloads 3,207 Views Citations

- **Health Canada's Wind Turbine Noise and Health Study—A Review Exploring Research Challenges, Methods, Limitations and Uncertainties of Some of the Findings**

Carmen M. Krogh, Anne Dumbrille, Robert Y. McMurtry, Richard James, Robert W. Rand, Michael A. Nissenbaum, Jeffery J. Aramini, Stephen E. Ambrose
Open Access Library Journal Vol.5 No.12, December 20, 2018
DOI: 10.4236/oalib.1105046 677 Downloads 2,745 Views Citations

- **Wind Turbines: Why Some Families Living in Proximity to Wind Energy Facilities Contemplate Vacating Their Homes: An Overview of Findings**

Carmen M. Krogh, Robert Y. McMurtry, W. Ben Johnson, Anne Dumbrille, Mariana Alves-Pereira, Jerry L. Punch, Debra Hughes, Linda Rogers, Robert W. Rand, Richard James, Stephen E. Ambrose, Lorrie Gillis
Open Access Library Journal Vol.7 No.6, June 28, 2020
DOI: 10.4236/oalib.1106443 814 Downloads 3,220 Views Citations

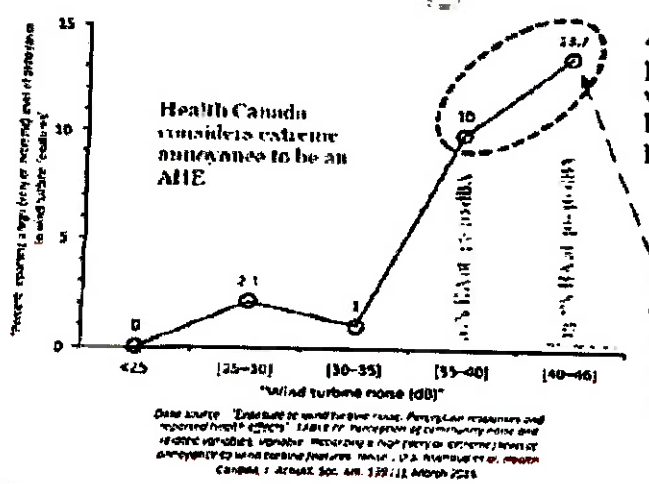
- **Grounded Theory as an Analytical Tool to Explore Housing Decisions Related to Living in the Vicinity of Industrial Wind Turbines**

Carmen M. Krogh, Robert Y. McMurtry, W. B. Johnson, Anne Dumbrille, Mariana Alves-Pereira, Jerry L. Punch, Debra Hughes, Linda Rogers, Robert W. Rand, Richard James, Stephen E. Ambrose, Lorrie Gillis
Open Access Library Journal Vol.8 No.3, March 26, 2021
DOI: 10.4236/oalib.1107233 411 Downloads 2,516 Views Citations

- **Wind Turbines: An Exploration of Research Participants' Living Experiences as a Consequence of Ontario's Green Energy Act**

Carmen M. Krogh, Robert Y. McMurtry, William Ben Johnson, Jerry L. Punch, Anne Dumbrille, Mariana Alves-Pereira, Debra Hughes, Linda Rogers, Robert W. Rand, Richard James, Stephen E. Ambrose, Lorrie Gillis
Open Access Library Journal Vol.10 No.6, June 29, 2023
DOI: 10.4236/oalib.1110043 112 Downloads 1,161 Views Citations

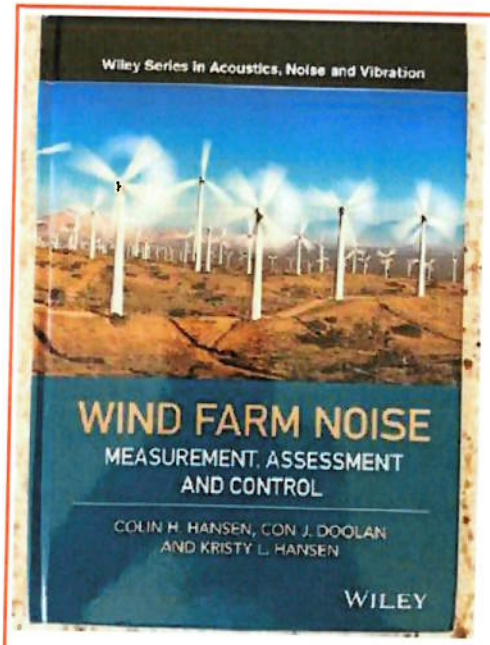
The Health Canada study found IWT noise highly annoying in a substantial number of people



Health Canada considers extreme annoyance to be an AHE

At least 1 out of 10 people in project area who were exposed to levels >35 dBA were highly annoyed.

Receptors who are exposed to levels above 40 dBA will experience higher annoyance levels.



Wind Farm Noise:
Measurement, Assessment and Control

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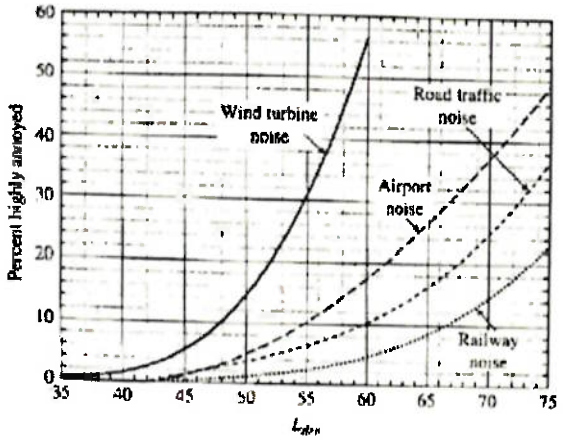


Figure 7.1 Dose–response functions for severe annoyance for wind turbine noise compared to transportation noise. Transportation noise curves from Miedema and Oudshoorn (2001) and wind farm curve from Janssen et al. (2008).

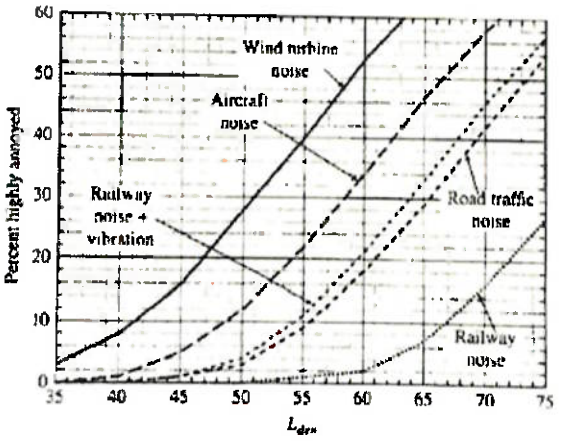


Figure 7.2 Dose response functions for high annoyance in communities found as part of the Health Canada study (Michaud et al., 2016)

Figure 7.2 Dose response functions for high annoyance in communities found as part of the Health Canada study (Michaud et al., 2016)

to specify allowable wind farm noise levels, instead of a more appropriate measure that emphasises low-frequency noise and infrasound has arisen for two reasons.

1. Most current guidelines and regulations are based on ETSU-R-97 (see Section 1.4.1), which uses A-weighting criteria (see Section 2.2.11). Although this was in line with the current practice of environmental noise assessment, it did not take into account any annoying characteristics that made wind farm noise more annoying than indicated by its A-weighted level. Use of A-weighted criteria in isolation has resulted in

3.2 Walker

In addressing at the impact of "wind turbine infrasound" Walker has utilised a low frequency speaker system with a D class amplifier to demonstrate wind turbine infrasound [13] instead of using actual wave files

Reference 13 includes the results of LAeq FFT analysis of turbines at Cape Bridgewater (Figure 55 in reference 4) to create a waveform computed as the sum of the sine waves at the six peak spectral amplitudes. Walker considered the wave as essentially a Ch-Wave truncated at the 6th harmonic.

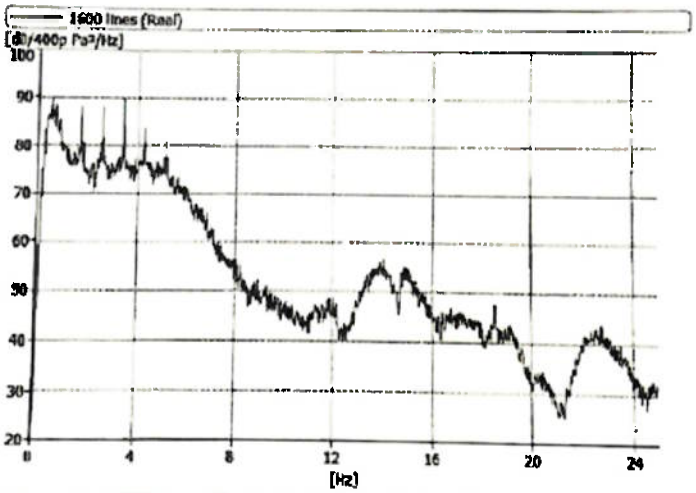


Figure 3: 1600 lines, 0 – 25 Hz FFT analysis – figure 55 from ref 4

Figure 2: Wind Turbine Infrasound Measurements

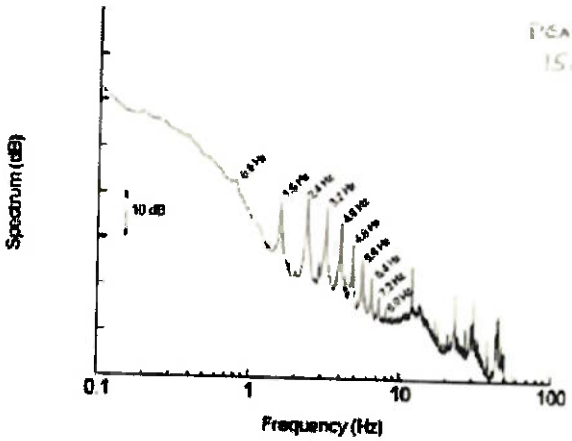


Figure 47 (from the Shirley Wind Farm report) provides a direct comparison of the WTS inside and outside a dwelling. In general the fundamental frequency (the blade pass frequency) is found to have a lower amplitude than the 2nd – 6th harmonics of that frequency.

In looking at the WTS it is necessary to have the appropriate instrumentation that can accurately record the WTS in that many microphones/sound level meters have dynamic and frequency amplitude drifts below 10 Hz (or lower) that affect the accuracy of the reported results (see Section 10 on Measurement Uncertainty).

The presence of the WTS occurs when the wind farm is operating but not when the wind farm is shutdown or alternatively in the "natural environment". As identified in the above extract from Health Canada the WTS has the ability to isolate the operation of a turbine/wind farm in an environment. The WTS has been recorded by the author and Hansen [31] out to 10 km from an operating wind farm and is readily apparent at the three houses used in this subject study.

Part 7: Selected Topics

Nocebo Effect

This concept is a central piece of quoted evidence by Wind Energy to explain the origins of "annoyance" as being a psychological response, or an "attitudinal defect" of residents. This was directly mentioned by a physician (neurologist/sleep specialist) who was a paid consultant for Mid-American Energy when he provided oral testimony at the original Madison County Board of Adjustments and by Peter S. Thorne, PhD - Toxicology, in his comments to the Madison County Board of Health.

The "Nocebo Effect" has been used to explain the development of "annoyance to IWTs" based on resident's generalized subjective impression of the turbine impact on their senses. This has been popularized (essentially only) by the Wind Energy faction. The WHO has completely rejected any relevance of the nocebo effect. Frankly, a person's reaction in having to acknowledge, accept and then daily endure an object constantly viewed as "negative" in the presence of their home environment – is "what it is". The first recorded "annoyance response" toward IWTs was observed during the first U.S. operation of a large wind turbine during initial prototype turbine operations (ND Kelley) in North Carolina in the 1980's. The usual symptoms of sleep disturbance, headache, tinnitus, irritability, problems with concentration and memory developed in a significant proportion of nearby residents – it is likely NONE of them had any pre-exposure negative opinions about the turbines.... it was after all, one of the very first times that an IWT had ever been operated.

In the textbook: Wind Farm Noise, the authors include this in their section on "The Nocebo Effect":

There are a few pro-wind-farm advocates who claim, via various web sites, that any adverse health effects due to wind farms are imagined, that wind farms do not make any audible noise and that complaints only began after anti-wind-farm activists began their campaigns to stop the construction of future wind farms. They attribute reported adverse health effects to mass hysteria and use pseudoscientific terms such as 'mass psychogenic illness' or 'psychogenic nocebo phenomenon'. Others (for example, Knopper et al. (2013) agree that wind farms produce sufficient noise to annoy some people, but suggest that the only adverse effect of wind farm noise is annoyance, which can manifest as physical symptoms in some people. Whether this is the case or whether low-frequency noise and infrasound generated by wind farms have a direct adverse physiological effect, as suggested by Salt and Lichtenhan (2014) is still unproven. However, all of the literature claiming to prove that all adverse health effects are a result of a nocebo effect is based on suspect data, such as records of complaints produced by the wind farm industry, with no acknowledgement that over the past few years, wind turbines and the number of them in a wind farm have become much greater and that it takes time for people to realize what is causing their symptoms. Literature in favor of a nocebo-effect explanation universally fail to acknowledge work published by research in the U.S.A., New Zealand and Canada (Krogh, et al., 2011; Moller and Pedersen, 2011, Shepherd et al., 2011), who found that many wind farm neighbors who were in favor of wind farm operations prior to their construction, changed their view after the turbines began operating and adverse health effects became noticeable.

In support of the argument denying the nocebo effect, there are at least two instances of acoustic engineering professionals succumbing to illness during and soon after undertaking measurements in homes of people complaining of wind farm noise (Ambrose et al., 2012; Swinbanks, 2015). These symptoms came on entirely unexpectedly and the professionals involved did not have any prior expectations that they would suffer any effects. It is interesting to note that in the Swinbanks case, periodic infrasound was measured, with the highest peak level of 55 dB in the narrowband frequency spectrum and the cumulative effects of all the harmonics raising the peak level in the time domain to between 69 and 72 dB, indicating that spectral analysis can considerably underestimate the true peak of a noise. However, even this level is below what would normally be detected by a human subject, indicating that infrasound levels below the normal detection threshold may have ill effects on some people.

In the Punch and James article, the authors thoroughly review the reported "nocebo effect".

In the textbook "Wind Farm Noise" the authors wrote "Much more extensive testing has to be done to determine a dose-response relationship that reflects real-world wind farm noise exposure and this will take a long time, even if funding becomes available to undertake the work. Before this work is completed, we must make do with case studies and self reporting incidents. These latter have now become so numerous that the construction of future wind farms should only proceed with care, ensuring that resulting low-frequency noise levels and infrasound at residences is below the thresholds (discussed in section 1.6 in their textbook). There should also be a commitment by a wind farm developer to pay appropriate compensation to, or purchase residential property from, anyone suffering adverse effects within the first six months of turbines beginning to operate.

A Need to Site IWT at Distances that Reasonably Achieve "Sound Safety" - Best Described as "Near" Background Levels; Is it 'fair' to Annoy /Harm a Sensitive Minority?

The key to more healthy (mental and physical) coexistence is siting of IWTs far enough away from ordinary human interaction that annoyance is rare. How far away does it need to be - from not visible (to avoid any visible annoyance) to something closer which may always invoke some degree of annoyance in some people. People are "biologically designed" and thus generally behave in their responses in a "normally distributed fashion. There are some individuals will always recognize (and react "briskly") and some (at the other end of the curve) who will never respond. The majority in the middle will have "some recognition with an average response". At greater, and toward higher, physiologically-damaging levels of noise exposure, this normal distribution is no longer relevant with the "center" of the distribution shift rightward reflecting a high percentage of highly annoyed individuals.

Wind turbine sound is perceived to be more annoying than other equally loud sources (Pedersen, Bakker, Bourma & Van den Berg, 2009). Higher levels of annoyance may be partly explained by wind turbine noise amplitude modulation, lack of night-time abatement and visual impacts. Wind turbine tonal and audible low-frequency sound are also plausible causes of wind turbine noise annoyance (Moller & Pedersen, 2011) and reported health effects (Minnesota Department of Health, 2009) and, may play an important part in the cause for adverse community reaction to large IWTs installed close to residences in quiet areas. Wind turbine low-frequency energy presents a recurring and/or unpredictable pressure signature, with audibility requiring forced judgement occurring over a much longer period of time than other environmental sources of low-frequency energy.

Sound Perception

Harrison concluded that "IWTs caused annoyance in about 20% of residents living within a distance considered acceptable by most regulatory authorities and that for many of the 20%, the annoyance and sleep disturbance lead to adverse health effects (AHEs)". Thorne noted that human perception of noise is based primarily on sound character rather than sounds level, and that wind turbines are unique sound sources that exhibit special audible and inaudible modulated and tonal characteristics. He stated that sound levels of 32dB (A) Leq outside a residence and/or above an individual's threshold of hearing inside the home are markers for serious AHEs - especially among susceptible individuals.

In New Zealand (another country that has been seen as a huge proponent of alternative forms of energy), studies have concluded that people who live within 2 Km of IWTs have been found to have a lower quality of life, lower physical quality of life and lower environmental quality of life. Such victims also report experiencing a significant lower quality of sleep. There is a rapidly growing amount of literature by acousticians, academics and health professionals that focus on the adverse health effects of being in the vicinity of IWTs (Dr. Donald Deever, 6/13/2018 - Public Comment: Opposition to a Proposed Wind Turbine Project).

A 2011 Ontario Review Tribunal Decision found that wind turbines can cause harm if placed too close to residents stating: "This case has successfully shown that the debate should not be simplified to one about whether wind turbines can cause harm to humans. The evidence presented to the Tribunal demonstrates that they can, if facilities are placed too close to residents. The debate has now evolved to one of degree. (Erickson v. Director, 2011).

Human Rights and Social Justice

What allows a Wind Energy company to decide they can study a wind map and begin planning a wind farm without the acceptance of all parties who might be involved? Was it the transition from small early farms turbines that were of essentially no consequence to health or scenery considerations to a slightly larger (but still not obtrusive and annoying) but more sophisticated models of the early 1970s that suddenly (because of a natural progression - "alway bigger") produced the current, massive scale turbines that we see today? Have we lost sight of the consequences of that transition...in terms of annoyance, sound generation and being unconcerned about unknown biophysical ramifications?

What was initially an image of closely-spaced turbines clustered along a remote canyon ridge in California became a sudden, uninvited, and "unstudied for safety ramifications" rush literally into our backyards. What may have been an easily accepted small structure a century ago became a forced placement of "dominating eyesore" with potentially seriously harmful health consequences and otherwise, completely unwanted. When did we stop considering the impact of these massive structures; when did we stop being considerate and respectful of our neighbors?

Canada has ratified an "international convention" which recognize the individual's right to the enjoyment of the highest attainable standard of health. The deployment of IWTs in Canada presents a contemporary example of the individual's right to health in conflict with competing interests as described in a May, 2017 article by Krogh and Horner. Through the review of government publications, documents and websites they confirmed the following health principles that have been adopted and supported by Canada.

1) Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity.

2) Individuals have a fundamental human right to the highest attainable standard of health.
3) Governments have a shared-right responsibility to help Canadians maintain and improve their health, while respecting individual choices and circumstances.
4) A primary role and responsibility of government is to generate effective responses for the prevention and control of non-communicable diseases.
5) No one shall be subjected without their free consent to medical or scientific experimentation.
They quoted Health Canada's "broad mandate to protect and maintain the health of Canadians - including protecting people from risks in the environment where they work, live and play...." and the "...public expects government to mitigate those risks...." The main health risks of noise identified by the WHO were listed and exposure to IWTs were described as a plausible cause of reported health effects. Among many, the important ones identified were annoyance, sleep disturbances and all its consequences on a long and short- term basis, cardiovascular effects, hormonal responses and the possible consequences on human metabolism and the immune system. Despite these risks, the Canadian government has approved deployment of IWTs despite municipal governments having declared their jurisdictions to be unwilling hosts of wind energy projects.
The authors concluded, through review of government documents, peer reviewed literature and other references, "that Wind Energy deployment in Canada can be expected to result in harm to human health. The resulting harm is deemed avoidable and conflicts with the individual's fundamental human to the highest attainable standard of health". Furthermore, they stated that "governments have a responsibility to help Canadians maintain and improve their health by generating effective responses for the prevention of avoidable harm. Individuals have a right to make informed decisions about their health. IWT knowledge gaps and potential risks to health should be fully disclosed". Individuals should not be exposed to IWTs without their informed consent.
The same set of protections should apply to residents of this county. The owners of the wind turbine and/or local government do NOT fully know the full extent of adverse health consequences of chronic exposure to wind turbines. Industrial Wind Turbines have NOT been shown to free of adverse health consequences. If, upon completing informed consent of the unknown risks, the resident decides not to accept the risks, then it should not be permissible that wind turbines be placed within a distance where AHEs are potentially deemed possible given our current understanding (approximately 1.25 miles to avoid sleep disturbance due to ILFN - see below in Table where various investigators have submitted their recommendations).
The real question: Why is it the responsibility of the potential sufferer (some would say likely) to prove the proposed adverse health effects rather than the initiator (Wind Energy proponents) of the risk to adequately demonstrate the absence of health consequences prior to initiating the risk.
If IWTs are used, they should be sited such that their potential negative impacts are profoundly curtailed and that nearby resident's rights to live in a healthy environment are honored - especially their right to live and raise their children and grow old - both children and the elderly being considered more vulnerable to wind turbine noises.
Shain (2011) point out that wind farms represent a trade-off of adverse health effect of a few to beneficial health effects of many in the form of reduced carbon emissions. (That argument was voiced by a number of citizens at various County hearings). There is also an inherent argument that the government can interfere with the rights of a few for the benefit of many. However, in many other cases, the few disadvantaged people are usually fairly well compensated by the corporation causing the disadvantage. Unfortunately, the same is not true for people adversely affected by wind farms. **The rapid multiplication of wind farms in recent times seems to be in conflict with the precautionary principle, that would require that a particularly industrial activity not be undertaken unless there is no doubt that such an activity will not harm any people.** In many countries there is also a common law requirement that there is a duty to ensure that one does not cause predictable harm to their neighbor's interests.

Vulnerable Populations

The United States accepted the WHO's constitution in 1948: Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity.
In 1989, the "Rights of the Child" was unanimously adopted by the UN General Assembly with 193 countries ratifying - the most widely ratified human rights treaty.
The proclamation state that "childhood is entitled to special care and assistance".
WHO - defines vulnerable groups of children as:
The fetus and babies
Preterm, low birth weight and small for gestational age babies
Children with dyslexia and hyperactivity
Children on "ototoxic medications"

Who is most affected?
Children require more sleep than adults
Sleep disturbance at night can lead to an increase in medical visits, spending on medications... affects families' budgets and countries' health expenditures
Autism: in a survey of 17,000 children with autism spectrum disorders, over 40% were hypersensitive to sounds.
Concern over shadow flicker - noting shadow-processing mechanism are abnormal in autism (cast shadows interfere rather than help object recognition)
Autistic children and adolescents suffer from sleep problems, particularly insomnia 40-80% higher than normal developing children
Children's learning is affected by noise - both at home and at school
Pierpont: Case Study: 7 out of 10 school-age children and teens did worse in school during exposure to turbines, compared to before or after, including unexpected problems in reading, math, concentration and test performance - noted by both parent and teachers. Teachers sent notes home asking what was wrong with children.
Over 90% of Pierpont sample of affected people - both adults and children, "had cognitive difficulties during wind turbine exposure - problems that linger and resolve slowly after exposure ended.
These included difficulties with reading, math, spelling, writing, multitasking in kitchen and home, remembering a series of errands, maintaining a train of thought in a telephone conversation, following the plot of a TV show, following recipes and following directions to put together furniture."
Impairment of early childhood development and education caused by noise may have lifelong effects on academic achievement and health. Noise is an underestimated threat that can cause a number of short- and long-term health problems, e.g. sleep disturbance, cardiovascular effects, poorer work and school performance, hearing impairment, etc.
It is likely that children represent a group which is particularly vulnerable to the non-auditory health effects of noise. They have less cognitive capacity to understand and anticipate stressors and lack well-developed coping strategies. Moreover, in view of the fact that children are still developing both physically and cognitively, there is a possible risk that exposure to an environmental stressor such as noise may have irreversible negative consequences for this group. Bronzaft (2011) pointed out the adverse effects of train noise on students in a classroom and showed that high achievers more often came from families that respect quiet and provided quiet areas for their children to study and sleep. In addition, he asserted that if parents are stressed by wind farm noise to the extent that they are suffering sleep deprivation, then their children are likely to suffer from poorer parenting.

Potential Concerns of IWTs in Proximity to Schools
Schools are places of learning where speaking and listening are the primary communications modes. It has only been in the last approximately 20 years, that school planners and the general public became aware of the significant negative effect of noise and excessive reverberation in the learning process.
Studies have shown that students learn faster, and comprehend and retain more in proper acoustic environments and this is even more critical for the youngest students who are still learning how to pronounce words. The hearing impaired also require good acoustics. Studies demonstrate that children need the following:
1) An acoustic signal (e.g. speaking teacher) that is at least 15 dBA more intense than the level of the background noise.
2) Overall sound levels (e.g. speaking voice plus noise) that are no greater than 70 dBA throughout the room.
3) Background noise that is less than 35 dBA throughout the unoccupied room.
4) Sound absorbing materials such as acoustic tiles that minimize reverberation, resulting in reverberation times of less than 0.6 seconds in unoccupied rooms.
Children need these conditions because:
1) Young children are ineffective listeners for speech in noise until they reach adolescence, when they achieve levels of speech understanding similar to those of adults.
2) Young children do not effectively listen and understand speech in reverberant conditions.
3) Children are especially susceptible to ear infections that can impair hearing for weeks to months.
4) Many children (up to 20%) have permanent hearing loss as a result of congenital, genetic and environmental causes. All people with hearing loss are adversely affected by both background noise and reverberation.
5) Significant numbers of children are learning in a language not spoken in their homes. All people listening in a non-native language are susceptible to interference from background noise.

6) Many children have difficulty focusing their attention on speech in background noise, even though they have normal hearing sensitivity and are learning in their native language. These students have auditory attention and learning problems and make up an estimated 10-15% of the student body.
Evidence also shows that noisy classrooms require teacher to speak at vocal levels that cause stress and fatigue to their voices. Many teachers complain of tired voices, vocal strain and health concerns because of their need to speak at such high vocal levels. In quieter classrooms, teachers can speak at more comfortable levels and their voices can still be heard throughout the room. When classrooms meet the ANSI S12.60 standard criteria, communication will occur at a clear signal-to-noise ratio of +15 dB (i.e. speech signal is 15 dB louder than the background noise).
To restate: For full-sentence intelligibility in listeners with normal hearing, the signal-to-noise ratio (i.e. the difference between speech level and the sound level of the interfering noise) should be at least 15 dBA. Since the sound pressure level of normal speech is about 50 dBA, noise with sound levels of 35 dBA or more interferes with the intelligibility of speech in smaller rooms (taken from "Guidelines for Community Noise" from the WHO expert task force held in London, 1999)
Low-frequency noise, and even at low levels has unusual annoyance properties related to other frequency content or its absence. Situations of isolated low-frequency noise without other noise or with other noise of very low level may be more annoying than when other noise is present with the same or louder noise level.
Consider that turbines near schools and residential neighborhoods will impact people - both inside and outside. Inside, the ILFN will be perceived as "rumble" outside. Outside, the turbine noise will increase the background sound levels thus reducing the listening radius. Listening radius is our auditory perception of how quiet a community is based on how far away we can hear distant sounds. In a quiet rural community with quiet nights (30dBA or less at night), this distance can be a mile or more. With wind turbines, even those designed for 40 dBA at the homes, the listening radius will be a few hundred feet.
It should be clearly recognized that "learning" goes on at home as well as in schools. In addition, high quality, restorative sleep - a critical part of healthy brain development - is needed when children return home. Both audible (at sound levels of >30dBA) as well as perceived (not necessarily "heard") infrasound, low-frequency noise emitted from nearby wind turbines has been shown to disrupt normal sleep processes. Those disruptions have been described as producing "neuro-cognitive" developmental deficits. Several sound experts, particularly concerned about ILFN, suggest separations of >1-2 miles from IWT to home to minimize but not eliminate the health risks. This is particularly relevant for the community of Earlham, which, if the Arbor Hills windfarm extension into Madison County occurs, will bring a very large contiguous collection of large-scale IWTs located to the south and west of the town's perimeter. Minimal setbacks of only two miles may affect the learning environment of its schools, but also its citizen's health and dramatically discourage town growth. It is a completely avoidable likely problem. Placing IWTs as proposed in close proximity of the outskirts of any town is a virtual "death knell" for a small town's future - principally through the addition of a closely-created harmful environment and a lack of potential growth at the edge of town. I would suggest at least a 5- mile setback from current housing on the edge of town to the closest placed IWT.
Increased Cardiovascular Disease associated with Life in Rural Areas
Although advances in health care have brought improvements in cardiovascular outcomes, cardiovascular disease remains the leading cause of death in the United States. Unfortunately, in recent years, declines in cardiovascular mortality have stalled with some conditions such as stroke and heart failure are showing increasing death rates - these trends have been worse for people living in rural counties in the United States. Madison County, Iowa is considered a rural county without an urban core. In the U.S., health outcomes have widened markedly between rural and urban areas over the past 3 decades and health outcomes are now significantly worse in rural than in urban areas. There is now at least a 20% disparity with rural counties having worse death rate as measured by "excess death rate" per 100,000. Life expectancy gaps continue to separate over time - being >3 years shorter in rural counties as measured in 2014. Similar patterns have been seen for cardiovascular disease. Data from the 2017 Center for Disease Control and Prevention showed a 40% higher prevalence of heart disease among rural residents - a gap that has grown over the past decade. Rural areas have higher death rates for cardiovascular disease and stroke than urban areas and gaps are widening. Coronary heart disease death rates were significantly higher as compared with urban areas with rural residents having a 30% increased risk for stroke mortality. Rural women face higher maternal mortality rates with that mortality growth being driven largely by an increase in cardiovascular deaths.
Rural areas have significantly higher rates of uncontrolled traditional cardiovascular risk factors compared with urban areas. Rural populations are significantly older and have higher rates of diabetes mellitus, obesity and hypertension. Tobacco use is higher in rural areas than urban areas. Data from the Behavioral Risk Factor Surveillance System

suggest that roughly 25% of adults in rural counties report active tobacco abuse compared with 16% in metropolitan centers. Rural smokeless tobacco use was 8.5% versus 3% in metropolitan areas.

Rural areas have a higher prevalence of obesity, diabetes, elevated lipid levels and hypertension. In addition to less favorable physical health, rural areas experience less favorable mental and behavioral health, which has been tied to cardiovascular disease incidence, prevalence and mortality in both adults and children. Rates of depression and suicide are higher in rural areas. Among children, suicide rates are nearly twice as high in rural as in urban locations and these differences are increasing over time. This does not appear to be related to social isolation and loneliness.

Recent U.S. Upward Trending Death Rates from Hypertension - Over 3 X Higher in Rural Areas

In data just presented in the last 6 weeks, the U.S. death rates from hypertension related cardiovascular disease rose from 2007 to 2017. This trend was noted to accelerate starting in 2012 while the rate of decline from cardiovascular deaths started to slow down since 2011: the two endpoints are felt related.

Age-adjusted death rates rose from 18.3 per 100,000 to 23 per 100,000 people (probability for trend was <.001). The age-adjusted death rates rose 72% in rural areas and was 20% in urban areas ($p<.001$ for both trends). Rates rose about the same for men and women. The authors of the report felt the rise to be due to many factors - including the rise in obesity and diabetes as well as disparities in the social determinants of health as well as disparities in health care access and delivery to these areas.

Electricity Costs:

MidAmerican Energy keeps emphasizing how Wind Energy will keep power costs low. My MidAmerican electric energy costs went up 20% last year. Having said that, the price of residential electricity has risen lockstep with growth in renewable capacity in Europe but not in the U.S., and because of these European residential rates are now roughly twice U.S. rates. (Energy, Environment and Policy - posted April 31, 2018 by Roger Andrews). The reasons for the difference are

a) that renewables surcharges are added to residential electricity bills in Europe but not in the U.S. and

b) that residential electricity bills in Europe have increased roughly in proportion to the amount of money spent on renewable growth. Residential rates in U.S. states are set by state Public Utility Commissions that are legally obligated to set prices at levels that are fair to both consumer and providers. As a result, the European bill payer pays for new wind, solar, etc. while U.S. renewables expenditures are offset by adjustments to the federal budget that are not itemized but which ultimately get paid by the U.S. taxpayer. I have included a graph (2014 data) that correlates residential electricity prices in various European countries as a function of installed wind + solar capacity (Watts) per capita. (See graphs at end of this Part) The more installed renewables, the higher the residential electricity price. Denmark, the home of the IWT-manufacturing company that sells their turbines to MAE, has the greatest percentage of their power production from wind energy and also the highest cost per energy unit. In the U.S., a lot of the increased cost is absorbed by into the federal budget destined to be eventually paid by the taxpayer. Make no mistake, renewables are more expensive than existing methods of energy production.

But even more important, it is about the goal of less carbon production to achieve electricity. The total CO_2 production ("cost consequence") of IWTs facility manufacturing, erection, raw materials extraction/refining/transport and ongoing maintenance costs are all considerable. Every turbine has a magnet made of neodymium that comes almost exclusively from China that requires an extremely toxic mining and refining process that involves repeated boiling in acid with radioactive thorium as a waste product that has leached into the soil and is threatening ground water supplies in Inner Mongolia.

One must include the accompanying expenses of fossil fuel fired co-generation capabilities into the final comparison equation - that data is extremely hard to clarify. I also found another set of graphs that describe the obligate need of a co-generation plant working "with renewables" in order to provide continuous power 24/7 that can adapt to momentary changing of wind and solar energy resources.

This was shown in the April, 2020 National Geographic Magazine in an Earth Day, 50th Anniversary Special Issue. It appears that by 2045, the total generation of renewable power in the U.S with be nearly equal to the power generation produced through natural gas - and that at a level equal to "peak coal" in 2007. Currently, wind energy makes up a larger part of renewable than solar but "not for long". Solar is projected to triple its share by 2050 to become the leading renewable. This is in large part due to the herein-evidenced rejection by landowners of having IWTs "placed harmfully close" to their residences. Add the energy for constructing power lines and major transformer stations, erection costs and dirt moving among others. In that same issue was the picture of steel rebar - soon to be encased in CO_2-producing concrete for one of the bases of 120 future IWTs in Texas to produce 338 MW of electricity to power more fracking for oil and gas. The magazine briefly touched the issue of nuclear power in the U.S. commenting about the closure of several nuclear reactors. ... finishing their comments with "much of their carbon-free

electricity will be replaced by emissions-rich natural gas". The debate about the future of nuclear is complex and increasingly ideological". Nowhere is there a complete discussion in this article about regenerative agriculture but instead unsubstantiated dreams of greater yields (with more chemicals, more genetics and the attendant need for energy to produce these "additives") on soils driven to "extinction".

Also, as equally concerning is the evolving reality of the under-realized functional lifespan of IWTs in comparison to conventional energy production modes and the costs of decommissioning turbines faced with shorter functional service lifespans. When you see where a lot of the energy produced by Wind Energy is being used, it appears to be heading out of state. The calls by Wind Energy to achieve 100% of our energy sources will never be possible. Such "rally-cries" are delusional and serve as grossly inaccurate promotional misinformation for a failed concept to "save the planet". Robert Bryce's recent investigative journalism book "A Question of Power" clearly reviewed the financial and logistical impossibility of achieving 80% (let alone 100%) "renewable" electrical energy production in this country (mostly through analysis of the California effort, lithium-based battery technology, land-availability limitations and extraordinary costs. He also reviewed the merits of nuclear power as a much more viable source of "clean energy". One really needs to think about the misleading statements being made about the value of renewables. Instead, we need to focus on the real needs to change current patterns of energy consumption and dramatically increase carbon sequestration and perhaps reconsider looking in nuclear energy production options. In the final analysis, "it" will have to come to embracing future commerce with carbon credits. We need clear-thinking, realistic leadership with responsible allocation of our country's increasingly limited financial resources.

Decommissioning Implications - Costs: Unknown and Skyrocketing?

Comments from Isaac Orr - in Energy, Environment Sept 9, 2019 - while interviewing various wind energy experts.... Concerns for implications of relatively short useable lifetime of IWTs: Past turbines with 12-20-year lifespan based on experiences from Europe. Current U.S. experience with >10-year-old IWTs show significant needs to replace "blades and cells" despite the current IWT generation with reported 20-25 year expected lifespan. In comparison, coal-fired plants have 50-60-year functional life. Stated estimated total cost to taxpayers of the wind production tax credit between 2016-2020 will be $23.7 billion.

Estimates for "tear-down" cost for a single IWT is $200,000. Given roughly 50,000 wind turbines spinning in the U.S., decommissioning costs are estimated at $10 billion. In Texas, this could mean a potential current expense of $2.3 billion. This potentially would have to borne by landowners and counties pending financial viability and guaranteed protected funds for such actions. Options for upgrading with new models pending continuation of federal wind subsidies could be pursued but is not assured. There is significant disagreement about "set aside decommissioning funds."

Concerns: 1) extracting valuable materials from the turbines is not easy. Removal of copper from insulation would likely require significant labor costs,

2) Reducing the steel casings enormous sizes would require specialized cutting tools,

3) blades are high-tech wonders of composite materials which experts agree cannot be separated into its component materials and is thus worthless for recycling,

4) with turbine removal, the company is committed to restoring the site to its previous state.

In another story relating costs of decommissioning, it was reported that Germany is finding that disposing of their aging wind turbines could cost hundreds of millions of Euros **more** than previously planned and overwhelm Germany's capacity to dispose of non-recyclable wind turbine blades. Locally, the removal of 18 wind turbines in Chippewa County, Minnesota would cost, in 2019 dollars an estimated $632,000 each. It would make sense to ensure that decommissioning costs are completely covered **at whatever time** (likely requiring periodic reassessment of cost with contractual obligations to increase "bond coverage") in their life cycle as clearly stated in permitting requirements. If they refuse to cover that anticipated decommissioning cost with "irrevocable" availability of funds for some future need, that should be seen as their "commitment" to civic responsibility and "partnering" with the county and its residents. Things, people and times change; get all the decommissioning cost coverage confirmed in writing and keep that amount current with real-time costs. I would also suggest that all litigation costs regarding this specific item (in the event of MAE/current owner's unwillingness/inability to perform) "shall be borne" by MAE. MAE should not be allowed to "off-load" this responsibility to an insolvent "shell" corporation. IMPORTANTLY, MAE/current easement owner should not be able to assume/acquire ownership of the entire easement property to produce equity for decommissioning costs.

Smaller wind farm companies, with fewer financial resources may be tempted to just "walk away" when aging turbines no longer spin a profit. Some experts suggest that this may occur even before wind turbines outlive their

useful life as manufacturing warranties on the big turbines expire. What is unknown is "at what point does the cost of maintenance tip over to the point it's not worth maintaining a turbine?'
They note that as wind turbine manufacturing has improved, the length of warranties on these products has decreased dramatically and today the terms cover between 5 and 10 years. Despite the obvious paradox of improved manufacturing with advertised longer functional service periods **and** shorter warranties, many turbine manufacturers have found a valuable revenue stream in selling extended warranties. It "could get ugly" when we see turbines needing work, and are no longer under warranty and not generating enough electricity to keep running them". Such scenarios should be specifically addressed in Wind Ordinance language. (This will be another cost eventually passed down to the consumer).

Litigation: A Replacement of Science and Failure of Leadership

Australian Senate Select committee on Wind Turbines held June 29, 2015 established that there is a **direct** pathway to disease resulting from wind turbine noise.
Since 2015, 248 government entities from Maine to California have restricted or rejected wind projects.
The following educational links were provided on a "gofundme" site to assist with grass-roots efforts by citizens affect by IWT threats to their health and way of life. The individual, Hamish Cummings has been working hard for years trying to expose the truth about wind farms, the approval process and ramifications of ill-sited wind turbines.
This is an example of what has been happening across the entire planet in response to "IWT forced community intrusions". It's NOT "NIMBY - (not in my backyard), it is NOT in anybody's backyard!

Wind Energy works from the same "playbook".
LINKS
Human Impacts: http://windvictimsontario.com/; http://globalwindenergyimpact.com/; http://mothersagainstwindturbines.com/; http://waubrafoundation.org.au/; http://www.windturbinesyndrome.com/; Recording Impacts: http://www.illwind.org/ Property Loss: http://windturbinepropertyloss.org/site/; Fire: http://turbinesonfire.org/; Informative sites: http://www.wind-watch.org/; http://stopthesethings.com/; http://quixoteslaststand.com/; http://www.windwiseradio.org/; http://www.friends-against-wind.org/; Wind Energy Performance: http://energy.anero.id.au/wind-energy Links to over 2000 international anti-wind groups: http://quixoteslaststand.com/worldwide-anti-wind-groups/; http://ontario-wind-resistance.org/; http://epaw.org/; http://na-paw.org/; http://www.windaction.org/;
In another, more local case in Wisconsin that has been contested for over a decade in a state where turbine regulations exist at the state level:
The Brown County Town Health Board in Wisconsin recently declared Duke Energy's Shirley Industrial Wind Turbine Development to be a Human Health Hazard. The precise wording of the declaration follows: "To declare the Industrial Wind Turbines in the Town of Glenmore, Brown county, Wisconsin, a Human Health Hazard for all people (residents, workers, visitors, and sensitive passerby) who are exposed to Infrasound/Low Frequency Noise and other emissions potentially harmful to human health"
Human Health Hazard has been defined as a "substance, activity or condition that is known to have the potential to cause acute or chronic illness or death if exposure to the substance, activity or condition is not abated" (definition used in Brown County, Wisconsin Ordinance).
In the last 20 years, it has been estimated that over 5000 separate "anti-wind" coalition groups have formed in their desperate attempt to protect **their** life's work in their created homes, **their** view of land aesthetics and the importance of safe natural environments, **their** health - individual, family, community because **we** (wind energy victims and their representative leaders) don't listen and seek out safe compromise for **our** world. Again, lofty ideals.... but unique to this issue of "forced, unproven in safety, non-integrated to community wholeness" essentially unregulated and unsupervised placement of IWTs by Wind Energy industry primarily motivated by profits assured by non-consenting taxpayers. I recognize that industry incentives were approved by Congress, but **I would bet that Congress was never told the full story about potential health effects involving IWTs. If they had, they would've requested oversight and safe health standards.**

It is not clear whether affirming votes made by County Board of Adjustment or Supervisors to permit IWTs could create individual Supervisor or Madison County liability - having had specifically been presented with compelling data about IWT's inherent health risks and collateral negative impacts as projected with MAE's proposed plan. MAE has provided no facts nor supportive data to eliminate those potential "loss of quality of life or health" let alone "life

and death" concerns. Again, Wind Energy has never been proven to be safe. This is even more concerning in that a supermajority of citizens polled within the footprint of the proposed Arbor Hills project have specifically stated that they did NOT want the turbines because of their concerns over health risks and violation of property rights. Indeed, MAE (through the comments made by their industry-supported speakers at the Board of Health hearings) has acknowledged that "annoyance" is a health risk **and** that it is possible/feasible/plausible that IWTs could cause sleep disturbance that has been associated with cardiovascular disease as seen with other environmental noise sources. Finally, Dr. Thorne, a spokesman for MidAmerican Energy who spoke at that hearing agreed with me (personally, in a private conversation) that Wind Energy has never proven their turbines to be safe (in terms of health).

SCADA and NRO

Supervisory control and data acquisition are a control system architecture comprising computers, networked data communications and graphical use interfaces for high-level process supervisory management, while also comprising other peripheral device like programmable logic controllers and discrete proportional-integral-derivative controllers to interface with process plant or machinery. The SCADA concept was developed to be a universal means of remote-access to a variety of local control modules, which could be from different manufacturers and allowing access through standard automation protocols. It is one of the most commonly-used types of industrial control systems, in spite of concerns about SCADA systems being vulnerable to cyberwarfare attacks.

The Human-Machine Interface (HMI) is the operator wind of the supervisory system. It presents plant information to the operating personnel graphically in the form of mimic diagrams, which are a schematic representation of the plant being controlled, and alarm and event logging pages. The HMI is linked to the SCADA supervisory computer to provide live data to drive the mimic diagrams, alarm displays and trending graphs. In many installations the HMI is the graphical user interface for the operator, collects all data from external devices, creates reports, performs alarming, send notifications, etc. (Wikipedia)

Noise Reduction Operating Modes (NRO modes) are roughly considered to be a "throttle" option (as directed through SCADA) to control noise production and maximally achieve power production within the regulatory parameters. There is Mode 0 which is "pedal to the metal; noise be damned". Then there is NRO mode 1 which drops the energy output by 10% for a 1 dBA noise reduction. Each successive NRO mode, 2, 3 ,4 and 5 each reduce the noise another 10% and in NRO mode 5 the noise reduced about 5 dBA. This is not economical for the operator, which is why they are better off selecting one of the new quiet blade design options which can reduce the noise about 5 dBA from the older style and less expensive blades rather than buying "cheap" and then being forced by complaints to run their equipment at 50% energy output at night in NRO Mode 5 to meet a penalty for violating the regulatory limits.

Blade Throw

During the Joint Supervisor/Public Wind Ordinance Writing Workshop, there was some discussion about the setback distance between the IWT and the residence. Mr. Clifton decided that 1500 feet was the distance he wanted. Concern over the distance from the tower to the property line was discussed with again, preference for MAE standard language usage of 1.1 times the total tower (including to the top of blade) height. There continues to be no guidance from the manufacturer about a safety zone **specific** to the **physical size of a given model**. As happened many times as the public tries to secure the physical safety of its property, again, the public was told that the same safety zone was recommended for the V-110 2MW IWT as was recommended for the less powerful and shorter V-90. Concern from the public (attending) of potential tower toppling/blade throwing/nacelle fire with ember showering were again mentioned and completely ignored by Mr. Clifton. One would think that a given product (in this case a turbine model, e.g. Vestas Model 110, 2 MW) - is perhaps slightly different than a previous generation product (e.g. Vestas Model V-90, 1.8 MW) and that new written, model-specific recommendations should be mandated. Perhaps the materials and their sourcing/purity/manufacturing/testing of raw materials and finished products would need to be done to assure maximal safety. As such, specific safety specifications need to be stated on product documentation that is made available to the consumer (MAE) but also should be made available to the county where the product is installed. Such important information would be a record of the testing specific to assessing component failures should be made available to the County Supervisors, the County Engineer, the EMS infrastructure and, MOST importantly, to the resident whose property is in potential risk-proximity to the erected IWT. That information is not on the website (for the V-110) NOR has been disclosed by MAE despite multiple requests and has been ignored/not pursued by Supervisors or zoning administrators. The Zoning Administrator says it has been "addressed"... but short of actual model-specific paperwork and the manufacturer's appraisal and transparency of potential risk, I would safely state that this request has not been addressed. Once addressed, the public should be able to review the contents of that court-admissible document.

An early 2018 article appeared in the journal, Wind Energy (2018:1-9) co-authored by Scott Larwood from the Mechanical Engineering Department at the University of the Pacific and David Simms from the National Wind Technology Center (NWTC). The authors described concerns about past modeling of blade fragment risk and appropriate setbacks. The purpose of the study was to analyze the risk posed by rotor fragments from wind turbines to roads and buildings as studied at the NWTC. Contemporary sized IWTs from 0.6 to 3 MW capacities were studied. The analysis used a previously developed model for the blade fragment trajectory and the associated probability of impact around the turbines. This study, from a university engineering department in conjunction with a Wind Energy consultant at a national IWT testing center made the following conclusions and recommendations.

1) a setback of 2 times the overall turbine height (hub height plus rotor radius) to a **property line** resulted in a "routine risk", which would "probably be adequate" for public safety.

2) a setback of 3 times the overall turbine height resulted in a **probability of impact with a dwelling that would increase the risk "above routine"**. Therefore, a setback of 3.5 times the overall turbine height is proposed to lower the risk.

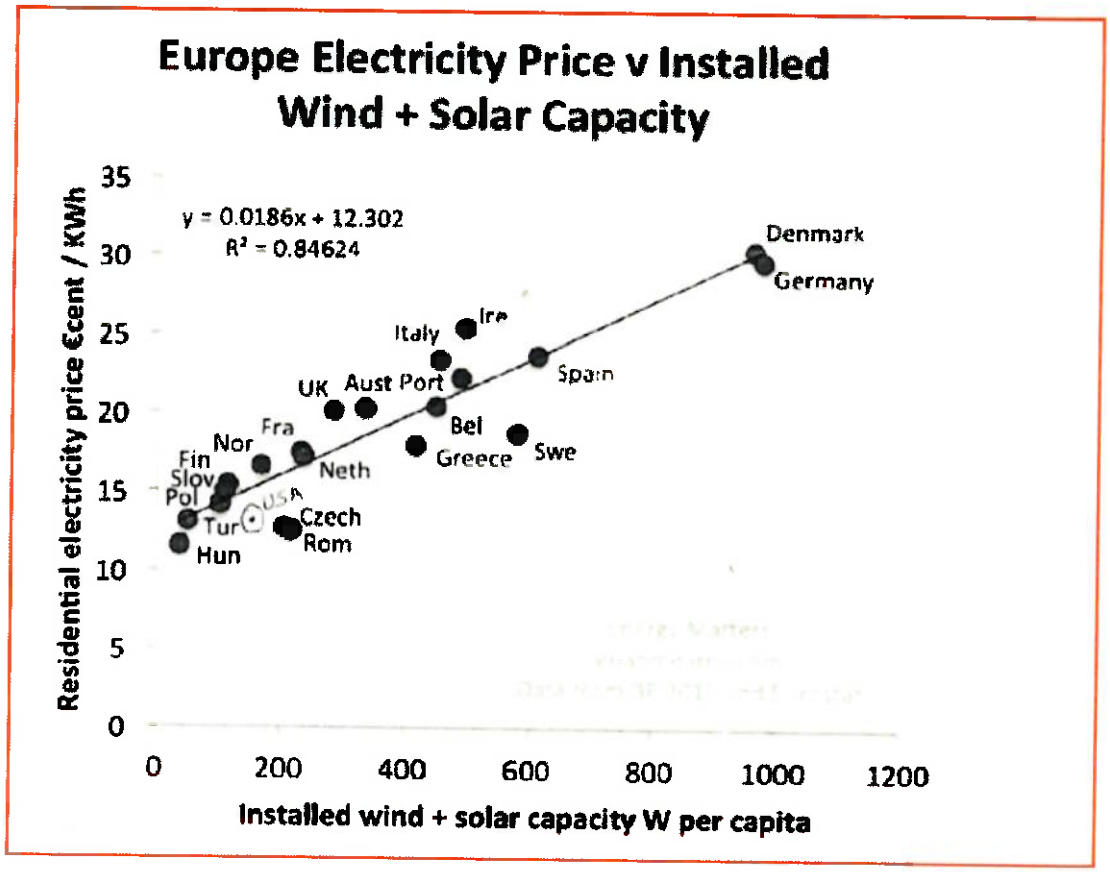
It would seem appropriate to incorporate both of these setback recommendations that were formulated with engineering principles and a goal to achieve more optimal public safety. The modeling they used reflected current technology "standards" of constructing/erecting and maintaining IWTs and reflect needed and appropriate risk vs benefit analysis to best promote citizen safety.

Mr. Clifton's current recommendation of 1.1 times height to the property line and 3 times height to a residence ignores non-participating property rights of the adjacent property owner and is inadequate to protect human safety and land use operations. In addition, it violates the intrinsic value of the property to future development or sale by the owner. This author sees the recent erection of several IWTs "nearly immediately" adjacent to (on the south side of) I-80 (inside of Adair county), between Earlham and Stewart, as also creating great potential risk to the public in the event of a turbine failure. I have also seen many other IWTs placed with inappropriately (my appraisal) close approximation to active roadways around the State of Iowa. I have also seen "still" turbines with a missing blade "broken off near the hub" as well as pictures of nacelles/blade components on fire.

Apparently, it is acceptable to ignore science when it might impact Wind Energy Industry/Contractors' financial gain. I can see no other reasoning that would allow/incentivize such "reckless" turbine placement. The public expects and deserves protection from massive towers associated with largescale kinetics that they literally know nothing about. IWT deployment should reflect best current science and highest safety concerns. Because we have failed to protect the public in the past does not mean we should continue those potentially unsafe practices.

Appendix – Part 7: Other Selected Topic

Note European "equalized" relative energy pricing for combined solar and wind renewable sources from 2014. Highest penetration of renewable energies is in Denmark and Germany. The relative positioning of the U.S. is located along the lower left portion of the "line". The correlation of this association is remarkably "robust" with a R-squared value of 0.85. The current subsidies for renewable resources have, so far, protected the cost of electricity in the U.S. Future "plans" are for disappearance of subsidies that will likely dramatically raise energy prices and push U.S. prices toward eventual price tripling if Renewables become more prevalent.


Europe Electricity Price v Installed Wind + Solar Capacity
y = 0.0186x + 12.302
R² = 0.84624
Residential electricity price €cent / KWh
Installed wind + solar capacity W per capita
0
5
10
15
20
25
30
35
0
200
400
600
800
1000
1200
Denmark
Germany
Ire
Italy
Spain
UK
Aust
Port
Bel
Greece
Swe
Fra
Nor
Fin
Slov
Pol
Neth
Tur
USA
Czech
Rom
Hun

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, digitallysimulated version require that the sound being measured is **steady over the period of time required to the saturate the filter.** For frequencies above 20 Hz filter, saturation times are only a few hundred milliseconds. In stark contrast, to measure the sound pressure level at 1 Hz, to reach 90% filter saturation, the filter must be steady for 4989 msecs (almost 5 seconds). IWT infrasonic pressure pulses last about 10-20 msec. Measuring sound of low frequency content with a short 10-20 msec pulse to a filter means that the filter never reaches 90% saturation - not even close. Thus, sound pressure levels that are "outputted" by the filter are all artificially much lower than they really are. The lowest 1/3 octave band sound pressure filter that can accurately measure a 10 msec pulse is 500 Hz. This information describing filter saturation times is found in "appendix 2" at the end of the Article: Noise-Con 2011, July 25, 2011 "Dynamic Measurements of Wind Turbine Acoustic Signals, Employing Sound Quality Engineering Methods Considering the Time and Frequency Sensitivities of Human Perception" and was written by Wade Bray and Richard James - both independent acoustic consultants in the U.S.

The proper analysis of infrasound pulsations, as opposed to steady infrasound, is to make a high-quality recording using a digital recorder and an infrasound-rated microphone. The recording is analyzed using methods based on Fast Fourier Transformation (FFT) which can convert a time domain signal into its frequency domain sound pressure levels without the use of digital octave or 1/3rd octave band filters like the majority of professional sound levels meters use. This is described in the ANSI S12.9 Part 7, Appendix D. The main part of the "Part & Standard" works very well for infrasound that is reasonably **steady over time**. However, the short pulses from the blade-tower interaction (10-20 msec duration pressure pulses) will be dampened by the filters as if being averaged, and, depending on the ratio of onto- off time, will be much lower than the true peak level (which is what we perceive). We feel the peaks or crests of the pressure waves. We do not feel the average of the sound over the period it takes for a digital filter to fully saturate. In multiple subsequent legal hearings over the years, Rick James has recurrently made this point with offering the data of Appendix 2 as evidence... eventually Wind Energy stopped citing their original incorrect information. Despite the eventual acceptance by Wind Energy of their "flawed assumption at many levels", it is of interest that a Madison County resident during a private conversation with a Wind Energy representative in Madison County (early in the course of MAE's efforts), was again told that IWT infrasound noise levels are less than environmental background levels.

"Normal" People don't Run from the facts ... or, simply not comment. Conveniently ignore the truth

Demand ABSOLUTE Causality when very little in the world can be "proved absolutely".

In a remarkable speech, Dr. Mauri Johansson, MD, MHH, a specialist in community and occupational medicine, delivered a speech at the general meeting of Vestas on Thursday, March 29, 2012 in Denmark.

Previous to and after this speech, he has been active in the area of describing adverse health effects created by wind turbine exposure.

A copy of the translated speech is this Part's appendix.

It has become apparent to me that there is a huge worldwide deception in play. "How can this level of deception exist?", I asked to many (un-named) who have been witness to this business for the last 40 years. Their collective response: "(I) see it in many businesses, especially in the unregulated utilities that are multinational. It is a business

model for large firms... through PR firms, lobbyists and outright control of our country's politicians and courts...together work to make themselves richer and immune to citizen oversight".
We have to understand the goals of Wind Energy and their messengers and the rehearsed presentations and their hiding behind their hollow arguments of their "science" and their workings without empathy, or concern ... failing to hear the cries of victims of their manufactured oppression
They (must) struggle violently to believe they are in the right and that "we" are incapable of understanding their (misguided) insights and righteousness
It is not green, sustainable, renewable nor humane... it is not the answer.
This section reveals the extent to which Wind Energy has gone is the past and continues to the very present to champion their industrial wind turbines. The "Non-Wind", i.e.-Health" science is better, more accurate and more complete. The most accurate science that their Wind Energy's acousticians have produced were done by Dr. Leventhall prior to 2004. After that, having become a champion of Wind Energy, those "correct" initial interpretation of ILFN were ignored (but not publicly disputed) by Dr. Leventhall. Once "captured" by Wind Energy, "they" worked together to bring their version of infrasound to the nations of the world that would absolve them of willfully "harming" the recipient residents. The ETSU-R-97 was contrived by a large group of pro-wind supporters (and complicit governmental ministers who adopted the guidelines that brought commerce and the illusion of clean power to the U.K. and then was later spread to their colonies and eventually to the U.S. (in the vacuum of federal oversight) with pseudo-science that allowed loud audible sound and hence also louder infrasound to be produced at night to levels over 20 dBA above background - among many other nonscience supported assertions.
Wind Energy worked hard to control the narrative particularly when they recognized that they could engineer and produce larger sized IWT with higher energy-producing capabilities. They pressured universities to silence world-acclaimed acousticians who correctly correlated increased IWT size with higher IWT noise emission level in the ILFN spectrum - creating more potential harm to more residents and at farther distances.
Vestas badgered their own government to lessened sound limits on low-frequency noise, then were able to circumvent it through political means.
Vestas badgered the Australian government with incorrect narrative of anti-wind activists and the harmlessness of infrasound
Dr. Johansson saw through their business plan carefully obscured by sanctifying corporate appearances and hollow assertions. It should become much more apparent of what is happening then as is now as one reads his clear distillment of Vestas' real interests. Please read the speech text included in the appendix.
It should surprise no one that the Chairman of the Board of the American Wind Association is leader of the North American Business Unit for Vestas.
These comments are my opinions. I have provided documentation where able. I believe I have made conclusions (included herein) that are reasonable and could be considered as such by a reasonable person. I have fact-checked and cross-checked as best I can. I believe this section's commentary and evidence are crucial for a reasonable person to better understand Wind Energy's Stance on adverse health effects from IWTs.
Click on file below to find 2005 British Wind Energy 2-page informational sheet on their "views" about infrasound noise component in IWTs

Procedure for the assessment of low frequency noise complaints. Dr. Andy Moorhouse, Dr. David Waddington, Dr. Mags Adams University of Salford. Manchester. Defra. Revision 1 . December 2011 Contract no NANR45

1. INTRODUCTION AND SCOPE

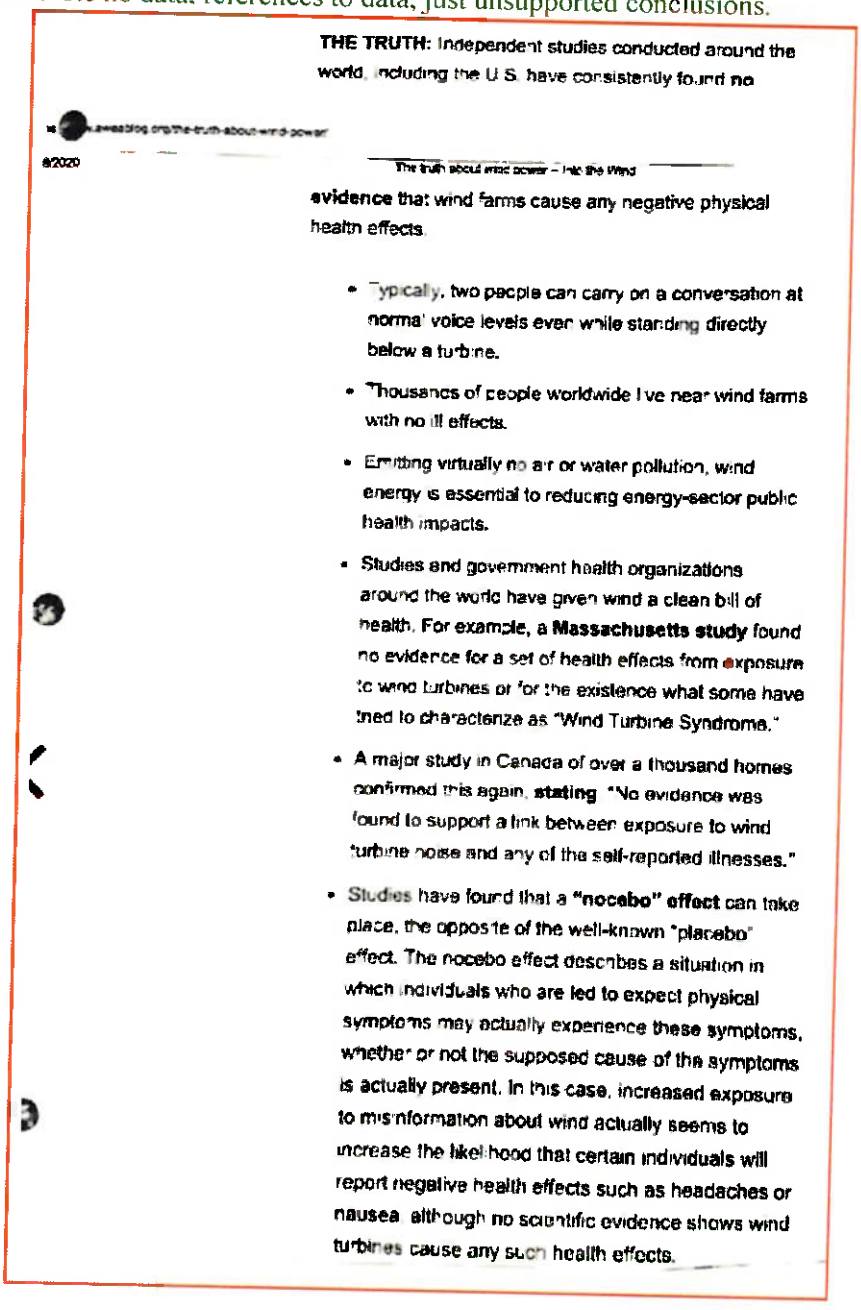
Low frequency noise (LFN) is now a recognised problem in many countries in the world. Experience of LFN complaints from the last 30 years has built up a good picture of the typical situations in which disturbance arises. While only a relatively small number of people are affected, those who are tend to suffer severe distress. It is not unusual for sufferers to sleep in a car or shed to avoid the sound, and they may suffer various symptoms such as depression or even feel suicidal. In some cases a source of LFN is found and can be dealt with. However, in many cases (typically 50% to 80% of cases), no environmental sound that could account for the sufferer"s reaction can be found, and the cause of the disturbance remains a mystery.
This guidance leads on from previous reports published by Defra: [Le03] and [Mo11].
Most Local Authorities will receive complaints about LFN at some point, and usually find them particularly difficult to deal with for several reasons. Firstly, existing noise criteria are not appropriate for evaluating LFN; in almost all

other situations the established noise descriptors are based on the A weighted sound level (dB(A)) which effectively filters out low frequency sounds.
Secondly, LFN cannot be reliably evaluated on the basis of the investigator"s experience; indeed, officers investigating a case of LFN may not even be able to hear the LFN themselves. This is possible because disturbance by LFN is known to occur at levels only slightly higher than hearing threshold, which varies from one individual to the next. Also, the rate of growth of perceived loudness with level is more rapid at low frequencies so that a sound could appear loud to one person whilst still inaudible to another. An additional factor is that "sensitisation" to low frequency sound appears to occur over time, and therefore a brief visit may not give an accurate impression of what it is like to live with the sound.
Thus, the investigator is left with no suitable criteria and without even personal experience to guide them. Thirdly, the measurement of low frequency sound can be technically difficult. Against this background, criteria for determining acceptable levels of LFN have been introduced in Germany, Denmark, Sweden, Poland and the Netherlands since 1997; the guidance presented in this document has been requested and funded by Defra with the aim of developing a method for the assessment of low frequency noise suitable for use by Environmental Health practitioners in the UK.

Assessment of low-frequency noise from wind turbines under different weather conditions. Chun-Hsiang Chiu , Shih-Chun Candice Lung. J Environ Health Sci Eng . 2020 May 21;18(2):505–514. doi: 10.1007/s40201-020-00478-9
Background
Wind power is used around the world as a source of clean energy. However, wind turbines generate a broad spectrum of low-frequency noise (LFN) in the range of 20–200 Hz, which may be audible or inaudible. LFN generated from wind turbines can be broadly categorized as aerodynamic noise or mechanical noise. With the wind blowing below the cut-in speed, the turbine blades rotate very slowly or are stationary and "parked", thus generating only minimal noise . Sound power level then increases monotonically when the turbine operates between the cut-in and cut-off wind speed, approximately 4 m/s and 30 m/s, measured at hub height, respectively. The most important component of wind turbine noise emission is aerodynamic noise associated with the passage of air over the blade. Sources of aerodynamic noise include trailing edge noise, impulsive noise, inflow turbulence sound, blade tip noise, and blade-tower interaction. The aerodynamic sound level generally increases with rotor speed, which in turn increases with wind speed.
Studies have widely affirmed that exposure to LFN can have adverse health effects on humans, including annoyance, stress, sleep disturbance, headache, tinnitus, irritation, exhaustion, anxiety, as well as hearing loss, impaired concentration, and in some cases chronic fatigue. LFN from wind turbines may cause vibroacoustic disease, characterized by an increased risk of epilepsy, cardiovascular effects, and coronary artery disease. The percentage of people suffering ill effects of LFN increases with increasing noise levels.
Residents near wind farms are constantly exposed to LFN. Residents' exposure to turbine LFN can be obtained through either actual measurement or estimation using LFN propagation models. However, a critical parameter of the model, sound power level of wind turbines ($L_{W,A}$), is neither provided by wind turbine manufacturers, nor found in other documentation. Only $L_{W,A}$ 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 $L_{W,A}$ 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

...ressing on the truth about wind power

8/2020

The truth about wind power – Into the Wind

evidence that wind farms cause any negative physical health effects.

- Typically, two people can carry on a conversation at normal voice levels even while standing directly below a turbine.
- Thousands of people worldwide live near wind farms with no ill effects.
- Emitting virtually no air or water pollution, wind energy is essential to reducing energy-sector public health impacts.
- Studies and government health organizations around the world have given wind a clean bill of health. For example, a **Massachusetts study** found no evidence for a set of health effects from exposure to wind turbines or for the existence what some have tried to characterize as "Wind Turbine Syndrome."
- A major study in Canada of over a thousand homes confirmed this again, **stating** "No evidence was found to support a link between exposure to wind turbine noise and any of the self-reported illnesses."
- Studies have found that a **"nocebo" effect** can take place, the opposite of the well-known "placebo" effect. The nocebo effect describes a situation in which individuals who are led to expect physical symptoms may actually experience these symptoms, whether or not the supposed cause of the symptoms is actually present. In this case, increased exposure to misinformation about wind actually seems to increase the likelihood that certain individuals will report negative health effects such as headaches or nausea although no scientific evidence shows wind turbines cause any such health effects.

Danish Physician Mauri Johansson Addresses Vestas Corporate Meeting about need to focus on health safety for potentially affected residents. It is sobering, incredibly insightful and the message is still relevant today. This can be opened and reviewed below:

To my great joy, I read on Vestas' website that "Vestas welcomes the public debate about wind energy – and we hope to provide factual inputs and balanced perspectives". I would like to avail myself of that today.

I searched for 'noise' and 'health'. Issues like noise and health, visual impact and wildlife are often debated when discussing wind energy. I did not find anything about this topic on the Danish website.
However, the English website showed a couple of video clips where a neatly dressed gentleman in a convincing voice alleged that noise has NO negative health consequences. He managed (in a biased manner) to smear one critical report but did not mention a single independent scientific report documenting that there are NO problems.
This is because such reports do not exist, neither in Denmark nor in any other countries, but there are many that document a growing number of serious problems.
Vestas has a huge market in Australia.
At a Senate hearing in the Australian Parliament in March 2011 on the health consequences and potential illnesses caused by neighbouring wind turbines, Vestas' local representative in Australia (Ken McAlpine) stated: "Obviously, the one [issue] that is of most interest to us and closest to our heart is safety. Vestas has safety as its No. 1 priority." … "There is nothing about wind turbines that is unsafe. There is nothing about them that is unhealthy" …
" I can tell you again that there is nothing about the wind turbines that we are installing that would be unhealthy or harmful to people's health and wellbeing."
I think Ken McAlpine's statement was weak and untruthful in several respects.
The Chairman of the National Health and Medical Research Council in Australia, Professor W. Anderson, indeed refuted Ken McAlpine's allegations at the same hearing. Ken McAlpine's submission to the New South Wales [draft proposal] on wind turbines dated 14 March 2012, which proposes that the entire section on health be deleted, is even more outrageous.
Is it really good export policy to despatch a man like McAlpine to run errands on behalf of Vestas in view of the Danish Government's recently announced policy on Corporate Social Responsibility (CSR), now that Denmark clearly HAS recognised that wind turbine noise causes considerable problems, especially low-frequency noise, and has proceeded to regulate the area? Isn't the moral standard too low compared with Vestas' ethical high jumps?
By contrast, I am impressed by what Vestas writes on its website and in the 2011 Annual Report on topics that have been a great interest of mine throughout my adult life and still are: social conditions, environment, human rights (including the right to health), as my medical specialty is community and occupational medicine, including environmental medicine.

A couple of quotes:
Principles in the Vestas Code of Conduct on Ethics and Morals: The Vestas Code of Conduct is a set of rules governing ethical behaviour. It sets standards in different areas which all Vestas employees must adhere to in order to uphold Vestas' reputation as a company with a high degree of integrity and trustworthiness …
p. 8: All Vestas managers and supervisors must act as role models for the employees by adhering to the Code of Conduct.
p. 5: … we will be judged by the methods we use to achieve results.
p. 32: Competition: The only way in which Vestas can maintain its position as No. 1 in Modern Energy in the long term is to conduct business in a legal, honest and competitive manner. In addition to harming Vestas' business and reputation, illegal and anti-competitive measures will result in severe punishment for Vestas …
p. 36: Vestas' role in society: A company is responsible – according to legislation and public opinion – for the impact the company's activities have on nature and the local and global society. [MJ: I must presume that this also applies to humans, i.e. the health and quality of life of wind turbine neighbours?
Vestas is an international company and endeavours to be a socially responsible company at a global level … However, Vestas is also of the view that it is in the best interests of the company, the employees and the owners in the long term to take responsibility for Vestas' impact on its surroundings: the environment [MJ: In this regard, Danish and EU environmental legislation very much covers the health of individuals and the general population and the local, national and global [MJ: cf. Australia] society and their inhabitants.
Environment
"Environmental considerations are a fundamental part of Vestas' business concept. Vestas endeavours to produce wind turbines that are as environmentally friendly as possible" [MJ: i.e. also for people living in the immediate vicinity of erected wind turbines – or?]
Vestas undertakes:
… to comply with legal requirements to environmental protection [MJ: the Act on Environmental Protection says: "Section 1(1). The Act shall contribute to protecting nature and the environment to ensure that societal development takes place on a sustainable basis with due respect for man's living conditions and the protection of flora and fauna.

(2) This Act specifically aims at preventing and controlling pollution of … as well as nuisances caused by vibration and noise].
… to consider the environmental consequences of all new products …
… to reduce waste and pollution in all its activities [MJ: i.e. also the considerable amount of noise emission, which is not mentioned at all in the 2011 Annual Report? Or, what has also not been mentioned, the considerable emission of CO2 and other toxic emissions from traditional power plants as a result of the extensive back-up requirements that will always exist due to the unreliable power production of the wind turbine system – these are external factors for Vestas but deadly serious issues for the average power consumer, tax payer and citizen].

Political co-operation
Vestas supports political activities that promote wind energy. These include activities such as the lobbying of governments, information campaigns or meetings about wind energy with public servants or politicians. But what about the neighbours?
But what happens in real life?
At this general meeting, it is impossible to present the entire amount of evidence of well- documented serious nuisances, sleep disturbance, stress and illnesses that exist today, but Vestas in Denmark, in Australia and elsewhere continues to deny it, and continues to ignore scientific knowledge.
An extremely brief reference list is attached. Vestas says that the company has spent DKK 15 billion on research, but not a single krone of this huge amount of money has been spent on impartial research to ensure that wind turbine neighbours do not suffer nuisances or become sick.
Is this in accordance with Vestas' ethical principles? Research aimed at preventing the considerable increase in the proportion of low-frequency noise, including infrasound, in the latest wind turbine models do not exactly impress – just think of the rumbling of the 3 MW wind turbines.
For decades, Vestas and the wind turbine industry have ruthlessly been pressurising politicians and public servants with demands not to impose stricter rules on noise and minimum distances, knowing full well that the ever larger wind turbines cannot comply with the current (as of 1 January 2012) threshold values aiming to ensure the health of the population, which they fail to do. All problems can be prevented 100% if the limits for noise and distance are high enough. Exactly what is 'ENOUGH' must be clarified by impartial professional health research with the assistance of other disciplines. Until then, all precautionary principles must be strictly adhered to.
This is the responsibility of the municipalities, but they do not know enough about the subject. I and others have obtained documentation for all this by means of our right of access to public documents, including a letter from Managing Director Engel dated 29 June 2011 to the Minister for the Environment (is a CEO a good role model here?) and minutes of meetings from the Danish Environmental Protection Agency, etc. showing how a powerful industry makes demands that are more like ultimatums to the authorities who give in to the powerful industry and ignore weighty, even medical hearing material; documentation that clearly demonstrates that the authorities are bending the 'truth' to the detriment of wind turbine neighbours.
The Danish rules, and often financing schemes as well, have been exported together with the wind turbines and are thus causing damage the world over. The wind turbines have grown steadily larger due to the unhealthy subsidy schemes – money-making machines rather than power plants. Is this an honest and legal way to conduct business? Does it amount to social responsibility? Social consciousness? Trustworthiness?
Why is the company's lack of acceptance of the potential harmful impact of wind turbines on neighbours during operation not mentioned but only the health and safety issues in connection with production and scrapping? And why do the auditors accept this?
On the basis of the above, I have come here to strongly recommend that Vestas, now that so much has to be radically changed anyway, admit the errors they have committed by denying the facts that the wind turbines DO HAVE negative health consequences and start afresh with the development of a completely new wind turbine concept that is sustainable, without subsidies, and of a type that does not harm the health of nearby residents but provide them and others with an additional option for sustainable energy and electricity for the benefit and joy of others than the wind turbine industry and wind turbine owners.
Why not focus on wave energy and geothermal heat? Contact the health authorities and start collaborating with the Danish Society of Occupational and Environmental Medicine (DASAM). Take a look at the more restrictive Swedish noise regulations and adopt them, spearheaded by the two Swedish members of the new board.
References:

1. Christopher D Hanning & Alun Evans: Wind turbine noise. Seems to affect health adversely and an independent review of evidence is needed. Editorial, BMJ 8 March, 2012
2. Carl V. Phillips: Properly Implementing the Epidemiological Evidence. About the Health Effects of Industrial Turbines on Nearby Residents. July 19. 2011
3. Wolfgang Babish: in Occup Environ Med 2003;60:739–745): Policy implications: "Chronic environmental noise stress increases the risk of ischaemic heart disease." "Two conclusions can be drawn from the study: Firstly, noise annoyance/disturbance is associated with IHD incidence (shown in men without pre-existing disease) and may be a risk factor. Secondly, annoyance/disturbance ratings from subjects with health problems (men with pre-existing disease) may be influenced by other factors."
4. Same author: Editorial from 2011 in Noise & Health (May-June, 13:52,201-4): "It is well understood that noise levels below the hearing damaging criterion cause annoyance, sleep disturbance, cognitive impairment, physiological stress reactions, endocrine imbalance, and cardiovascular disorders." "The question at present is no longer whether noise causes cardiovascular effects, it is rather: what is the magnitude of the effect in terms of the exposure-response relationship (slope) and the onset or possible threshold (intercept) of the increase in risk."
5. Bolin/Bluhm: Review of wind turbine noise: (Environ. Res. Lett. 6 (2011) 035103): "the effects on the cardiovascular system by noise are assumed to be stress related and triggered by noise annoyance and sleep disturbance (Babisch 2002). Wind turbine noise is causing noise annoyance, and possibly also sleep disturbance, which means that one cannot completely rule out effects on the cardiovascular system after prolonged exposure to wind turbine noise, despite moderate levels of exposure."
6. Moller & Pedersen: "Low Frequency Noise from Large Turbines" J Acoustical Society America 2011 129:3727-3744: **http://www.wind-** watch.org/documents/low-frequency-noise-from-large-wind-turbines-2/
7. Vestas submission to NSW Dept of Planning: **comment here**.
8. David Shepherd & al.: Evaluating the impact of wind turbine noise on health-related quality of life. Noise & Health September-October 2011 13:54,333-9

Mauri Johansson, MHH
Specialist in community and occupational medicine – last draft for speech, corrected 30 March in accordance with what was said at the meeting.

The PDF document below was opened and printed below. The PDF filed is also available to be opened to see original letter format. This 2012 document reflects Vestas' objections to the introduced potential "safety-related" restriction proposed for Wind Energy. Toward the end, they minimize concerns about low-frequency noise.

14 March 2012
Policy, Planning Systems and Reform
NSW Department of Planning and Infrastructure
GPO Box 39
SYDNEY NSW 2001
By email: innovation@planning.nsw.gov.au
Dear Sir/Madam

DRAFT NSW PLANNING GUIDELINES: WIND FARMS

Thanks you for the opportunity to make a submission on the *Draft NSW Planning Guidelines: Wind Farms* (**the Draft Guidelines**).

Vestas Australian Wind Technology Pty Ltd is the local subsidiary of Vestas Wind Systems A/S, the world's largest manufacturer of wind turbines.

Vestas is the world's leading supplier of wind power solutions, having installed more than 41,000 wind turbines across the globe. Worldwide, Vestas employs more than 23,000 people in the design, manufacture, sales, installation, operation and maintenance of wind turbines.

While the home country of Vestas is Denmark, we have significant operations all across the world and we are experienced in comparing policies and regulations in all our markets.

In Australia we have been responsible for the supply of more than half of the wind energy capacity to date. However Vestas is not a developer or owner of wind farms or wind energy projects, and so does not seek planning permits.

Vestas is also a member of the Clean Energy Council (**CEC**), and in addition to our own submission we would also refer you to the CEC's submission regarding the Draft Guidelines.

Executive summary

Vestas opposes the Draft Guidelines, primarily because of the sheer number of new and additional requirements and barriers that would be placed in front of the wind energy industry without any clear evidence, justification or demonstrated need for this additional regulation.

The Draft Guidelines appear to be in conflict with the New South Wales (**NSW**) Government's own renewable energy policies and seem to be primarily motivated by an attempt to appease anti-wind protest groups.

The Draft Guidelines impose new rules that are not faced by any other industry in NSW, and directly discriminate against wind energy.

Some concepts, such as the requirement to assess impacts on property values and the introduction of a 2km "gateway" are at odds with many years of existing case law in the planning portfolio.

Other concepts such as the new noise requirements are more stringent than any other jurisdiction in the world, without any justification as to why this is required.

Even though we suspect the Draft Guidelines have been drafted in response to the lobbying of anti-wind activist groups, we confidently predict that the Draft Guidelines will not be accepted by those groups.

Such groups are not interested in compromise or balanced outcomes. They care little for evidence-based policy or addressing genuine impacts that wind farms might cause in specific locations. They seek nothing less than the demise of the wind farm industry, wherever it may be located.

Unfortunately, higher electricity prices will be the legacy of this attempt by the NSW Government to appease a noisy minority of activists. In addition, job growth and investment attraction will also suffer.

This will occur because the additional requirements and barriers in the Draft Guidelines for wind farms will make them more expensive to build and operate, and will force them to be located in areas where wind speeds are lower or transmission access is harder to secure.

By contrast, South Australia provides a good example of how a state government has worked with the wind industry and local communities to attract investment and jobs, build record levels of wind farms and keep power prices low. NSW would do well to follow this example and ignore the small but noisy group of activists that are seeking to destroy the wind industry and keep NSW reliant on fossil fuels.

Background

Over the past decade in Australia, the wind energy industry has grown substantially in almost all states and territories, to the point where more than 2000 megawatts of installed wind capacity is now operating. A further 6000 megawatts of new wind energy projects are currently being investigated or are in the planning stages, many of them in NSW.

Part of the reason for the industry's growth has been the Federal Government's 20% Renewable Energy Target (**RET**) scheme, which has driven most of the investments in wind energy in Australia since 2001. The decision in 2009 by the Australian parliament to lift that target to 20% by 2020 will continue that growth over the next decade.

The other key driver behind this growth has been the policy imperative for all nations around the world to cut greenhouse emissions in an effort to reduce the impact of climate change. Wind power is the most cost-effective form of renewable energy with zero greenhouse emissions, and is forecast to retain this status for many years to come.

Wind energy and its role in energy policy

Wind energy is just one source of energy available to NSW. Historically, NSW has relied heavily on coal to supply its electricity. While coal has provided low-cost electricity during the previous century, this does not mean that this is likely to continue in this century. Labor costs, extraction costs and pollution costs are all good reasons for NSW to consider moving away from such a heavy reliance upon coal and gas.

In addition, the further expansion of coal mining and gas extraction has been facing increased community concern, particularly from farmers. Coal mining is an activity which is not able to coexist with farming activities in most cases, as it usually entails open cut methods or involves such significant activity at the mine mouth that growing crops or managing livestock becomes problematic, and in many cases impossible in the same location as the mining activity or gas extraction.

In addition, access to water is also a major factor that makes it difficult for coal mining and gas extraction to coexist with farming. Unlike other users of water, power stations often obtain their water at sub-commercial rates and this has been under challenge in recent years.

The National Water Commission has examined these issues and said electricity generators "should face the full economic costs of their consumption decisions, so they have incentives to invest in more efficient technologies"1. Coal-fired power stations use large volumes of water for cooling purposes, so this is no small issue.

By contrast, wind energy does not face these issues. Barely any water is required for the operation of wind turbines. They cause no air or water pollution. There are no greenhouse gas emissions from wind turbines. And wind energy, unlike many other forms of electricity generation, does not have a fuel cost.

1 "*Water and the Electricity Generation Industry: implications of use*" National Water Commission, 2009

While other states and countries do not have significant renewable energy resources, NSW does2. It would be prudent for the NSW Government to focus on diversifying into wind energy over the coming years, which appears to be the approach now being taken.

It has been pleasing to see that the NSW Premier and a number of his ministers have restated their support for the 20% RET and indicated their willingness to attract investment in renewable energy to help achieve the target, including a statement by Planning Minister Brad Hazzard on radio on 9 February this year.

An increase in wind energy generation in NSW is an excellent strategic move in light of water and greenhouse gas constraints, and such a move will also act as a natural hedge against any increase in the fuel costs of coal and gas-fired power stations.

Against that background, the proposed introduction of a new and discriminatory set of planning guidelines that makes it more difficult to build wind farms in NSW seems short-sighted and highly questionable given the strategic issues discussed above.

Rationale and principles behind the Draft Guidelines

The Executive Summary of the Draft Guidelines includes the following statement:

The NSW Planning Guidelines: Wind Farms have been designed to deliver improved consistency and rigour in the planning assessment process and ensure effective consultation with local communities.

Presumably such goals would also be worthy of pursuing in relation to the planning assessment process for all kind of land use, not just for wind farms.

It is imperative that any proposed changes to the planning assessment process are fair, transparent and efficient. Assessment of wind farms should be based on objective criteria that all stakeholders can understand.

This can be achieved by ensuring the Draft Guidelines do not place additional burdens on the development of wind farms by creating delays or uncertainties in the planning process.

As is discussed below, many of the provisions of the Draft Guidelines discriminate against wind farm development and should be amended to ensure this discrimination does not occur.

2 "*Australian Energy Resource Assessment*" Department of Resources, Energy and Tourism, 2010

Specific responses to the Draft Guidelines

Section 1.2 Which development assessment process applies?

We note that the minimum 30 days exhibition time for state significant development (**SSD**) projects has been extended to a 60 day minimum in the case of wind farms that are deemed SSD.

While the duration of this period does not particularly trouble us, the discrimination against one form of development certainly does.

In practice, we would expect that wind farm project proponents would work with local communities, local councils and the Department of Planning and Infrastructure

(**DP&I**) to agree on a longer exhibition time for highly complex projects where this is considered to be necessary. However, we consider it is inappropriate and discriminatory to entrench a longer exhibition period for wind farms as a blanket rule, and we do not consider that the basis for this decision has been justified by DP&I.

Section 1.3 (a) Proximity of turbines to existing residential dwellings (2km)

Vestas welcomes the increased focus on community consultation and engagement in the Draft Guidelines. We also support the requirement to comprehensively document the views of nearby landowners, including any concerns they may have with proposed wind farms.

However, we do not support the requirement to explicitly seek the written consent of all landowners within a 2km range between proposed wind turbines and existing residential dwellings, or the requirement for a Site Compatibility Certificate in the event that written consent is not obtained.

Such a requirement does not apply to any other kind of development to our knowledge, and accordingly it is discriminatory against wind farms without any clear justification for this.

In fact, setting a specified zone for engagement may actually reduce the capacity for wind farm proponents to comprehensively consult with local communities and residents.

In relation to the 2km "gateway" zone, we would note that the 2011 Senate Inquiry into Rural Wind Farms concluded that "the application of scientific measurements for sound and for shadow flicker to alleviate problems for wind farm

neighbours may be preferable to prescribed setbacks. Prescribed setbacks are arbitrary and may be too great or too small"3.

That statement is consistent with existing case law. The 2010 decision of the NSW Land & Environment Court on the Gullen Range Wind Farm rejected the local council's proposal of an arbitrary setback distance of 2km, stating that "assessment of impacts on properties should be done on an individual basis taking into account topography, orientation of houses and distances to visible turbines"4.

It has not been made clear by DP&I why NSW should now move away from established law as well as the findings of the Senate Committee. It has not been made clear why wind farms should be subject to this discriminatory form of assessment compared to every other kind of land use.

If it was thought by DP&I that a 2km zone would go some way towards appeasing the various anti-wind groups from the constant political campaigning against wind farms, it won't work. The stated goal of the anti-wind activist groups is to have a 10km buffer zone between residential dwellings and wind turbines5. They continue to claim that wind farms cause direct and adverse health impacts, even though the peer reviewed evidence on this topic indicates the exact opposite.

In addition, there are practical concerns regarding the very early stage at which landowner consent is required. When developers are investigating sites, various technical aspects are simultaneously investigated including wind resource and planning constraints. This process can take months during which community consultation will be taking place. However, the developer is unlikely to know exactly where turbines will go and thus what consents are required. The proposal to secure approval for turbines within 2km at the beginning of the project will prove unworkable. it is impossible for the Joint Regional Planning Panel (**JRPP**) to fairly review the impact of a project in the absence of a complete analysis of the project, which can only occur once all the detailed studies have been undertaken.

A wind farm project continues to evolve from the initial turbine layout in response to constraints identified in studies (environmental, technical, cultural, local amenity) as well as in response to consultation with the community. This would be impossible without access to the Director General's Requirements upon which these studies are based.

3 *The Social and Economic Impact of Rural Wind Farms*, report of the Senate Community Affairs References Committee, June 2011, p.20

4 http://www.austlii.edu.au/cgibin/sinodisp/au/cases/nsw/NSWLEC/2010/1102.html?stem=0&synonyms=0&query=%22property%20value%20

5 For example, see the "Explicit Cautionary Notice", viewed at www.waubrafoundation.com.au on 22February 2012

Section 1.3 (b) Community consultation

See comments below in response to Section 2.2.

Section 1.3 (c) Visual amenity

Vestas rejects the need for a requirement for a Site Compatibility Certificate for turbines within 2km of neighbouring homes, for the reasons set out above in the discussion of Section 1.3 (a).

Section 1.3 (d) Noise

See comments below in response to Appendix B.

Section 1.3 (e) Health

The proposed requirement to reference "up to date evidence-based research" gives little guidance as to how this would be judged by a JRPP or any other decision-maker in the planning process. What qualifies as "evidence-based research" is a frequently debated topic, so this clause provides no certainty to anyone involved in the planning process.

Certainly the anti-wind farm activist groups refuse to accept the peer-reviewed evidence on this topic and have continued to rely on the scaremongering of unregistered doctor Sarah Laurie and information they have harvested from various anti-wind websites.

Given that most wind farm planning stakeholders are not medical experts, we think it would be more appropriate if the Draft Guidelines were amended to require that project proponents consider the project's impact on health, with reference to the latest statements from the National Health and Medical Research Council (**NHMRC**) and NSW Department of Health.

Ideally, the entirety of Section 1.3 (e) should be deleted so as not to give the impression that the NSW Government places any credibility in the false claims of the anti-wind activist groups on the topic of health impacts.

Section 1.3 (f) Decommissioning

The Draft Guidelines state that "wind turbines typically have an expected operating life of around 20-25 years at which point they are usually decommissioned".
There are no wind farms of that age in Australia and so what "typically" happens to the turbines at this point is unknown. Thus the statement is a ridiculous one to include in a document of this nature, and it looks suspiciously like the kind of statement that is more likely to have been made by the anti-wind activist groups.
Vestas does support the inclusion of a Decommissioning and Rehabilitation Plan in the environmental assessment report.
However, we do not support the requirement for proponents to provide a decommissioning bond. It is not clear how DP&I would calculate the level of this bond and until this is defined, we suggest that the requirement is removed from the Draft Guidelines.
Additionally, the requirement for the decommissioning plan to be updated every five years is an unnecessary burden not required of projects in other sectors. Wind farm operators have a clear incentive to maintain their assets for as long as possible because unlike most other power stations the "fuel" for a wind farm (i.e. the wind) is free. Hence this additional requirement is unnecessary.

Section 1.3 (g) Auditing and compliance

We note this section allows neighbours of wind farms to write to the Director General of DP&I to request independent noise monitoring at their house. This section gives no further detail on what grounds this request would be agreed to, such as:
who would undertake the monitoring,
who would pay for it; and
what actions would result if the readings show compliance or noncompliance.
At a bare minimum, such matters should be clarified.

Section 1.4 Preparing an Environmental Effects Statement

No comment.

Section 2.1 Consultation requirements (documenting "effective engagement")

Vestas agrees that consultation should be "aimed at identifying and considering options for eliminating or reducing impacts". That seems in line with accepted practice and on the face of it is a good policy.
However, the requirement in 2.1(a) that "the proponent's assessment report will not be accepted until evidence of effective consultation has been presented and it has been demonstrated that the issues raised during consultations have been appropriately addressed" could cause major issues.
Without further definition of "appropriately addressed", this requirement could be used by project opponents to delay projects indefinitely. The Draft Guidelines need to clearly state the requirements to be satisfied by the project proponent.
On the specific issue of property values, this is discussed below under Section 3.2.

Section 2.2 Who to consult

Vestas supports wide community consultation with respect to wind farm developments. However, as noted earlier in this submission, we consider the list of required stakeholders should be restricted to **only those who are impacted by the proposed project**.
This means that "organisations that represent those with a state, national or global interest, e.g. peak environment groups and national industry associations" and the "Aerial Agricultural Association of Australia" that currently appear on the list in 2.2 should not require consultation.
Many of them are nothing more than lobby groups, and in any other scenario would not have standing to interfere in a process like this as they are not local residents. In most cases the views of such organisations are well known and are not directly relevant to local planning issues.
The proponent should only have to consult with people, companies and agencies that are directly impacted by the wind farm in the local area.
Any diversion from this key principle leaves the process open to manipulation by organised protest groups who may not have members who live anywhere near a proposed major project.
Furthermore, given the Government's intention to restore planning powers to local communities, we would recommend that any objections to projects should only be deemed relevant if: the objections are from local agencies or members of the public living within a limited distance from the project, perhaps between 0 and 5 kilometres; the objections are not merely "form letters" or other verbatim forms of communication; and the nature of the objections are restricted to matters relating to the impact of any project on the local environment.

Such restrictions would be likely to focus the planning assessment process so that it addresses local environmental issues and other practical impacts rather than allow anti-development groups from outside the local area to add delay, extra costs and spurious matters and prevent SSD projects from proceeding and making economic contributions to local economies in NSW.

Section 2.3 Consultation approaches

No comment.

Section 3.2 Identifying relevant assessment issues (also the subject of Appendix A)

The list of "issues that typically need to be assessed for a wind farm application" is a long one, and includes many issues that have been raised by anti-wind activist groups in addition to matters that are normally addressed in planning assessments.

Vestas wishes to make comment on a number of them.

Health

As set out in the discussion of Section 1.3 (e) above, Vestas rejects the claims of the anti-wind groups regarding adverse health impacts of wind turbines. We consider that this item should be removed from the Draft Guidelines to properly reflect the most recent peer-reviewed evidence and findings of the NHMRC and the NSW Department of Health on this topic, and to ensure the baseless claims of anti-wind activists are not given any credibility by such a specific reference.

Property values

Property values are not considered valid grounds in planning matters, yet for some reason have been included as a proposed matter for consideration in the Draft Guidelines. In the Taralga and Gullen Range Land and Environment Court decisions this issue was raised and subsequently dismissed as a relevant consideration in the planning framework6.

The quote below makes it clear that the inclusion of such a matter would be contrary to the objectives of the relevant planning legislation:

160 Creating such a right to compensation (for creating such a right it would be) would not merely strike at the basis of the conventional framework of land use planning but would also be contrary to the relevant objective of the Act, in s 5(a)(ii), for "the promotion and co-ordination of the orderly and economic use and development of land".

In any event, the 2009 independent study commissioned by the NSW Valuer General revealed that wind farms had no identifiable impact on the value of nearby properties7.

That alone means that this particular section of the Draft Guidelines would be yet another example of regulation that is not evidence-based.

6 See in particular paragraphs 107 to 109 and 159 to 160 at http://www.austlii.edu.au/cgibin/sinodisp/au/cases/nsw/NSWLEC/2010/1102.html?stem=0&synonyms=0&query=property%20value%20

7 Preliminary Assessment of the Impact of Wind Farms on Surrounding Land Values in Australia, Duponts, August 2009

Blade throw

The occurrence of an incident where a blade from a wind turbine becomes detached from the generator is a rare one, yet perhaps because of its novelty factor has become a common topic raised by anti-wind groups to scare local communities as part of a campaign to stop wind farms being built.

Inclusion of any references to "blade throw" in the Draft Guidelines may please the anti-wind groups but would be in contrast to most other aspects of planning and environmental assessment, which are evidence-based.

DP&I has not provided any evidence to justify such a rare occurrence becoming a necessary issue for consideration in planning assessments. In addition, there are already laws in existence for owners and operators of wind farms to maintain a safe workplace and fulfil their duty of care towards others in the community.

The proposal for planning applications to address such a rare eventuality really widens the scope of matters that proponents need to cover in their applications, and sets a dangerous precedent for all types of planning assessment. For example, in recent times we have seen reports of anti-wind activists who claim that wind farms could interfere with the migratory patterns of whales8. Again, no evidence is provided for such a claim.

At best, the inclusion of "blade throw" as a relevant consideration in the planning assessment framework is another example where the Draft Guidelines discriminate by placing additional regulatory requirements on wind farms when compared with other forms of development and land use.
At worst, the inclusion of this topic as a relevant consideration sets a precedent that would see all kinds of additional spurious topics included in the planning assessment framework for other kinds of development.
Like health and property values, it should be removed from the list of relevant assessment issues.

Section 3.3 Conditions of consent and compliance

No comment.

Section 3.4 Community infrastructure contributions

Vestas supports private arrangements between project proponents and individuals and/or community organisations to deliver community benefits outside of the statutory planning process or assessment framework.
8 Eden Magnet newspaper, 9 February 2012 Section 3.4 of the Draft Guidelines suggests that "The consent may require the applicant to provide a contribution, including monetary, land or in-kind contributions, towards community infrastructure". However they also state that "private arrangements with individuals and or community organisations... are outside of the statutory planning process and are therefore not relevant to the assessment".
The Draft Guidelines should clearly state whether voluntary payments (whether to a local council or to an individual or community group) are relevant or irrelevant to the planning permit. It should not distinguish between these two types of voluntary payments.

Appendix A: Meeting assessment requirements

Many of the issues we have with this section have been discussed above, namely the references to health, property values and blade throw. These should all be deleted from Appendix A for the reasons stated elsewhere in this submission.
In addition, the statement on typical turbine life discussed in Section 1.3 (f) appears again in Appendix A and should also be deleted.

Appendix B: Noise guidelines

Vestas does not support the adoption of the noise guidelines set out in Appendix B as they are unnecessary, discriminatory and unclear.
The Draft Guidelines suggest additional, more stringent requirements and assessments with respect to noise compliance. No justification is provided for moving to a new set of regulations that are self-proclaimed as the toughest noise standards in the world.
Despite a lack of evidence that the current standards are inadequate, these additional requirements add to the large body of standards and guidelines already in use in Australia, which are already some of the most stringent in the world.
Rather than introduce new and more stringent noise guidelines, New South Wales should adopt noise limits in line with accepted standards such as NZS6808:2010.
This will allow for the separate day time and night time limits, and will allow for the differentiation of residential zones labelled 'rural living' and 'high amenity' (where a stricter limit will apply).

Low frequency noise

The Draft Guidelines state that "Analysis of wind turbine spectra shows that low frequency noise is typically not a significant feature of modern wind turbine noise and is generally less than that of other industrial and environmental sources."
It is therefore unnecessary to require the prediction and monitoring of low frequency noise emissions from wind turbines. This is especially so, given the absence of regulation or limits upon the low frequency noise from "other industrial and environmental sources" as mentioned in the above statement from the Draft Guidelines. This is a further example of the way in which the Draft Guidelines discriminate against wind farms.
In addition, the existing and well validated industry standard models for acoustic propagation are not designed to deal with frequencies at the low end of the audible spectrum, specifically because noise emissions in this band are not considered to pose issues likely to affect the surrounding environment.
Accordingly, Vestas suggests the removal of the requirement to measure low frequency noise from the Draft Guidelines.

Definitions and additional management of noise characteristics

In the Draft Guidelines, the definition of a "sustained exceedance" requires that characteristics are present for not more than 30% in any season.

This places an unfair burden on wind farm proponents who would be forced to test for 12 months in order to demonstrate compliance.

A more reasonable test would be when the characteristic was shown to be evident for 30% of the measurement period which must be more than 14 days (typically the duration required to gather sufficient data for assessment against NZS6808:2010).

When considering special audible characteristics (tonality for example) a sustained exceedance should be used as the test of non-compliance, using our preferred definition above.

Appendices C, D, E and F

No comment.

Retrospective application to existing wind farm proposals and projects

The Draft Guidelines do not make it clear which set of rules will apply to existing wind farm proposals that have already begun their path through the planning system, as well as projects that have already been constructed.

The "Questions & Answers" document issued by DP&I in December 2011 states "it is intended that the guidelines will apply" to "existing SSD and transitional applications". Such a proposal has already created significant uncertainty amongst investors and should be rejected completely. The Draft Guidelines should only be applicable to future projects after this current consultation process has been concluded. All other wind energy projects that have already been constructed or commenced their journey through the planning system should be assessed against existing rules rather than the Draft Guidelines.

Further steps

Vestas staff would be pleased to meet with DP&I staff to discuss this letter and answer any other questions you may have. Please contact the writer on (03) 86987300 to do so.

Yours sincerely,

[signed]

Ken McAlpine
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On the Next page, find:
Vestas Letter of Protest to Danish Government regarding Request to Lessen IWT Noise Emissions

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[Stamp:RECEIVED
BY THE DEPARTMENT
30 JUNE 2011]

Date
Randers, 29 June 2011 Aarhus

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 these 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 countries.

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 of recent research studies that the proposed new regulations do in fact introduce 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 it 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 in a business perspective. By means of its high wind penetration, 24% in 2010 - soon to be increased - 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 - just like in many an history shows - that the proposed limit 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

Part - 10 Carbon Management

We Agree on Some Things

Climate Change has been proposed as a potential "existential threat" for over a hundred years. With our expanding human population, Man has increasingly sought and extracted sequestered carbon fuels that were then oxidized to gather the energy held between the atoms of hydrocarbons for the purpose of creating energy and heat. As a specie, over our "brief" moment of time on Earth, we have rapidly transformed at least half of our world's landscape into food production and places where we work and live - all facilitated by the creation of carbon dioxide and other heating-retaining molecules. We have grossly overwhelmed the planet's capability to handle our world ecosystems perturbations and now are facing weather extremes that will overwhelm our ability to cope. Having actively left long ago our willingness to remain "integral" to our natural world, we now created a "planet in crisis". At 7.7+ billion current members of this species, with a projection of reaching 10.5 billion before the year 2100, ALL possible modes of reestablishing more natural and sustainable resource-use patterns over a relatively "short-term" time frame will be essential to minimize further natural systems losses and our viability as a specie.

Planet of the Humans

This concept recently was highlighted in the Movie "Planet of the Humans". Not available on Redbox, it can be viewed on YouTube: https://www.youtube.com/watch?v=Zk11vI-7czE . There was a greater focus on Biomass as an energy producing option than the financial folly of IWTs. Unfortunately, the movie did not highlight the real concerns of adverse health effects. They viewed recent Renewable Energy focuses as a "profit-driven" venture from the merger of environmentalists and capitalism. The Renewable Energy Tax Credit only incentivizes Wind Energy and their perpetuation of continuing to promote harmful wind farm installations. The movie commented at the end that "it is not CO2 that is destroying the planet, it is us."

Hard Realities that are Catching Up and Now Need Action

We need not only better (safer and more efficient) forms of electrical energy production but also to recognize the central tenets of permaculture design as we transform/adapt our current way of living to more planet-healthy partnering. Single focus, high-expense, non-integrated, inherently unhealthy energy-producing infrastructure is NOT what we ultimately need, nor where we should squander our finite (and borrowed) financial resources. In 2018, two Harvard researchers found that meeting current U.S. electricity needs with wind would require "covering" a land area twice the size of California with IWTs. International efforts to bring answers needs to be first approached with (national to local) appraisals of potential impacts of introduced "solutions". People's health (in all its forms) and a safe integration of energy production, food production must be defined, promoted and observed. Actively cultivating and providing healthy human interactions that fosters inner peace, satisfaction in our relationships with others, and inspiration - coupled with empowerment - to embrace joy in our world should be our steadfast goal. Lofty thoughts indeed, but it is worthwhile to examine our current course and truly ask where we should be heading.

The forced intrusion of closely sited IWTs into human habitation is immoral and deeply divides our communities. Conquering our "carbon problem" will require multi-level responses and re-examination of current energy usages. Responding to slow/halt/reverse this process will require global commitment enforced with incentives - at international to individual levels. Indeed, future energy security will be dependent on simultaneously reduced as well as more efficient and careful energy expenditure. Perhaps more important will be active implementation of enhanced carbon capturing - particularly in farming practices across the world. Truly, to flourish, let alone survive as a specie and as an integrated planet, will take a sobering embracement of "how nature works" implementing realistic rules of natural energy chains and bonding the human psyche back to its ancestral relationship of being wholly dependent on maintaining "vigorous planetary health". The future will be won by understanding, then accepting a sequence of daily opportunities to "live within our means".

Much smaller-sized IWTs (avoiding infrasound production and carefully sited to avoid health concerns) may have a future in a growing mosaic of blended energy sources. At healthy and environmental-safe sizing and spacing, they could be a part of localized groupings of distributed energy sources, like solar, wind, in-stream hydro together with better future energy storage or backup generation and load management tools. Akin to local food production serving local food needs, the system could operate as a stand-alone entity or its users can plug into the large grid as needed - hopefully on existing power transmission systems - and collectively supply that grid with bi-directional metering. If able to be built and operated economically, and be sited and retain mandated healthy and safe operational status, such microgrids could be ideally positioned in rural areas along with preservation of food production, near larger cities. Additional, but safely buried energy transmission lines could be added only when necessary; it needs to be presented as and TRULY BE a "win: win" situation.

Renewable Options Without IWT Risks

1) Initiate and incentivize farms to work to restore the ORIGINAL richness of our depleted soils through more complex crop rotations, no-till/less soil disruptive planting, use of multi-specie mixtures of cover cropping AND progressive tapering use of chemical control that perturb and threaten entire ecosystem viabilities. (See below)
2) Energy production with PV arrays and roof-top solar water heating. Surge ahead with battery energy-storage development at "acceptable" environmental cost. "True 100% renewable energy" will be ONLY possible with affordable, reliable, and massive-scale battery storage of energy. As long as we depend on "carbon-producing" back-up energy generation (natural gas, coal, petroleum) to supplement "when the wind doesn't blow and the sun doesn't shine", we are not 100% renewable –despite what the commercials on TV state.
3) Micro-grids with shared co-generation back-up and be willing to support research and development of nuclear options that are reportedly becoming safer.
4) Implement/Re-direct wind energy production to natural environments not shared with human places of work and living. Yes, I understand the concept of long-distance electrical energy transmission and concomitant inherent energy loss. OFF-shore IWT placement might be reasonable (though expensive) and current estimates of potential wind energy world production could be 22,000 Terawatts of power- far greater than projected future needs. (a Terawatt is equal to 1000 Gigawatts). I caution that we should clearly recognize the tradeoffs of off-shore IWTs on that ecosystem (whale groundings, adverse impacts on key natural coastal areas - fisheries, turtles, etc. MUST be done). Cost implications are horrendous with even greater costs/kw energy produced. Responsible, independent and transparent decisions of environmental impact must be incorporated into controlling levels of government that HAVE the scientific resources to evaluate environment noises of all frequencies. The world's current implementation of massive on-shore IWTs being placed close to people is and will, in retrospect, be considered irresponsible. It is very remarkable that when PBS and NOVA educational shows and television advertisements are seen, nearly all have IWTs operating in areas where homes, cities, and workplaces are NOT seen. It used to be only a couple years ago that MAE would show IWTs on the Iowa landscape associated with farmsteads… that is changing. Again, Wind Energy is working to portray their IWTs as "benign" even though they are not implemented as such.
5) In 2018, the IPCC estimated that we'd need to plant 1 billion hectares (1 hectare equals 2.47 acres) of forest by 2050 to keep the globe from warming 1.5-degree C. They commented that not only was that "undoubtably achievable" but global tree sequestration is "our most effective climate change solution to date." This is achievable and absolutely vital at many levels. I have planted, with the help of my family, over five thousand native trees and bushes on marginal land near my home over the last 25 years. Such activities foster personal and participating family hope to help the world ahead and beyond generations present. Participation by all Iowans at "county scales"- at least in shared shovels - to reestablish in Iowa natural diversity and vigor - could bring ownership of our personal and trans-generational destiny, and firm-up the shared responsibility of maintaining our global spaceship.

An Extraordinary Opportunity for Iowa

For the last 70 years, the process of "agrochemical farming" has depleted our soils of the organic component that defines soil fertility. Pre-settlement organic content approached 10% which now has declined to 1-2%, reflecting past farming practices and necessitating current dependence on nutrient supplementation and pest control additives. I am not critical of past farming practices, but now with recent recognition of these agronomic consequences and the impacts on global climate health, we must stop and reassess. Regenerative agricultural practices restore "degraded" land - land which we consider to be our best. Farming practices, including no tillage, diverse (and constant) cover crops, onfarm fertility, no or minimal pesticides or synthetic fertilizers and multiple crop rotations, will help to restore on agricultural fields. Upon implementation over 3-5 years of these practices, farmers will start to reverse depleted fertility and reconnect natural nutrient transport systems in the soil horizons and likely provide greater net profit returns due to the reduced costs of fewer inputs. The practice creates more resilient soil structure that allows greater rain retention at a time of increasingly bigger single event rains and will provide greater drought protection - both needed as climate change brings wider weather swings. It will reverse current farming practices from carbon positive to carbon negative through reconnecting soil mycorrhizal fungi to crop roots returning (sequestering) carbon to the soil and reducing our direct and indirect dependence on carbon fuels currently used to produce crops. There are much better options we have to individually fight climate change than allowing IWTs to dominate our land use. Very rapid, incentivized, widespread adoption of restorative agriculture would give us a few more years to develop other, less harmful energy production. Wind energy will NEVER be able to stand-alone for our electrical needs. That model will always require increasing large-scale utilization of natural gas (currently being dramatically expanded in usage) that significantly negates the value of "renewables".
It may be that only nuclear energy (in a much safer and secure form) along with maximized solar energy production can save our world. All of this MUST be coupled to dramatically reduced (through improved efficiencies) energy

consumption and carbon sequestration along with world-wide adoption of carbon crediting. In the end we will have to face the reality of "living within our means".
I agree with the concept and the threat of Climate Change. (That is the major reason I care so much about understanding the place of turbines in our county and our world). I originally liked the concept of "clean energy", but once learning of the realities of the noise that IWTs make and the human harm they cause (directly or indirectly), I have had to reposition the value of IWTs in the solutions we need to power our planet. After careful study and deep hunting for the "disconnects" of Wind Energy's behavior and position on AHEs, it is my opinion that they must say the "half-truths" that they do because to now acknowledge the much more rational stance against wind turbine noise and AHEs would mean the end of their expansion into populated areas and could possibly topple "the empire" they have created so far.
A Revealing Insight of what has happening in Germany as they struggle to "go Green". Please copy then paste to your address bar to read this May 2019 review.
https://www.forbes.com/sites/michaelshellenberger/2019/05/06/the-reason-renewables-cant-powermodern-civilization-is-because-they-were-never-meant-to/amp/?__twitter_impression=true

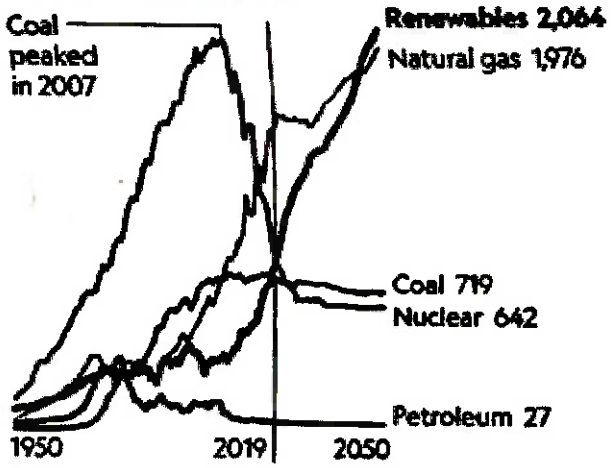
Appendix:
National Geographic Projection of Electrical Generation by 2050. Note Winners and losers of various energy product means. Of note is the steady rise of "renewables" shadowed by expensive back-up generation of power through natural gas carbon-producing sources. Nuclear and coal have plateaued.
Likely net-zero Carbon state has been reached by 2050.

Taken from **National Geographic**, April 2020

Graphs from Earth Day 50th Anniversary Special Issue

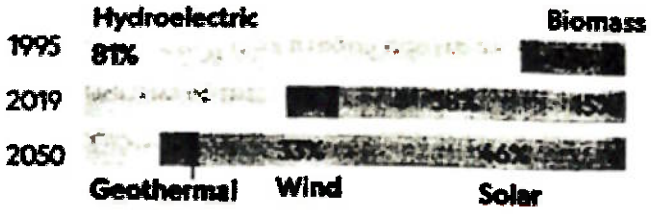
An Optimist's Guide to Life on Earth in 2070

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

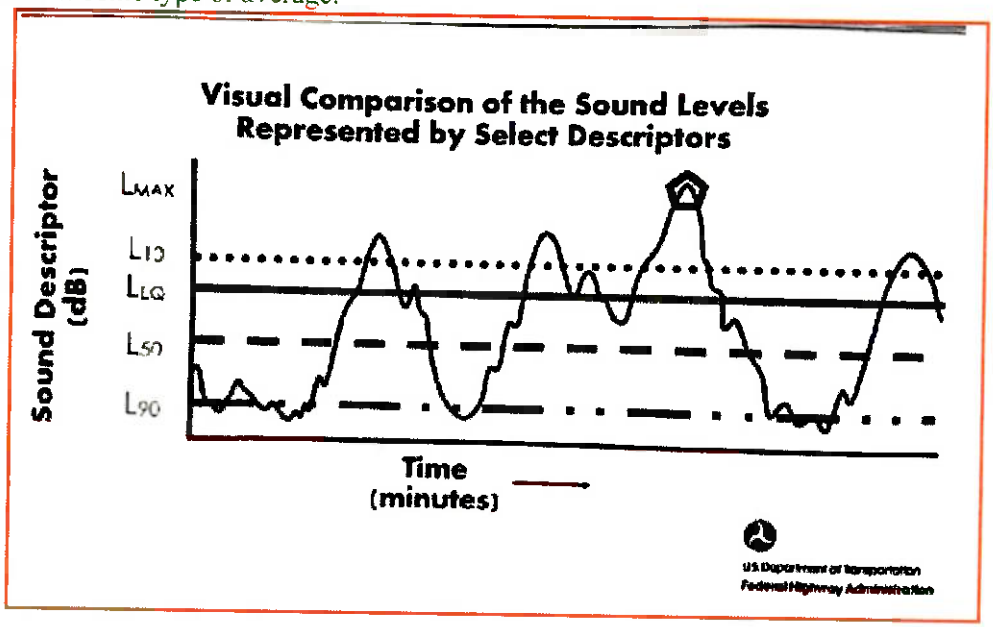
For five turbines with same distance, add 7 dBA to results
Sound levels changes at 6 dB per doubling of distance out to 3000 feet
The closest turbine or turbines control the sound level at a location
Decibels should be quoted to the nearest whole number (round up or down)

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 is dBs can be 0 to 7 for frequencies of 20-100 Hz. For frequencies below 20 Hz that range become smaller, and when the room resonant frequency is similar to the frequency of the outside sounds it can create a higher sound level inside than outside.

The above is one issue that is very influenced by each family's lifestyle and the type and age of their home. To further complicate things, modern homes are built and use HVAC systems that result in very low sound levels inside the homes when people are sleeping. Levels of 18 dBA or lower are common.

That means with the introduction of the newest generation of "quieter" air conditioning systems that the IWT-produced low frequency rumble is no longer "masked" as had been experienced by previous generations of "louder" air conditioning systems at night when people are at rest. Sometimes now, people suffering annoyance during attempted sleep due to significant interior home IWTs noise levels, often have had to purchase "noisy" box fans and run them at night to provide adequate masking noise.

Others have bought Bluetooth speakers and use their smartphones to play white noise or other masking sounds. The point being that modern homes can be too quiet (well sound insulated) if one lives in a noisy neighborhood. And, for a rural population not accustomed to nighttime noise, the new intrusions will be very unwelcome and a source of disturbance. That is why ANSI S12.9, Part 4, Appendix F includes a statement that installing a new noise source in a previously quiet community requires a penalty of 10dBA on that rural noise source to equal the annoyance for a similar noise in a suburban community.

Any way you look at it, IWT will likely disturb your sleep when sited too close to your home. Sleep disturbance is a serious adverse health effect. The only solution is substantial distance separation (2-3 km, 1.25 -2 miles) or (as has been court-ordered after wind farm construction) complete inactivation of IWTs during the night (10 PM to 7AM). At distances of <1.25 miles in flat ground without "grouping" or "in-line" turbine placement, you will have complaints.

Complaints mean that the county has failed to protect their residents.

2007 WHO Nighttime Noise Guidelines

The 2007 World Health Organization revised its guidelines for nighttime noise. Those guidelines provide the definition of what is required for a causal link to be established between an exterior forcing agent like noise and health. They state:

"Sufficient Evidence": A causal relation has been established between exposure to night noise and a health effect. In studies where coincidence, bias and distortion could be excluded, the relation could be observed. The biological plausibility of the noise leading to the health effect is also well established.

"Limited Evidence": A relation between the noise and the health effect has not been observed directly, but there is available evidence of good quality supporting the causal association. Indirect evidence is often abundant, linking noise exposure to an intermediate effect of physiological changes which lead to the adverse health effects.

In Table 3 of the 2007 Guidelines, the WHO presents the maximum sound levels that should be permitted **outside the walls** of a home to prevent health effects. The new criteria are based on recent research into nighttime noise and health that was not available in the 1999 guidelines. The outdoor criteria (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

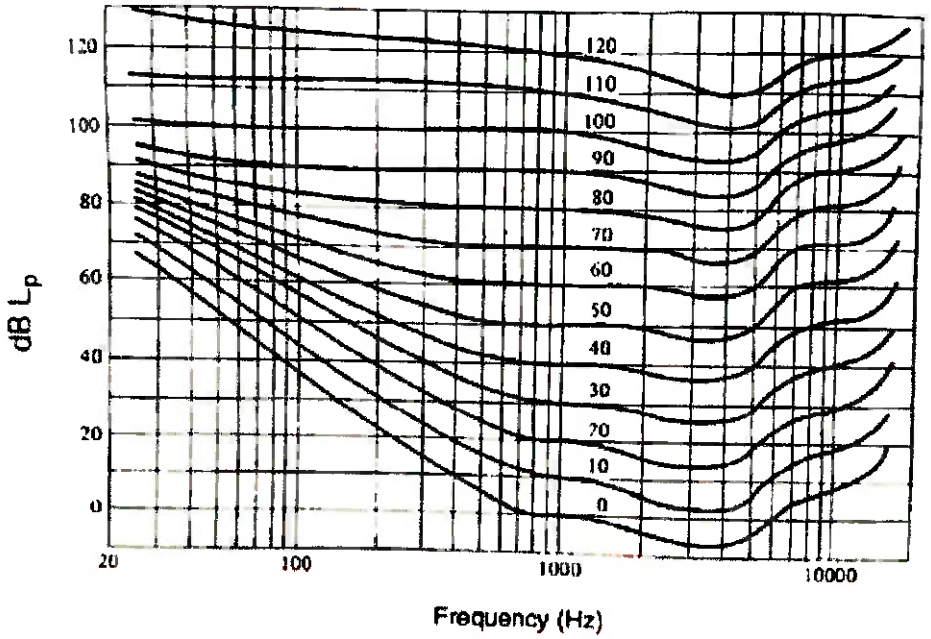
Equating decibel differences (more or less than reference) to a change in loudness varies over the range of the sound spectrum. The "Phon" loudness chart below (40 phon = 40 dB Lp at 1000 Hz) shows how low frequency noise "loudness" at smaller decibel changes.

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.

Cardiologist's Investigation and Response
to Industrial Wind Turbines in the Rural Residential Countryside **Nov. 28, 2020**



Part - 12 Ordinance Examples and Regulation

(This is huge topic; I have included SOME of the more important concepts)

Setbacks - Considerations and Recommendations Designed to Minimize Adverse Health Effects

Setbacks should be measured from a non-participant's property line. Wind Energy's template ordinance suggests (essentially assumes) that the receptor locale will be the house. By defining that "house" as the measuring locale, it becomes the closest structure (of importance) to the closest platted IWT. A setback measured from a dwelling limit the non-participating landowner's use of their property, and greatly reduces protections for non-participants from noise pollution and its proven ill effects, shadow flicker, property devaluation and potential property damage from blade failure or fire.

All landowners should have the right to do with their land what they choose as long as it doesn't harm or impede a neighboring land owner. A setback for safety reasons, regardless of its distance, must be maintained. Any ordinance that allows a wind turbine to be built closely next to a non-participant's property line eliminates that property owner from safely using that land. It creates a virtual access easement over the neighboring, non-participating property that eliminates the owner from any further developments. This amount to an uncompensated taking of private property rights.

In Robert Bryce's book "A Question of Power", on page 198, he mentioned in Henry County, Indiana, where seven communities passed resolutions establishing a four-mile buffer zone around their towns.

He also related the thoughts of Kevon Martis who has consulted with dozens of rural governments in the Midwest to help them craft and implement land-use regulations that will protect them from the encroachment of Big Wind. Martis believes the fundamental problems is that, by installing huge turbines, the wind industry if getting "uncompensated nuisance and safety easements" on the unleased property that sits nearby. The result is what he calls "trespass zoning". By establishing setback and noise limits from homes rather than property lines, Martis says that the wind industry is getting a de facto subsidy from neighbors without compensating them. That he argues, "is fundamentally unjust and flies in the face of sound zoning principles". Martis asserts that the only way for the wind industry to continue expanding is for it to acknowledge the costs it is imposing on nearby landowners and to buy easements from them. Of particular clarity, acousticians remark that enforcement of pollution (including sound pollution) begins at the property line.

Siting turbines should include consideration of:

IWT audible noise levels and all potentially harmful IWT emissions (including ILFN) that could impact adjacent, non-participating properties

Safety zone requirements made by the manufacturer

Wake turbulence

Consideration of proximity of other turbines (even not in the same county or owned/operated by same power company requesting permitting) – will increase lower frequency noise levels through amplitude modulation. In general, regulation by NOISE/IWT emissions should be through measured values.

Wind Energy templates often do not specifically measure those noise levels but will state only a distance (e.g. 1500 feet). If accepted, it is not uncommon that IWT clumping or arrangements in a linear row, "can be done" that may markedly increase noise levels at the receptor while remaining in compliance for distance.

Future growth of towns and cities and likely concomitant new hospitals and schools. County Board of Zoning and local communities should coordinate together to anticipate possible 58 years of community potential growth being unthreatened by future unhealthy Wind Energy noise emissions.

Setback Proposals

Because of widespread concerns about health and safety, many jurisdictions scattered around the United States and Canada have adopted larger setbacks.

Noise level regulation typically includes dBA sound rating with more comprehensive noise protection includes some measure noise level that more accurately quantitates the ILFN emissions. The Punch and James review listed several distance setbacks that varies but the average distance was 1.25 miles or 2 km. This distance was chosen to protect against harmful low frequency emissions. That distance was most often derived from evaluations of setbacks that did not produce noise or symptoms complaints attributed to noise emissions. Increasingly – particularly with recent Wind Contractor's practice of re-tooling IWT with larger blades/nacelle generators – that can substantially increase ILFN noise emissions that lead to increased complaints. It might be advisable to limit re-tooling options and limit increases in turbine heights. The impact of multiple adjacent IWT re-tooling to, e.g. 0.5 MW or greater, could markedly increase receptor noise levels changing a marginally tolerable environment to one which requires night-time evacuation to achieve restorative sleep.

Permitted sound levels across most Australian States for all industrial equipment are background noise levels plus 5dBA or 35dBA whichever is less, whereas for wind turbines they are background plus 5dBA or 40dBA whichever is more. There is no scientific evidence or reason for this difference. An increase of 5 dBA represents an approximate doubling of the sound level. Most rural environments have a background noise level of 18dBA to 25 dBA, approximately averaging 22 dBA at night. This represents a huge increase in audible sound. Increases of 10dBA at night are long known by acoustic consultants to raise complaints, and increases of 15-20 dB are associated with widespread complaints and legal action. Averaging measured levels of sound across too-wide of frequency bands also allows the hiding of sound pressure peaks to which the ear responds, understating the true extent of facility noise emission levels.

The WHO (World Health Organization) Night Noise Guidelines for Europe quote the 1999 Community Noise Guidelines: **"If negative effects on sleep are to be avoided, the equivalent sound pressure level should not exceed 30dbA indoors for continuous noise" Cities** have a higher background noise than country areas. Denmark limits indoor noise from industrial sources, including wind turbines, to a maximum of 20 dBA at night.

The currently permitted outdoor noise level in New Zealand and some Australian states has been ameliorated somewhat by the addition of a deduction of 5dBA from the 40 dBA limit to allow for especially quiet environments. History has shown that these Australian guidelines were based on ETSU97 from the UK, and were expressly designed to encourage development of the wind industry, not to protect the health of rural residents from wind turbine noise. Predictably, because the Kelley criteria limiting exposure to impulsive ILFN were ignored, these guidelines have turned out to be completely unsafe. (noted Hanning, et. al. review of ETSU-R-97 guidelines and significant deficiencies to protect health).

It is therefore necessary to predict and measure sound pressure levels across the full spectrum of frequencies in order to predict and control sound energy impacts on project neighbors.

The L (max) indoors, can be related to regulatory requirements outdoors, via recent testing done in Vermont showing the outside-to-inside noise reduction (OINR is -6 for window partially open). If you want to prevent impacts such as motility - (a marker for sleep arousal associated with potential sleep disturbance) (32dBL(max) indoors) then the intrusive noise outdoors (Lmax) should not exceed 32+6 or 38 dBA Lmax.

Waking up at night Lmax = 42 dBA indoors. Add 6dB, to get a limit of 48 dBA Lmax outdoors. Both motility and awakenings reflect disturbed sleep - **BOTH EFFECTS SHOULD BE AVOIDED through ordinance language to reduce in-bedroom levels.**

Wind industry predicts average, not Lmax, noise levels. However recent testimony from wind industry consultants (Epsilon, RSG) set the range of average Leq to maximum Lmax at +6 to +11 dB

So, to determine conservatively the **average** wind industry predicted-level limit, subtract 11dB from 48 and get 37 dB Leq. Anything above that is associated to "waking up in the night" with the windows partially open.

Additional Published Sound Limits:

Health Canada determined highly annoyed residents ramped up quickly above 35 dBA outdoors ANSI (American National Standards Institute) standards for Compatibility with Land use determine in rural residential land use, unfamiliar intrusive noise is incompatible at night above 35 dBA, marginally compatible between 30 and 35 dBA and compatible below 30 dBA.

Hayes-McKenzie Partnership recommendations made in 2006 limited maximum wind turbine sound levels at residences to 38 dBA and no more than 33dBA if "beating noises" are audible.

Michael Nissenbaum, M.D. issued his findings in 2010 from his medical study at Mars Hill, recommending a 7000-foot setback for public health.

Stephen Ambrose and Robert Rand, professional acoustical consultants with decades of experiences with IWT sound emissions, advise the noise level not exceed 32 dBA at the property line of any abutting wind turbine facility to ensure minimal LFN and infrasound content; the 32 dBA measurement would also be a proxy for LFN and infrasound. Wind turbine facility designers and their acoustical consultants would need to have a design target of 30 dBA to ensure 32dBA is realized. Further, if utility-scale (1.5MW to 3 MW) wind turbines are sited at least 1 mile from the property line of any abutting property, it is likely any audible noise will be attenuated below 32 dBA. To avoid devaluating any abutter's property, etc., the abutter property line is used.

Rick James and George Kamperman, professional acoustical consultants, have extensively studied wind turbine noise. They recommend a noise LIMIT at the property line for: 1) audible noise: 35 dBA or no more than 5 dBA above the pre-construction ambient dBA level, whichever is **lower**. 2) LFN 50 dBC or no more than 20 dBC above the pre-construction ambient dBC level, whichever is lower. We need to start quantifying infrasound and LFN permissible

levels which will require that Wind Turbine producers need to provide emissions data to reflect "worst possible scenario".
Rural Oregon has set minimum setback at 2 miles.
Victoria and New South Wales, NZ have set the minimum setback at 2 km (1.25 miles) - this despite Vestas getting the approval to "eliminate consideration of infrasound".
In a settlement reached in a wind turbine dispute in Fayette County, Pennsylvania, the setback was set at 6000 feet (1.1 miles)
An investigation into wind farms and noise by the UK Noise association finds an appropriate setback to be 1 to 1.5 miles. (7,900 feet)
Recommendations on the siting of wind farms in the Vicinity of Eskdalemuir, Scotland (2005) found an appropriate setback to be 10 km (6.2 miles or 32,730 feet)
Professor Moller, an internationally known acoustical scientist commented that "at low frequencies, the perceived intensity, the loudness, increases more steeply above threshold than at higher frequencies.
A few people would probably accept 25 dBA **in their home at night**, but hardly anyone would accept 30 dBA".

Part - 13 Recommendations

Recommendations:

Sound levels Limits should be described as (Lmax) and not (Leq). This sound level characterization is more important when considering sleep/school sound environments. It is also a more consistent sound target thus being more than enforceable than Leq. Observed IWT siting patterns by MAE suggest a preference for clustering thus making accurate predictions of target sound level more difficult.

Consideration for IWT siting reflecting the possibility +11 dBA audible sound level amplification likelihood during strong, unsteady winds should be observed. Worst case scenarios should be incorporated into setback calculations NOT just from the manufacturer's listed power sound level (e.g. for V-110 2 MW is 108 dBA) but from that value and perhaps an added 10 dBA to avoid any transient sound levels of >3-5 dBA in "worst case scenarios".

Stated noise limits as "shall-not-exceed"-__dBA Lmax (fast) (fill in the upper range of noise as measured in dBA that you wish. 35,40,45 dBA – the lower, the quieter the noise becomes – particularly at night which is the most important time as that is when the turbines produce the most energy and the wind are more consistently higher aloft. In addition, using a C-weighted Lmax dBC level to regulate ILFN is also advisable with the increasingly common desire to increase energy production density within a wind farm. Values of 50,55,60 have been used. I would point the reader to George Hessler's 2004 article (Noise Control Engineering Journal, 52 (4), 2004 Jul-Aug). The initial summary begins with the recognition that excessive low-frequency noise from (industrial sources) as a serious noise and vibration problem since the early 1970. At the time of this article there was no standardized noise criteria in the U.S. to consult for guide. His paper proposed a C-weighted level criterion. In table 1 – labelled as maximal allowable C-weighted sound level (dBC Lmax) at residential areas to minimize infrasound noise and vibration problems. For very quiet suburban or rural residential areas, with extensive or 24/7 source operation, levels of 60dBC were suggested.

Siting should be connected to a single proposed IWT power design. Re-tooling at a later date with a more powerful IWT **WILL produce** a different spectrum of sound emissions. With larger MW turbines, a much greater percentage of produced sound frequencies will be in the infrasound and low-frequency ranges and sound levels will be higher at every frequency in the ILFN sound spectrum. The frequency ranges can be more harmful in sensitized individuals producing greater sleep disturbance. Indeed, sound profiles may shift such that audible sound produced in the low-frequency spectrum may become louder than those present in the more usual audible frequencies (>200 HZ) - this may be true EVEN if 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 Residential	45	40	35
Urban mixed	50	45	40

However, they comment: As wind turbines are mostly in rural areas, a level of 25 dBA is very difficult to achieve, which is why the most stringent regulations currently in force recommend a limit of 35 dBA in sensitive noise areas. Textbook author's direct quote: "However, this limit is too high for many residents so 30 dBA Lmax may be a reasonable compromise for the maximum allowed noise at the exterior of rural residencies". They listed several recommendations from the 2008 Kamperman and James publication. To determine background noise, precise standard conditions were specified:

LA90 is determined using several 10-minute measurements during the quiet night hours between 10 PM and 4 AM when the wind is blowing slightly (<2 m/s at 1.5 m above the ground) from the wind farm to the residence and the wind farm is NOT operating. Daytime levels can be 5 dBA higher.

3. Adjustment for Uncertainties Any noise level calculated using a generally accepted propagation model with down-wind conditions (not turbine design) included, should have 4 dBA added to the calculated level to account for uncertainties in turbine sound powers and uncertainties in the propagation model parameters.

Examples of under-prediction of wind farm noise levels are presented.

Despite "uncertainty adjustments", regulation that clearly state a Lmax value (at any time day or night), subsequent post-construction measures of emitted IWT turbines that exceed that discrete Lmax level are not in compliance and should be shut-down or substantially limited via NRO Programming from the SCADA unit while verification of non-compliance is obtained using independent, non-biased, certified acousticians who have access to the SCADA data at the time of the complaint. It has been recognized by extremely experienced, IWT-specialist acousticians that "routine" monitoring of turbines operating at least at "half-power", measures to excess noise production above limit averages 8dBA and can be as high as 12 dBA. Insisting absolute compliance or face marked power reduction reprogramming or turbine removal if compliance cannot be obtained, has and should be a part of a protective ordinance.

4. Maximum Allowed Calculated low-frequency noise level

Maximum allowed calculated low frequency noise level in the range 10-160 Hz should be less than 25 dBA at the exterior of non-participating homes with a 4 dBA allowance for calculation uncertainty, so the calculated level is actually less than 21 dBA. There are also DEFRA guidelines for the 1/3-octave band unweighted noise (Leq) that were exhaustively developed to avoid annoyance. This is a very important aspect of health protection - particularly as IWTs are rapidly increasing in size and power capacity - both directly related to increasing amounts of ILFN production. Limiting total turbine height to <500 feet should prevent introduction of harmful excessive ILFN. Please note above, the use of dBC Lmax language.

5. Accounting for Multiple Wind Farms

There should be the requirement that takes into account the development of more than one wind farm in the same general area. the existing ambient sound level should be the one that existed prior to construction of the first wind farm.

6. Determination of a Compliance Testing Method.

Detail of such testing are complex and could be referred to. Cost to be borne by wind developer.

7. No Change to Turbine Model.

The wind farm developer should not be permitted to change the turbine model after development approval has been given without undertaking another noise prediction study with the new turbines. If the resulting sound levels at any residence are higher than originally calculated, an amendment to the development approval should be sought. Again, a maximal height limit of 500 feet should be enforced and will be necessary to prevent introduction of more dangerous and larger models of IWTs.

However! I have recently learned that MAE is "re-tooling" prior towers with longer blades (forcing the separation from ground to lowest excursion of blade to be shorter) thus allowing a greater "swept area" and a larger power generation capacity. As such, given the risks of ILFN as a concept, the subsequent increased noise emissions (particularly of ILFN) of the higher capacity IWT), and no way to limit emissions except through greater separation of IWT from property line/home, it should be stated that the replacement generator cannot be of a greater energy generating capacity than was the original sited turbine.

8. Acoustic Study Funding

The government body responsible for compliance assessment (should be funded by the wind farm developer) to choose and hire and acoustic consultant to do the testing **independent of any influence from the developer.**

9. Decommissioning Costs

Although not related to noise, it is important that any regulation specifies a required upfront payment for decommissioning (of the order of $350,000 per turbine in 2011, and $625,000 in 2018). This should be put into a long-term investment account or bonds, as it is likely that the company installing the wind farm will not exist when its design life expires (usually 25 years). Periodic reassessment (? every 3 years) of projected decommissioning expenses should be made and the current wind farm owner should produce additional funds (within 2 months of estimated additional cost) necessary to fully cover any decommissioning expenses. This is particularly important as turbine component recycling and removal/disposal may very likely become more rapidly expensive than other "costs of living expenses". This is a difficult point, but assuring (without any ambiguity) that adequate funds are available to remove, safely dispose of all components of the IWT and restore the land to its "original pre-turbine state" is essential. The values listed above are from one Midwest wind farm. Wind Energy may state that components could be recycled to offset any "bond posting", however, the monies realized through turbine part recycling is a very small percentage of the total costs of decommissioning.

10. Property Value Assessment

The value of properties within 5 km of a wind farm should be assessed by an independent commercial property assessor appointed by the local council prior to construction and the difference between that valuation and any sale price achieved within one-year post construction should be paid to the resident by the wind farm operator at the time of sale. Alternatively, if the property cannot be sold for a reasonable price, the wind farm operator should be required to purchase the property at the market value prior to construction of the wind farm. This would not apply to owners having the property in easement with the Wind Developer nor to any landowner who does not wish to have an appraisal of their property.

11. Existing Noise Ordinances and Regulations

These should be listed and the wind farm operator should be obliged to be in compliance with those existing sound ordinances. Normally those are listed as a part of the Comprehensive Plan which also has instructions for compliance.

12. Clarification of Modeling Considerations:

Models of wind turbine utilities used for assessing land use compatibility should:

1) Recognize the research of the NASA reports and other research that wind turbine infra and low-frequency sound must be handled differently than mid and high frequency sound

2) Be the best suited for representing wind turbine sound propagation

3) Represent the **Predictable Worst-Case Condition**

4) Fully disclose assumptions, limitations and tolerances of any modeling calculations

5) Provide confidence limits to account for the inherent inaccuracy in any model representing a complex set of conditions.

13. Outside Independent Review of Proposal Prior to Beginning Construction

As noted, there are lots of complexities of modeling of IWT siting to protect the health, safety and welfare of affected residents living in/near the proposed wind industry location. The lives and lifestyles of those affected will be forever altered as well as for subsequent generations that may reside there for use that land. They deserve the right to have the opportunity to have project proposal reviewed by an **independent** engineering firm (selected by the citizens) with half of the cost born by the county and half by the affected residents. The reviewing engineer must be a member of the Institute of Noise Control Engineering. The INCE Member has experience in noise impact assessment and control

(complaints, annoyance, noise specs) and is committed to the Canon of Ethics. With regard to industrial noise, experts would have to demonstrate their commitment by oath or experience to protecting the safety, health and welfare of the public from industrial and power generation noise pollution.

14. The Bottom Line

Obtaining and reviewing recently developed "protective (to health)" enacted wind ordinance examples is crucial. The ordinances are written in such a way as to be easily transferred into other, developing ordinances. As noted elsewhere, there are NO federal and in most cases state-level experts that can help individual township or county-level citizen or non-captured Supervisors as they will invariably struggle to produce protective ordinances. In addition, any templates from Wind Energy or captured administrators or Supervisors will often include "preamble" verbiage to the effect that ordinance HAVE to be constructed that both protect residents but do not discourage wind turbine investments. That is IMPOSSIBLE. Wind Ordinances should be aggressive to fully protect the health, safety and welfare or the residents who will be living and sleeping nearby. Once safe "human-compatibility" safeguards are established and described, if a prospective Wind Contractor feels he can abide by that regulatory language, then it could be a win-win situation. My experience is that to achieve mutually agreeable but otherwise opposing requirements will be very difficult VERY difficult: Once Administrators or Supervisors have compromised human health protection; they have violated the trust of the citizens that elected them and have violated their oath taken to protect the residents of their county.

IT IS MY OPINION, that IWTs have become so massive and generate significantly dangerous and harmful noise emissions (that have never been proven to be safe … with that obligation being born and to date "ignored" by the "polluter" i.e. Wind Energy or its contractors) that they cannot be safely deployed in most rural residential areas. It is "curious" in that recent promotional television or paper ads for wind energy production have, over the last two years, largely eliminated any "semblance" of nearby human habitation or activity. It is almost as if Wind Energy is beginning to understand what they are "doing" to people.

Part – 14: Summary

Brief, High-Level Summary:

IWT = industrial wind turbine
AHEs = adverse health effects
ILFN = Infrasound, low-frequency noise
WHO=World Health Organization
MAE=MidAmerican Energy

In this lengthy section, there is an expedited review of 13 parts (separately chaptered) and sequentially combined to highlight important concepts. These will make reference to available additional data and relevant information that could be accessed with a specific review of that "part". In the front, there is a Table of Contents that will facilitate more rapid focusing to your requested data. Some portions of this summary are from the individual parts directly copied onto the Summary. My goal in beginning this data collection was to discover the "truth" in this highly contentious topic. It was immediately apparent that too little information was being made available from MAE and that the County resources had very little understanding of the implications of these turbines. I have attempted to learn the vocabulary and the concepts behind Wind Energy noise and focused, specifically and intensely, on adverse health implications. Having attended nearly all of the county-level meetings related to the proposed Arbor-Hills wind farm development by Mid-American Energy, it was immediately obvious that that two dramatically different interpretations of this data have evolved.

Review of imprecise definitions, different assertions, conflicting peer-reviewed data and major studies on IWT noise initially failed to clarify why there is such a difference in interpretations. I was then able to contact directly some of the key (literature) authors and ask my questions that led to the origins of international guidelines of turbine siting (e.g. ETSU-R-97) and ask if the principles they were founded upon still made "scientific sense". There were individual acousticians who were pivotal in the pro- Wind faction who initially described IWT noise in a very different "light". It is a remarkable trail to follow and to finally understand. My background in caring for patients and specialization in Cardiology and arrhythmias with a relatively recent recognition of untreated obstructive sleep apnea causing cardiovascular disease (seen repeatedly in my clinics) allowed me "confidence" to explore IWT noise and the development of possible chronic cardiovascular disease as well as other forms of "harm".

Published data in early 2019 of two studies that reported a link of sleep duration and cardiovascular disease - one clinical disease manifestation and the other showing objective increases in atherosclerotic disease progression in those populations with less quantities of sleep were pivotal in recognizing that environmental noise that seriously affect sleep - in quantity and quality - CAN cause serious health effects. Importantly, wind turbine noise is more "annoying/bothersome" than the other three WHO tracked environmental noise sources making the premise that IWT noise is likely harmful to health almost undeniable.

The content of this data collection is not peer reviewed as an entity. Nearly all of it comes from peer reviewed data and publications. My conclusions are supported by many sources and through many lines of logic. I have directly transferred published information from sources which I have referenced in the text into the paragraphs of the various document "parts". Currently, there are no plans for publication of this information (I do not have the time) but may make it available to readers on the Internet.

In the final view, the conclusions are mine being supported by the cited publications and from reputable professionals with vast experience in this area. Absolutely relevant and important "conclusions – made by me" about various organizations and individuals as I have come to "understand them" represent MY OPINION. I wish no malice toward anyone or entity. I just wanted to know "the best discoverable approximation of truth" so that I feel comfortable with my comments and conclusions. I take my responsibility as a health care provider in my community seriously and personally; I appreciate the respect and time you have given me and the TRUST in me that it shows. I have received no financial return in this extended endeavor.

Introduction - Part 1

This was a communication to the Madison County Board of Zoning in anticipation of reviewing Wind Ordinance elements. I will refer the reader to pages 17-19 where that "letter" can be found.

Part 2 - Sleep

The majority of the industrialized world struggles to obtain adequate and restorative sleep.

Inadequate sleep begets mental and physical stress which may beget chronic mental and physical disease. Disturbed sleep is the most concerning adverse health effect from industrial wind turbines. It may arise directly from the sound emissions of IWTs or may result from other forms of adverse health effects (AHEs) generally termed as annoyance. ANY annoyance (mild, moderate or severe) is considered to be an AHE. Sleep disturbance is the key to a cascade of

adverse physiologic consequences that may, in the extreme, be associated with a host of potentially serious cardiovascular outcomes. While it is clear that such a relationship may exist - as judged by the WHO -from exposure to automobile and train and aircraft noises, the data is not robust enough to confirm the same concerns with industrial wind turbines although there is accumulating data to support that association. It is worthwhile reviewing the process and importance of sleep. Recognizing the profound implications of turbine siting distance from homes to lessen the consequences of sleep disruption should be a primary focus in creating a protective Wind Ordinance for affected residents.

Sleep is composed of transitioning through various stages. Non-REM (Non-Rapid-Eye-Movement) sleep typically occupies 75-80% of total sleep each night. This period provides time for essential brain function recovery - tissue growth and repair, energy is stored and hormones that are essential for growth and development are released. REM sleep typically occupies 20-25% of total sleep each night.

This phase is when dreaming occurs, is essential for processing and consolidating emotions, stress and memories. It is reportedly vital for learning and stimulating the brain regions used in learning and new skill development.

Non-REM sleep (also termed slow-wave sleep) transitions through 3 successively "deeper" sleep levels during the night with transitioning to increasingly longer and "deeper" REM periods occurring toward morning. If the REM or non-REM cycles are interrupted multiple times through the night (either as brief, non-conscious arousals or as periods - however brief - of "full" awakening) then we may fail to reach the "deeper" periods of sleep where these "recharging events" can occur. As stated by the National Institutes of Health, "Sleep effects almost every type of tissue and system in the body – from the brain, heart and lungs to metabolism, immune function, mood and disease resistance. Research shows that a chronic lack of sleep, or getting poor quality sleep increases the risk of disorders including high blood pressure, cardiovascular disease, diabetes, depression and obesity".

Your need for sleep and your sleep patterns change as you age and this varies significantly. Babies initially sleep as much as 16 to 18 hours per day which may boost growth and development (especially of the brain). School age children and teens need about 9.5 hours of sleep per night. Generally, adults need between at least 6-7 hours. After age 60, nighttime sleep tends to be shorter, lighter and interrupted by multiple awakenings. Elderly people are also more likely to take medications that interfere with sleep. For these reasons, our younger and older county residents are considered more vulnerable in their age-related obstacles to achieve restorative sleep. In general, people are getting less sleep than they need due to longer work hours and the availability of round-the-clock entertainment and other activities. The idea of "catching up" on weekends actually never can be fully achieved.... although one may try: "sleeping-in on weekends" has been recently associated with heightened degrees of insulin resistances measures than simply returning to a normal sleep pattern.

We are a society plagued by increasing obesity (now about 40% of Americans are considered as obese with 7.7% being severely obese). The American Heart Association has now included obesity and severe obesity in children as cardiovascular risk factors. With the recent redefinition of hypertension going from 140/90 to 130/80 now >46% of American are considered hypertensive. The incidence of type II diabetes (the type related to "high" insulin levels due to acquired resistance of insulin action at the cellular level) continues to increase in incidence. Somewhere in this "modern health epidemic" is the problem of sleep quality and quantity. The 2019 Annual statistical update from the American Heart Association included a new section on sleep and cardiovascular health citing data from the Centers for disease Control and Prevention that only 65% of Americans have a healthy sleep duration (at least 7 hours).

Inadequate or disrupted sleep is the most common complaint from residents living near IWTs. It is extremely important to realize that not only does excessive audible noise cause sleep disruption but can also occur with amplitude modulation from the ILFN noise spectrum. ILFN emissions can travel up to 3-4 km from IWTs to a household given certain wind and atmospheric conditions. Sleep is "disrupted" through both unconscious arousals and with frank awakenings - both disrupting the otherwise healthy progressions through both non-REM and REM sleep periods.

At the 1500-foot setback proposed by Mr. Clifton, **average** sound levels (expressed as Leq) will be 45 dBA (with the 2 MW IWT proposed by MAE) as measured outside the house as predicted by computer modeling. Forty-five dBA Leq means that there may be recorded peaks as high as another 6-11 dBA above the 45 dBA Leq average. Albeit much less frequent that the average value, audible sound levels of 56 dbA are possible. Of even greater concern are possible still higher noise levels yet – reflecting possible poor individual turbine siting's (with IWT clumping, in-line arranging along prevailing wind axes, intermittent turbulent wind conditions or period of significant temperature inversions and other reasons). Turbine separation modeling occurs with the IWT model stated sound power level which reflect sound production with optimal winds and not "worst case scenarios"). Testimony under oath by Wind Energy representatives have confirmed these possible noise ranges that are expected from IWT sources. It also means to achieve bedroom

levels of 30 dBA your windows will need to be closed tightly with all exterior audible sound not exceeding 45 dBA. Opening the bedroom window even a little (cracked 6 inches) for cooling or fresh air circulation will markedly increase noise entry into the bedroom - enough to necessitate IWT separation another approximately 2000 -3000 feet farther to reach 30 dBA sound levels inside.

ILFN poses an even greater threat to sleep disruption. Infrasound generally attenuates (lessens in loudness) at half the rate as does audible sound. This means that (roughly) to achieve the same reduction in noise levels for audible sound, you have to go twice as far (in setback) to achieve the same noise level with infrasound. Infrasound travels to some extent by resonating in the ground that can then easily resonate a house foundation and structures within the house - being insignificantly lessened by wall/roof insulation. Infrasound "sound travel" is frequently described as "amplifying" in the house.

Low frequency sound also attenuates at rates less than audible sound ranges - intermediately as compared to infrasound. Low-frequency noise is audible being 40-60 dBs in the 20-200 Hz range.

This would be hard to ignore without sound protection equipment (ear plugs). The sounds in that frequency range are heard/perceived by people in their beds at night when the house is otherwise quiet as "vibrations", rumble and roar. While not particularly "loud", they are perceived because in the rural residential environment there are no other noises in the community to provide masking of these low frequencies. It is for that quality of quietness and solitude that the residents chose to live there.

I Have Seen the "Face" of IWT Harm

Three years ago, while inquiring about used farm machinery, I sought out a farmer who lived nearby in Guthrie county. Arriving at his farm perched along the "Mo-Miss Divide", I was fascinated at the distracting "surging" of spinning IWTs "for miles". Greeted by the farmer, I asked him about how "he and the turbines" got along. He noted that " a lot of people had moved away, and over half of those who agreed with their easement signing now regret having done so." Looking into his face, I could see the likely signature of chronic sleep deprivation (a distinctive appearance that I can easily recognize in those sent to me for atrial fibrillation consultations who have concomitant obstructive sleep apnea). His speech was a bit halting and searching.... I asked how his sleep was and whether he thought the turbines had created a problem sleeping. Looking inward, he paused, then scanned the ongoing turbine "wind chopping" and looked down then back up at me. "I don't think so... maybe you get used to it. A year ago, I built a new bedroom addition to my house putting in the best materials I could find with 2x6 construction, thicker insulation and heavier sheathing. It made it better.....(he paused) ...but on those windy nights I can still hear and feel that pounding...." I sensed an exhausted man who had resigned himself to "deal with it". He was imprisoned on his own farm with his entire livelihood around him.

Part – 3: Wind Turbine Noise - Basics

This part contains the conventional divisions of the sound spectrum. Hz = "hertz". One Hz is equal to one cycle/second, being a unit of "frequency". The greater the Hz value, the shorter the wavelength of the propagated sound. Infrasound is very remarkable for relatively long wavelengths which occur at frequencies of < 20 Hz (cycles per second).

Infrasound: 0.1-20 Hz

Low-Frequency Sound: 20-200 Hz (The lowest key on a piano resonates at 27 Hz)

Audible sound: 20-20,000 Hz

ILFN: Term combining infrasound and low frequency sound.

Unwanted sound is termed "noise"

Weight filtering reflects the "loudness", or "sound pressure level" as recorded within a certain frequency range. They come in multiple designations with "A" filtering being, by far, the most commonly used, which is "centered around" about 1000 Hz. It captures most conversational sound frequencies but, by virtue of the filter designed limitations, is unable to reflect (quantitatively) ongoing low frequencies (such as infrasound). On the other hand, the "Z" filter is "unweighted" and a stated value reflects sound levels combined for all frequencies being measured (e.g., by a microphone).

The industrial wind turbine creates sound from multiple sources: machinery noise in the nacelle (where generator is working behind the hub), the blades moving through the wind causing "blade swish" as air moves around the blade itself, and low frequency (still audible) noise from the blades due to in-flow turbulence - often around the tower. Impulsive sound is generated in the infrasound sound (usually at frequencies just under once/second) that reflect the "blade pass frequency". It is "recognized" not as a tone but as a "cyclic pressure wave" appreciated by the inner ear. Turbines have both down-wind and up-wind designs reflecting whether the turbine blades are downwind or up-wind of the supporting tower. Both designs were very thoroughly evaluated by NASA/Boeing joint-funded investigations -

primarily associated with N.D. Kelley's work (but there were several others who also contributed) in the late 1980s. Down-wind designs were intrinsically "noisier" and led to the current commercially-used upwind designs that produce less infrasound and audible noise.
Amplitude modulation involves air turbulence around the turbine blades and noise interactions with other turbines as well as other sources.
The (3) turbine blades are attached to the hub which is at the top of the tower. These blades can be rotated at that connection changing the fixed canted blade angle with respect to the air inflow interacting with the blade edge. The blades are rotated to achieve the greatest "air purchase" which then effects the efficiency of power production. Greater blade angle rotation can cause more noise production with VERY significant amounts of 11 dBA or more.
The "character" of noise created by IWTs has been described as "distinctly annoying". At a given A-weighted level, it is far MORE annoying than airport, truck traffic, railroad or industrial noise - due to special audible and inaudible modulated and tonal (distinct - sound) characteristics. The noise is often of low amplitude and shifting in character - such noise quality resists "habituation" (getting used to) and hence dramatically can frequently, in an on-going fashion, perpetuate suffering of annoyance. Of special importance is that IWT noise can be easily appreciated at up to 10 dBA BELOW background noise.
Computerized sound propagation models are imprecise, to say the least. There are so many ongoing variables that can influence sound transmission - certainly the weather, but also terrain variations among other factors. Consultants (including Mid-American Energy) claim to have very sophisticated modeling equipment (which they may have) BUT their siting of IWTs in adjacent Adair county (in rows, spaced closely together, particularly at short distances to inhabited residences (500 meters) is prone to calculational noise level errors. Errors in models of IWT noise propagation located on flat terrain have shown to have errors of 5-10dB when studied by independent acoustical engineers. A sound level of 10 dB above an estimate represents a roughly doubling of the perceived "loudness" of a noise.
Of great importance at the initial public courthouse presentation by MAE was the **absence** of a stated sound level that MAE was trying to not exceed (they only had a setback distance on their original Madison County "variance" request). Matt Ott, (apparent MAE engineer) with great imprecision at the time of variance request presentation stated (with hesitation and implied uncertainty) that noise levels at the "the front door of an occupied residence would be 45 dBA (Leq) and that it would be "safe".
"Worst Case Conditions" (to this writer) should represent the highest (loudest) sound levels ever heard/recorded at the receptor, e.g. property line. A lot of these "discrete, infrequent" episodes may occur at night during higher winds as can be associated with wind shear, temperature inversions or other events. Typical computerized calculation of sound levels is from the stated "sound power level" of a given turbine model. That rating, in terms of loudness, is done with steady winds. Such characterization of rated sound production is significantly lower than what could be produced by the IWT during periods of wind shear, blade angulation, or to other, not-infrequent "worst case scenarios".
I believe that IWT siting should be within 5 dBA of the worst possible noise levels that could be experienced and that level should be signified as a Lmax sound level. Any proposed wind farm "siting map" should state all assumptions and predict worse-case scenarios within 3 dBA. If they are not certain, turbines and residences should be more widely separated to avoid noise compliance penalties.

Part - 4: IWT Sound Emissions, Types -

Wind turbines produce infrasound along with low-frequency and audible noise. The more powerful the wind turbine, the greater the proportion of infrasound and low-frequency noise that is emitted.
Sound with frequencies below 20 Hz is labeled as infrasound. With its initial (historical) "labelling" it was described as not being able to be heard, but with greater scientific investigation, it actually **can** be heard at the higher end of the 20 Hz zone while "perceived" at the lower portions provided the sound pressure level is sufficiently high. The sound is perceived with the ears usually giving a feeling of pressure at the eardrums. Infrasound at an audible level is usually found on the car deck of a ferry and when driving a car with an open window. Infrasound is most often associated with sound at other frequencies, so the experience of listen to "pure" infrasound is uncommon.
The recent rapid introduction of IWTs into rural residential locations at close siting to resident structures of increasingly larger IWT for the purposes of larger energy production per turbine has been without ANY efforts by Wind Energy (as I can see or should have been told) to ensure public safety. These larger-sized turbines with reported production capacities of up to 4.8 MW have similar sound profiles - particularly in the infrasound range BUT produce sound levels that are higher along the ILFN sound spectrum. It has been pointed out by multiple acousticians (Moller, Kamperman) that the levels of sound (loudness in dBs) increase by 3-5 dB for every MW of electrical power generating capacity.

Wind Energy disputes that IWTs produce little, if any, appreciable infrasound. As stated, originally, acousticians were taught that human thresholds for hearing were much lower (i.e. unable to detect) than the typical sound levels produced by IWTs. A lot of scientific and peer-reviewed data has changed that original understanding. In all my readings, I have seen zero rebuttals, comments, critiques or expressed outrage by Wind Energy to any of these newer concepts as collectively they further challenge a fundamental tenant Wind Energy: denial of adverse health effects of ILFN.

1) In the 1970s, structures within the inner ear that allowed low frequency detection were recognized
2) In the 1980s, it was recognized that inner and outer hair cells possess dissimilar mechanical properties. Alec Salt demonstrated that the outer hair cells can be up to 40 dB more sensitive than the inner hair cells at 1 Hz.
3) Original hearing thresholds were defined by recognition of "pure tonal" sound whereas the real-world IWT sounds are more impulsive and varied. As the human ear "reaches" to embrace detection of IWTs, noise recognition can extend another 10-perhaps 15 dB lower.
4) Additional enhanced hearing detection in "some individuals" may extend another 10-12 dB lower.
5) Unique (but clearly demonstrated in "sensitized" individuals) capabilities of hearing or perceiving "socalled harmonic peaking of the blade pass frequency" during "heavy winds" has been noted and has been personally recognized by prominent acousticians.
6) Additional "sound recognition" through heightened tactile detection of vibration is possible
7) Finally, very recent demonstration of "brain recognition" yet not "cognitively perceived" infrasound has been documented during "functional" MRI imaging as seen with activation of "key autonomic brain centers" during sub-thresholds infrasound stimulation. (Max Planck Institute, 2019)

The full extent of our body's recognition of infrasound IWT emissions is incompletely characterized but as IWT noise is more "annoying than traffic, rail or aircraft noise" with these latter noise sources now associated with promoting cardiovascular disease, a reasonable and scientifically grounded individual should be very concerned about yet another environmental risk. Basner and McGuire (2018), published "WHO Environmental Noise guidelines for the European Region: A Systematic Review on Environmental Noise and Effects on Sleep". While they acknowledged the "incomplete state" of supportive research regarding IWTs and cardiovascular disease, they did comment "There is biologic plausibility that chronic nighttime exposure to relevant levels of noise can contribute to negative health consequences like cardiovascular disease". They did add, importantly, that "disturbed sleep has immediate next-day consequences (e.g., increased sleepiness, impaired cognitive performance) that may increase the risk for errors and accidents, and thus sleep deserves protection from noise even in the absence of a direct link to long-term health consequences. This is particularly concerning given the projected future decades of IWT exposure and a likely mechanism for triggering cardiovascular disease (#7 above).

In the 2018 WHO Environmental Noise Guidelines, their concern of IWT sound level exposure (based on the available research) generated the recommended reducing noise levels produced by wind turbines below 45 dBALden. No specific nighttime level was given. With "less annoying sound sources of road traffic, railway noise and aircraft noise, Lden were 53, 54 and 45 dB respectively with nighttime levels of 45, 44 and 40 dB respectively.

Low-frequency sound and annoyance are also described in more detail within Part - 4. Of particular visual intrigue is the ongoing display (Link provided) of modulated low-frequency noise presented by Dr. Cooper at a 2017 International Commission of Biological Effects of Noise. Annoyance **IS** an adverse health effect (AHE) as defined by multiple references (including the WHO) listed in the Conclusion section. Annoyance creates AHEs and with that suffering and a host of relevant health (physical and psychological) consequences. Wind Energy would argue that annoyance reflects a purely negative "attitudinal" response from the appearance, sound, financial implications and other factors that then produces the "annoyance". Such non-direct suffering by residents in windfarms has been rejected by nearly all except Wind Energy.

History - Part 5

This section is immensely important as it supports the scientific data that IWTs cause AHEs but also provides a trail to where the current harmful Wind Ordinance draft proposals originated. Also, it describes the setting where wind turbine manufacturers entered the regulation process and continue (in their protected and "facilitated" state) to introduce harmful noise into our communities.

The focus on community noise (unwanted sound) began (mostly) in the 1970s with the evaluation of low frequency audible and perceived sound associated with industrial compressors and turbines. Later, "sick buildings" were evaluated by highly trained acousticians who found HVAC installations were the source of vague complaints **with and without** noise recognition. Some of the symptoms experienced included mental tiredness, lack of concentration, and headaches were associated with reduced work performance and work satisfaction. Not all the workers complained of

symptoms or even audible rumble. It required special studies and tests developed by Dr. Leventhall and others to identify that the workers' sense of being uncomfortable or having other symptoms while in their offices was associated with the modified ILFN. These investigators convincingly showed that pulsations in the HVAC systems corresponded to times when the workers reported symptoms of mental tiredness, lack of concentration, headaches and reduced performance and work satisfaction. Importantly, subsequent research revealed a host of closely-matched symptoms that are reported by those experiencing adverse health effects from IWTs.

Apparently, Dr. Leventhall, despite his early clear research and clarification of ILFN being responsible for symptoms closely mirroring those from IWTs, in the years to follow, uniquely and inexplicably chose to develop and support Wind Energy's stance on the "benign" character of ILFN produced by wind turbines.

He became a champion and referenced leader in Wind Energy's promulgation of IWTs around the world.

Previous research had shown that at AUDIBLE levels, ILFN was able to produce physical responses.

However, many scientists and engineers assumed that inaudible levels could not cause any problems.

Indeed, Mid-American Energy (MAE) representatives in our Winterset Courthouse during the 2018 permitting process, repeated the saying "what you can't hear, can't hurt you". Many acoustical engineers were taught this as a part of their academic training regarding the perception of ILFN.

Subsequent studies by researchers such as Swinbanks, Ebbing and Ebbing's colleague Blazier, an independent acoustical consultant who worked in the HVAC industry, found evidence that SOME people responded to INAUDIBLE levels of ILFN produced by the machines.

Dr. Malcolm A. Swinbanks produced a nice review of this topic when presenting to the Australian Senate Select Committee on Wind Turbines on March 20, 2015. As noted in the previous paragraph that it is important to see IWT noise as "impulsive and complex".... mean levels of sound fail to take into account either the character of the sound or the relationship between adjacent frequency bands. He also referenced a number of reported cases in the literature where ILFN was clearly being perceived at significantly lower levels than would be assessed by such basic comparisons with the hearing threshold.

He summarized that "conventional hearing perception" is considered to take place via response of the inner hair cells of the cochlea (the sensing structure of the inner ear), but it has been shown that the cochlea outer hair cells respond with greater sensitivity at very low frequency, and induce additional neurological signals. Hitherto, these outer hair cells have been considered to perform only the task of controlling the overall sensitivity of the hearing process, but it is possible that they can also contribute directly to very low frequency perception". He continued with "a further mechanism has been proposed, whereby sound pressures acting through the lymphatic fluid directly on the otolith components of the vestibular (balance) organs have been calculated to exert comparable forces to those induced by motion and acceleration. Any non-uniformity in the compliance of the structures supporting these otolith sensors may then result in a response which is that of physical motion.

Indeed, it has been argued that the correlation between persons who suffer from motion sickness and those who report adverse effects from wind turbines is sufficient to be more than a result of mere chance". Of note is that a resident from NW Madison County, who turned west onto I-80 was faced by a horizon of revolving turbine blades. She soon thereafter felt sick, nauseated and vertiginous enough to be forced to stop her car on the side of the road, attempt to recover, and then proceeded off at the next exit.... eventually recovering upon exiting the turbine field. That same sensation has been noted by others with the above mechanism likely explaining her symptoms.

The U.S. government has known about health effects of infrasound and low frequency noise from wind turbines since 1987. It was concerned enough to commission a study. The study was a research project funded by the U.S. Department of Health, Contract No. DE-AC02-83CH10093. Among many impressive scientific papers, was the following: Dr. N.D. Kelley, Solar Energy Research Institute, Golden, Colorado: "A proposed Metric for Assessing the Potential of Community Annoyance from Wind Turbine Low-Frequency Noise Emissions" Note: "Community Annoyance" is now called Wind Turbine Syndrome;

"Low Frequency" includes infrasound; "Emissions" includes noise and vibrations.

Kelley et al, concluded: "...one of major causal agents responsible for the annoyance of nearby residents by wind turbine noise is the excitation of highly resonant structural and air volume modes by the coherent, low frequency sound radiated by large wind turbines. Further, there is evidence that the strong resonances found in the acoustic pressure field within rooms actually measured indicates a coupling of subaudible energy to human body resonances at 5, 12 and 17-25 Hz, resulting in a sensation of whole-body vibration." Additional investigation by Kelley, found that turbines radiated their **peak** sound power (maximal "SPL" or "loudness") in the infrasound range, typically between 1 and 10 Hz.

Annoyance was the result of a coupling of the turbine's impulsive low-frequency acoustic energy into the structures of homes and that the annoyance was frequently confined to "within the home itself".
In Kelley's and in three other investigators work, the studies report similar findings, namely that perception, generally is non-auditory in character, begins when the rms SPLs (loudness) of the modulating tones that are as low as 35 dB rms with increasing impacts as the rms levels rise to 50, 60 and to 70 db and higher. In all these studies the dynamic modulation of the blade-pass tones produces pressure peaks that are often 10 dB or more greater (sometimes much more), than the rms values.
I would strongly recommend that this link be opened (find listed in part 5) and the history of the recognition of infrasound and its potential for adverse health effects was first described by N.D. Kelley and how it was "forgotten or intentionally overlooked". Despite the recognition of potential human harm, this information was discarded by Wind Energy and specifically by the turbine manufacturer, Vestas, the manufacturer of turbines proposed for installation in Madison County.
Two primary researchers, Hubbard and Shepherd (1990) (30 years ago), reported the following:
1) Wind turbines produce primarily infrasound and low-frequency sound.
2) Sound propagates from IWTs at a decay rate half that of common (audible) "point" sources
3) IWT noise travels farther than other sounds.
4) IWT noise will be a significant indoor noise problem due to room resonance and a dominance of ILFN acoustic energy.
Fifteen hundred (1500) feet was the distance (in the original Mid-American Energy (MAE) request for siting of IWT from rural residences for the proposed Arbor Hills Wind Farm. At none of those initial and none of the subsequent follow-up meetings at any level was there a description of how that distance was proposed, how long it had been in use nor ANY description about the human health implications of that distance. Otherwise, in the written proposal, there was no listing of the anticipated noise exposure level to residents. Some of the presenting MAE representatives were not clear as to which model of IWT was planned for Arbor Hills (i.e. suggesting they do not link MW -rating with sound level productions). The only mention of noise levels incurred by the IWTs was the verbal comment (during the meeting) by Matt Ott (MAE) that he anticipated no more than 45 decibels at the front door of an occupied residence. He claimed that it was a safe level. Fifteen hundred feet setback was the only specification in not only Madison County's proposals but also that of Adair County and any proposal IWTs that I have seen for Iowa. So where did it come from?
Noise regulation in the United Kingdom was "originally" via the British Standard BS4142 (described as "method for rating industrial noise affecting mixed residential and industrial areas"). A document described as the Planning Policy Guidance 24 (PPG24) was generated in the UK that outlined some of the main considerations which local planning authorities should take into account in drawing up development plan policies and when determining planning applications. PPG24 provides advice on how the planning system can be used to minimize the adverse impact of noise without placing unreasonable restrictions on development or adding unduly to the costs and administrative burdens of business. The document introduced the concept of noise exposure categories (NECs) ranging from A-D for residential development and recommends appropriate levels for exposure to different sources of noise. A proposal for residential development needed a determination of which NEC categories would be operative also taking into account both day and night-time noise levels. The PPG24 takes into account the recommendations of the Noise Review Working Party which reported in October 1990. PPG24 - 1994 recommended using the British Standard BS4142. This regulation was formulated to assess facility external noise (outside at a property) based on the likelihood of complaints.
Background noise levels (LA90) should be measured. Source-specific noise levels (rating level) are then obtained from manufacturer's data or measured in situ. The background noise level is then subtracted from the Rating Level. If there is likely to be a tonal content or "specific character" to the building services plant noise then a +5 dBA correction is applied to the Rating Level. This assessment method is only applicable to external areas. Assessment of excess value:
1) A difference of around +10 dBA or more indicates that complaints are likely
2) A difference of around +5 dBA indicates a marginal significance of complaint.
This is the same formulation as used in the United States ... as in the ISO TC/43.
This BS4142 regulatory limit was based on reasonable likelihood of complaint generations was too restrictive for IWTs **as wind turbines have no noise control options except greater distancing**. Other industrial facilities don't have this problem, because they can enclose machinery in buildings, use mufflers, duct wrapping, etc. As such, Wind Industry had to come up with a "guideline" that raised background noise levels with the definition of 'LA90 -10 min' and convince U.K. regulators to use that guideline instead of BS4142. (Unfortunately, the LA90-10min measurement

is effective for broadband noise such as traffic noise but not when measuring intermittent noise as produced by wind turbines). And that is exactly what they did as they developed ETSU-97. BS4142 continues to be used for industrial permitting and apparently remains a thorn in the side of consultants working to permit wind turbines and promote more noise in rural areas.

ETSU-R-97

ETSU-97 is a set of guidelines and not a set of regulations. The acronym stands for "Energy Technology Support Unit". **The ETSU working group was formed by the British Wind Energy Association for the purpose of preparing wind energy friendly guidelines and research.** In that capacity, it worked on behalf of the Department of Trade and Industry (DTI); generally, with no independent oversight and no transparency. "The Assessment and Rating of Noise from Wind Farms" was published in 1997 and remains the UK government's preferred method of assessing wind farm noise for planning purposes.

Rick James (in his article "Wind Turbine Infra and Low-Frequency Sound: Warnings signs that Were Not Heard") described the "inadequate" design of the ETSU-R-97 which was a "guideline only" for the UK that was developed specifically to circumvent more science-based UK regulations that were more restrictive to IWT placement. The guideline was developed by the Working Group on Noise from Wind Turbines which consisted of several acoustical consultants with ties to the wind industry in the UK, representative of companies or their attorneys involved in or with the wind industry, several representative of local governments and the chairman, who represented the government's Department of Trade and Industry (DTI).

The introductory comments about ETSU's purpose to "offer a reasonable degree of protection to wind farm neighbors without unreasonable restriction on wind farm development" has been met with near universal worldwide contempt (as also occurred in Madison County during a joint writing session with the Supervisors) as the guidelines should not provide the justification to impose greater levels of wind turbine noise intrusion than would be permitted by other forms of development (or which could still produce human harm to nearby residing residents).

ETSU-97 compares the turbine noise with a level 5dB above background noise, but when background noise levels are low (particularly in rural areas), it sets a higher lower limit. The day time lower limit can be anywhere between 35 and 40 dBA and the night time lower limit is 43dBA. The most bizarre result is that night time background noise level can be "assigned" up to 8dBA more than the day time noise. No other standard anywhere in the world has a night time limit higher than a day time limit.

There are a host of other concerns listed in Part-5 that are reviewed. Others, such as method of background noise measurement techniques, also exist but are complicated to explain.

It appears that the ETSU-R-97 was produced to permit introduction of wind farms into inappropriate low background noise locations where they and other comparable industrial installations could not meet planning conditions derived from the long established BS4142. It could be reasonably supported that the Department of Trade and Industry (DTI) worked with the British Wind Energy Association that formed the ETSU to develop "fuzzy-science" based guidelines. I would view this as "pseudo-science to support policy, NOT policy to support science". The ETSU is lengthy and complicated - intentionally so - and contains assumptions and omitted critical considerations. These included, among many, the existence and (already described) risks of ILFN and amplitude modulation, and allowed night-time audible sound levels to exceed those of daytime limits - all based on assumptions of background noise level changes at night associated with increased wind speeds. These guidelines were adopted and have remained largely unchanged over the last 23 years despite enormous increased understanding of IWTs physics and health effects.

After being informally adopted (but not approved as regulation) by the British government, British acousticians Hayes and later Leventhall were pivotal in the adoption of the ETSU-R-97 tenets - particularly to former British colonies (Australia, New Zealand) - being presumably sent to establish control of the narrative and establish a template that the local firms could subsequently use for other wind energy projects. Leventhall formally started his pro-Wind energy work when he became a spokesperson for the British Wind Energy Association in the early 2000's after Dr. Van den Berg published his thesis "The Sound of High winds" and two other papers that observed wind turbine blades create pressure pulses as the blade passes the tower. For the next 15 years, reportedly at the request of industry trade groups, Leventhall and others organized "international" wind turbine noise conferences where research was promoted and reviewed that reflected the Wind Energy vision. Hayes (British acoustician) apparently consulted on a project in New York state in the mid-late 2000's where working with US consultants reportedly "borrowed ETSU concepts" to get their projects approved in later projects. Those "templates" reportedly initiated by Hayes were "used around the world" being only changed to accommodate regulations. It is highly likely that such "original" language perpetuates to this day; with the various "Wind Energy Associations" sharing the recipe to Wind Energy Industry – a great many of whom sit at the Wind Energy boards.

Meanwhile, interest and evolution of power production through wind conversion energy systems continued with continued evolution of turbine size to accommodate higher production capacity and progressive interfacing into rural residential areas of the U.S.

Madison County Supervisor Aaron Price stated, in a prior county meeting, something to the effect that the Federal government would not have allowed IWTs to become so "widespread" if there was some inherent risk to human health. The unspoken fact is: There is **NO** regulation of IWT by the federal government. This fact, in the course of my reading, remains completely unaddressed by Wind Energy: they get to define if IWTs are safe or not and convince local counties in Iowa that they are OK. They have found that financial incentives seem to facilitate adoption of IWT placement - both for the landowners and the county tax rolls.

The U.S. Environmental Protection Agency (EPA) created the Office of Noise Abatement and Control (ONAC) following enactment of the Noise Control Act of 1972. In 1981, Congress agreed to the Reagan Administration's proposal to cease funding for ONAC. Congress, however, did not repeal the Noise Control Act when it eliminated ONAC's funding.

Before its elimination, ONAC engaged in a wide variety of activities to abate noise pollution under authority of the Noise Control Act and, after 1978, the Quiet Communities Act.

The Quiet Communities Act of 1978 amended portions of the 1972 Noise Control Act to require coordination between federal agencies on noise control. It was intended to speed up FAA response to noise regulations proposed by the EPA and required the FAA to provide the public with a detailed analysis of EPA proposals. These included identifying sources of noise for regulation, promulgating noise emission standards, coordinating federal noise research and noise abatement, working with industry and international, state and local regulators to develop consensus standards, disseminating information and educational materials and sponsoring research concerning the effects of noise and the methods by which it can be abated. It also authorized the EPA to provide grants to state and local governments for noise abatement.

The EPA ceased most noise abatement activities after ONAC's funding was eliminated. There is still some minimal enforcement in the area of airport noise. Responsibility for the enforcement of EPA's railroad and motor carrier emission standards was shifted to the Department of Transportation.

Since defunding ONAC, federal noise emission and labeling standards have not been subjected (best I can find in the internet literature) to critical evaluations despite the evolution of relevant science and technology and a better understanding of the effects of noise on people. The EPA has been unable to provide technical assistance to state and local governments or to participate in private, standard-setting efforts. State and local governments have been preempted from adopting their own noise emission and labeling standards that differ from EPA standards for sources or products that EPA has regulated.

Apparently, there were never any EPA standards or regulations for industrial wind turbines. State and local governance has had to pick up that protective effort... but as said many times... without funding or other vital resources to do that. Specifically lacking are technical resources and highly trained engineering specialists to understand the science of industrial wind turbine sound emissions and interpret and stay current with the rapid explosion of our understanding of those sound emissions causing adverse health effects. Unfortunately, relying on Wind Energy and the Wind industry for objective knowledge and guidance in protecting human health has never happened. In my opinion, executing their agenda has, by necessity, eliminated their concerns of protecting human health.

Currently, control/monitoring of IWTs is mostly at the county level (as it is in Iowa). However, in some states, it is regulated at the "state level". Such governance levels lack the funding and personnel resources to adequately protect threatened residents. Over the past twenty years, the wind industry has presented "their" evidence implying that IWTs are "safe" near people's home. Yet the reports of nearby residents suffering annoyance, sleep disturbance and the consequences of chronic nonrestorative

sleep and body/vestibular responses have been received from people living within 2 or more kilometers of IWTs not only located in this country but in countries around the world. Responding to this suffering of the affected residents, individual scientists and acoustical engineers, citizen groups, national and international action groups have developed to counter the "effective playbook" developed in the wake of ETSU-R-97's acceptance and current twisted/mis-information provided to the targeted "unsuspecting" residents by Wind Energy and their industry developers.

Aside from individual acousticians and appropriately trained independent engineers and researchers, most of the safety information is provided to that governance level by Wind Energy and its paid promotional entities including the Iowa Environmental Council among many others.

Part – 6: Adverse Health Effects

This aspect of IWTs has been the focus of this entire review. Part 6 is quite lengthy with many studies being reviewed or summarized; there are many details that are worth reading. The first part reviewed Dr. Robert Thorne's 2012 study (Australian) as well as some of the concepts from his "textbookequivalent" (2014). It is important to recognize that annoyance (all forms) are adverse health effects.

Adverse health effects can "arise from extreme psychological stress from environmental noise, particularly low frequency noise with symptoms of sleep disturbance, headache, tinnitus, ear pressure, dizziness, vertigo, nausea, visual blurring, tachycardia, irritability, problems with concentration and memory, and panic attack episodes associated with such sensations when awake or asleep. More serious harm to health occurs when, related to the presence of IWT noise, residents suffer recurring sleep disturbance, anxiety and stress. Thorne's review suggested that 5-10% of the individuals in the vicinity of a large wind farm will experience serious harm to their health. That AHE prevalence was generated on his study of residents living at an average distance of 1400 meters which is three times farther than the distance proposed by Madison County supervisor, Phil Clifton. Within Thorne's study, the observed markers for serious health effects were noted with wind farm noise: 1) 32 dBA Leq or more OUTSIDE the resident and 2) if it is perceived or heard in any form inside the house. He defined "serious harm" if 1) the resident is obliged to remove themselves from the exposure in order to mitigate the harm 2) if three serious AHEs are present as listed as a state of constant anxiety, anger and helplessness and having abnormal "scores" from validated sleep and mental health surveys.

Many pieces of information are included, briefly:

Dr. Daniel Shepherd described Wind Energy's actions to deprive a resident of his health also extend to his well-being, quality of life and amenity.

Dr. Hanning commented on sleep disturbance (which I too have seen in patients presenting with heart arrhythmias and obstructive sleep apnea), that "inadequate sleep has been associated not just with fatigue, sleepiness and cognitive impairment but also with an increased risk of obesity, impaired glucose tolerance, high blood pressure, heart disease, and depression". Sleepy people have at least a doubling of their risk of traffic accident related mortality.

Dr. Michael Nissenbaum declared a "high probability" of significant AHEs for residents living within 1100 meters and a significant risk of AHEs in a significant subset of people living out to 2000 meters from an IWT. (Mr. Clifton has proposed 500-meter separation from IWT to residence).

Dr. C.V. Phillips in testimony before the Wisconsin Public Services Commission summarized that there is ample scientific evidence to conclude that wind turbines cause serious health problems for some people living nearby. In addition, he commented on the observation of people vacating their home being an "exposure-disease" combination. Furthermore, 'the (Wind Energy) reports that claim that there is no evidence of adverse health effects are based on a very simplistic understanding of epidemiology and self-serving definitions of what does not count as evidence. Though those reports probably seem convincing (on first appearances), they do not represent proper scientific reasoning, and in some cases the conclusions of those reports do not even match their own analysis".

McBride, et al (2014) found that some people living near wind farms had a lower quality of life than others due to increased levels of stress and poorer sleep. It also became apparent that the objective manifestations of health effects associated with noise-related annoyance may emerge after some years of exposure.

Schmidt (2014) produced a particularly "interesting" characterization about sound levels: "....at present, it seems reasonable to conclude that noise from wind turbines increases the risk of annoyance and disturbed sleep in exposed subjects in a dose-response relationship. There seems to be a tolerable limit of around Leq of 35 dBA. MY COMMENT: Why is the resident required to "tolerate" a detectable noise level? Toleration implies ongoing annoyance which, in itself, an AHE. The audible noise threshold (known for at least 20 years) is 30dBA as a Lmax, i.e. "shall not exceed" discrete sound limit. 32 dBA Lmax and above disturbs sleep which causes adverse health effects.

The remainder of the section reviews annoyance, low frequency noise related AHEs and infrasound recognition and AHEs. The latter two are felt by some investigators to be even more annoying than audible sound and potentially more concerning for serious adverse health effects.

Cardiovascular Disease:

(Some of this was reviewed in the prior section)

The World Health Organization in 2018 produced a document reviewing impacts from environmental sources. These focused-on road traffic, rail and air traffic and included wind turbine and leisure noise sources. The WHO data review boards measured 3 critical health outcomes of cardiovascular disease, effects on sleep and annoyance. Cardiovascular disease could lead to more severe disease and/or mortality and both sleep and annoyance may be in the causal pathway to cardiovascular disease. The data directly from available IWT exposure studies is considered "conditional" with

available studies not being of sufficient "power" to currently consider the evidence to be "strong" enough to include IWT noise. NONE of the available data suggested otherwise. Notable is that wind turbine noise has been described as having a character that makes it far more annoying and stressful than other sources of noise at the same A-weighted level, including traffic and industrial noise. Additionally, Thorne, has pointed out that human perception of noise is based primarily on sound character rather than sound level, and that wind turbines are unique sound sources that exhibit special audible and inaudible modulated and tonal characteristics.

Particularly noteworthy are the WHO recommendations to policy-makers to reduce exposure from wind turbines in the population exposed to levels of 45 db Lden. Other forms of environmental noise which also had recommended noise levels were:

Aircraft: 45 dB Lden, 40 dB Lnight

Railway: 54 dB Lden, 44 dB Lnight

Road Traffic: 53 dB Lden, 45 dB Lnight

Industrial Wind Turbines: 45 dB Lden - nothing specified for night given inadequate data to allow a recommendation.

The review data committee conditionally recommended that policy-makers implement suitable measure to reduce exposure from wind turbines in the population exposed to levels above the guideline values.

Given the current strength of available data, those sound level noise limits above are state in L"den" which means day, evening and night are set to hopefully avoid significant cardiovascular disease caused by environmental noise. Note that IWT level is equal to the aircraft level and much lower than railway or traffic noise. Lden is a "European 24-hour metric" with 5 and 10 dBA penalties for noise levels for evening and night respectively. A Lden of 45 dBA is approximately 38 dBA Leq that would imply (through normal calculation of Lden to Lnight - not specifically stated) a Lnight of 35 dBA Leq.

The reported guidelines were published by the WHO Regional Office for Europe. In terms of their health implications, the recommended exposure levels can be considered applicable in other regions and suitable for a global audience, as a large body of the evidence underpinning the recommendations was derived not only for European noise effect studies but also from research in other parts of the world - mainly America, Asia and Australia.

Under Part - 2 Sleep, I reviewed two more studies (that were published in 2019 - after the 2018 WHO report) that correlated sleep duration with cardiovascular disease presentation and with the development of asymptomatic cardiovascular disease (ultrasound-measured atherosclerotic vascular disease burden) These were large studies that linked sleep duration with disease endpoints without consideration of mention of sound levels, specific noise sources. Both of these studies initially appeared in "Cardiology Today" in February 2019 and were explained under the title of "Sleep: the new frontier in cardiovascular prevention". Both studies have been published in prominent cardiovascular journals.

We know (as described in Part-2), that sleep is a required body function to restore and maintain normal health. It is much more complex than a set minimum duration but is composed of a complex set of stages (characterized as "architecture") through which sleep progresses to achieve specific organized neural activity (brain waves) during which memories are laid down, and metabolic by-products are removed - all in preparation for the "the next day".

Stress (also termed allostatic load and caused by a variety of factors - sleep disturbance, annoyance - at various levels/sources) may interfere with "wholebody" health through chronic autonomic activation in mostly the "fight-or flight" (i.e. sympathetic) limb of an otherwise balanced and freely "oscillating" shift of the sympathetic and parasympathetic limbs.

Sleep duration in the studies above WAS associated with measured objective adverse cardiovascular endpoints. Obstructive sleep apnea has been associated with increased cardiovascular disease endpoints as has inhalation of very small particle sizes, post-traumatic stress disorders and an increasingly number of "chronic disease states". As described in the May, 2014 Journal of the American College of Cardiology, "Dysregulation of this system (autonomic) due to aging, acute and chronic stress, organic and idiopathic and other causes contribute to cardiovascular pathology, including hypertension, ischemic heart disease, arrhythmias and congestive heart failure and often contributes to fatal outcomes".

For the purpose of providing evidence of an existing framework through which autonomic dysregulation operate, I briefly described the mechanism involving the renin angiotensin aldosterone system (RAAS) and included a description of chronic stress and Endothelin-1 which is a vasoconstrictor agent that is integral to stress-triggered disease states. I also reviewed the complex relationship of obstructive sleep apnea (and associated chronic higher sympathetic tone) and the development of cardiovascular diseases.

Part - 7 Additional Topics

The Nocebo Effect, in my mind may be Wind Energy's most original piece of "science", however has no relevance to chronic annoyance associated with IWT exposure. The WHO has completely rejected any relevance of the Nocebo effect. The Wind Farm Noise textbook pronounced Wind Energy's literature "claiming to prove that all adverse health effects are a result of a nocebo effect" is based on suspect data. A fair and thorough critique of the nocebo effect also appeared in the Punch and James review article. They reviewed the Chapman, Crichton and Taylor studies and pointed out multiple shortcoming and improbable conclusions. They concluded that "we believe that while psychological expectations conceivably can influence perceptions of the effects of wind turbine noise on health status, no scientific studies have yet convincingly shown that psychological forces are the major driver of such perceptions. Punch and James believe those drivers are the physical stimuli themselves and the internal physiological reactions they induce. There exists a range of noise sensitivities across a population of people; there is NOT a precise and specific noise threshold for sound sensing for all people. People respond differently to different sound types and sound levels. This simple fact of normal human "variance of phenotype expression" (...everyone is a little different) is almost always missed or is unknown by most people. At the series of three Supervisor "town hall" meetings requesting public opinion about IWTs, many "pro-wind" individuals (who lived in the Macksburg Wind Farm) provided oral testimony saying that there was no danger from wind turbines as they were unaware of any problems they had noticed and that they could work all day and were not bothered by turbine sound. They also commonly mentioned that they "had no trouble sleeping". Such testimonies represent the "lucky ones"(....so far) as well as well-known auditory responses involving background noise levels, etc. Minor degrees of annoyance could include up to 30% of individuals where IWT siting is within 500 meters of a house. Such interpersonal differences do not reflect that IWT noise recognition is more emotional-based or subjective or easily ignored or in any way "contrived".

"Human rights and social justice" reflect upon and reviews the loss of respect that we have for our neighbors that are "forced" to endure chronic IWT noise and frequently become victims of its annoyance and adverse health effects. A very recent article (Krogh, et. al., published June 28th, 2020) on why residents evacuate their homes provides intimate connection to their perceptions of imposed injustice. One resident asks "why is it the responsibility of the potential sufferer to prove the proposed adverse health effects rather than the initiator of the risk to adequately demonstrate the absence of health consequences prior to initiating the risk? Affected residents rightly ask why they are considered "expendable". Current turbine approval practices violate the "precautionary principle" that would require that a particular industrial activity not be undertaken unless there is no doubt that such an activity will not harm any people. Again, my recurrent statement to Wind Energy: Industrial Wind Turbines have never been proven to be safe. No response - which is their response when they have nothing to counter that statement (and they hope the question eventually just "goes away").

There is a review of vulnerable populations in a very complete review of acoustic considerations for schools and other learning environments. The WHO and ANSI (American National Standards Institute) talk about the concerns of a noisy classroom, noting that a signal to noise ratio of +15 dB (i.e. speech signal is 15 dB louder than the background noise) is needed to optimize classroom communication.

Since 50 dBA is the sound pressure level of normal speech, room noise levels of 35 dBA or more interferes with the intelligibility of speech in smaller rooms. Mr. Clifton and Price believed that school room sound levels in West Des Moines were possibly 45 dBA. Of particular relevance is that "learning" goes on at home as well as in schools. In addition, high quality, restorative sleep with more sleep time needed by developing children - a critical part of health brain development - is needed when children return home. Such "brain development" may be affected by neuro-cognitive impairment from inadequate sleep.

Of substantial importance to the "healthy growth" of Earlham or any other town will be "room" to grow at outward from the current town margins. Please see my suggestion in that section.

Cardiovascular disease remains the leading cause of death in the United States - unfortunately that trend is increasing over recent years. The decrements in cardiovascular outcomes have been worse for people living in rural counties. Madison County is considered a rural county without an urban core.

There is now at least a 20% disparity with rural counties having a worse death rate as measured by "excess death rate" per 100,000. Data from the 2017 CDC showed a 40% higher prevalence of heart disease among rural residents - a gap that has grown over the past decade. Rural areas have higher rates of uncontrolled traditional cardiovascular risk factors compared with urban areas. There are other listed "sobering" facts. Placing annoying/sleep-depriving industrial wind turbines in rural populations seems particularly cruel and insensitive as the additional negative health (physical and mental) consequences of IWTs on rural populations will likely be much worse in that population with already worse existing cardiovascular disease.

I reviewed some thoughts about electricity costs, decommissioning costs, blade disposal, minimal recycling potential "realities", shrinking turbine warranty periods, and the usual practice of placing IWTs in close proximity to residents to essentially guarantee "resident outrage and annoyance". Current practices by MAE reliably invite litigation which should be seen as a "replacement of science and a failure of leadership".
Blade throw has been mentioned at most meetings concerning IWT placements and ordinances. A study from a university engineering department in conjunction with a Wind Energy consultant at a national IWT testing center made the follow conclusions and recommendations: setback from IWT to property line should be 2 times the overall turbine height and from IWT to residence should be 3.5 times the height. Mr. Clifton suggested 1.1- and 3.0-times height respectively without providing any source documentation for that empiric distance except to "try to get more turbines inside a section – his words".

Part – 8: Peer Review

I first describe the purpose and the execution of research undertaken (mostly in medical situations) of new products, new dosing or combinations of existing treatments, comparison of new treatment regimens to existing "current standard of care" treatment for human illness such as cancer and heart disease and a host of other human conditions. It also covers new devices - implantable insulin pumps, pacemakers, defibrillators, leads that used with such implantable devices, neuro-stimulators and many other "gadgets" in which safety is paramount and showing that the medications, treatment, device is effective. As commented, there are multiple layers of oversight from local to regional to national levels. Training of investigators and co-investigators is needed. Of particular importance is that close monitoring of "adverse events" is done and reported to the study sponsor and the local IRB (Investigative Review Board). The latter entity is charged with the protection of study subjects, acquiring informed consent from participating subjects, monitoring the occurrence and types of adverse events and making sure that death, heart attacks, bad infections and on and on.... are recognized, treated and changes to the research are made if necessary and close follow-up is maintained. The IRB has the right to "shut-down" an ongoing research study in which unexplained, or excessive amounts of serious events among other endpoints, occur.
An initial study examining potential adverse events associated with IWTs never occurred or I am sure I would've heard about it - particularly after describing it in an article I wrote for the Madisonian newspaper. I am not suggesting (because I do not know for sure), that "formal" IRB oversight for a trial designed to confirm safety should have been done but the shear amount of AHEs and the controversy and unsubstantiated claims made by Wind Energy/turbine manufacturers does demand a complete and transparent study examining health consequences. Given the amount of unreported events and uninvestigated problems associated with IWT exposure, unknown short- term vs long-term consequences of exposure and the complete (best I can tell) lack of detailed medical investigations of adverse health events by trained medical personnel in conjunction with biomedical engineers with ongoing dramatically increasing size and noise emissions outputs of new IWT models without initial and interval reassessment of human impact is (in my opinion), unethical. This is even a more dramatic omission given the rapid growth of our understanding of sleep and its importance and the environmental noise levels that trigger sleep disruption being substantially exceeded by "current accepted" practices of close siting of IWT to places of residence. Of particular concern which is essentially ignored, is the possibility of vibroacoustic disease in animals and humans occurring with resonance energy transference to solid organs. Visual complaints are not infrequent in residents in recently activated wind farms. Reports of blindness in ducks, donkeys, horses and occurrences of unexpected sudden death in farm animals, dogs and other pets has been reported by residents. Post-mortem examination on animals have found "enlarged organs". To my knowledge this has not been evaluated in formal studies. It certainly has not been reported by the manufacturer of IWTs nor energy contractors. The occurrence of these observations is not disclosed to easement participants. As I explained to our county supervisors, "I am not aware that people and their live animals are considered 'expendable' when forced to endure unwanted and uninvestigated powerful low-frequency noises".
Reading about infrasonic acoustical weapons research (where available) in the U.S. and the former Soviet Union, raises concern – particularly for more chronic (long-term) exposure at "just-less than weapons grade power levels". Remember, as the IWTs keep getting larger and more powerful, there is a progressive relative increase in levels of ILFN emissions they generate.
There is also a review of scientific processes to determine causality by properties of causal relationship. Sir Bradford Hill's work was summarized. The value of adverse health reports as related by Carl V. Phillips was reviewed. Outside critiques are included of one of Wind Energy's promoted studies that honor their view: the AWEA/CANWEA Report into Turbine Sound and Health.

Part – 9: A view toward "The Dark Side"

In this section, I listed several visions through the cracks in Wind Energy's veneer of corporate sainthood and righteousness. These primarily focus on the Danish company Vestas which is the leading manufacturers of industrial wind turbines. They are worth reading and placing into the bigger context of "why they say what they say and do what they do". I provide these as "past actions" that have happened. I do not cherish these "uncloaking`s" but, personally, they, at least, helped me understand the more important "bigger picture"... perhaps more important than "arguing decibels". Please see my disclaimers.

An exceptional "profile in courage" was a speech to Vestas Corporate by a Danish physician who (in my opinion) laid out the facts and asked Vestas to do the right thing. Powerful...

Part – 10: Carbon.... What to do.

Here I humbly present my concerns about global warming and review some of the concepts that keep me up at night - loss of biodiversity and loss of a lot of happiness.

I list what I believe are better choices for energy management in our future. I vaguely refer to "nuclear energy" as I have listened to others far brighter than I who see this as more sustainable, cleaner and, when deployed and monitored closely, much safer. What is clear and has been for far too long, is that our current ways of utilizing planet resources are simply not sustainable. I strongly believe in the environmental promise of regenerative agriculture which works to sequester atmospheric carbon particularly in Iowa. Although it has been a recognized way to farm for more than 150 years, (we) have switched to an agrochemical style farming practice (this opens up a huge area of complexity). Regenerative farming restores the CRITICAL connection between growing plants and organic soil rejuvenating processes. Others have seen this farming practice and jumped in to find extraordinary rewards. Observed phenomenal benefits of increased soil fertility through regenerated organic content of our soils are observed returning the soil back toward the complexity of pre-settlement soil architecture. Such increasingly restored soils facilitate much less carbon-producing farming practices, greater ability to retain water with better avoidance of soil erosion - the latter problem being another new reality of "Man-induced" global warming. It is truly a win-win option that we should acknowledge and pursue NOW – in Iowa and at a world-wide scale.

Part – 11: Applied Regulation of Noise

In this section, there is a focus on achieving an optimal residence sound level for achieving restorative sleep. Consideration of outside-to-inside audible sound attenuation are discussed in line with WHO recommendations. Difference of Leq vs Lmax are described and why, to protect sleep, the Lmax sound limits are much preferred. The math of decibels is described illustrating why 45 Leq as seen with a 2 MW IWT at 1500 feet from a residence will NOT achieve the recommended level of 30-32 dBA Lmax.... instead setbacks to be in compliance with those nighttime sound limit levels will require separations of 2km or about 1.25 miles WITHOUT IWT clumping or in-line siting. Anything shorter creates significant annoyance and leads to complaints, lawsuits, home evacuations and other severe adverse health effects.

Part – 12: Recommendations

In this section I included scenarios and considerations that protect the residence form annoyance and most other forms of adverse health effects. I do not believe a "compromise to permit co-existing industrial energy production that is associated with noise effects that harm residents are acceptable.

The energy developer must be willing to compensate or "buy-out" the resident if at a pre-wind farm placement appraisal price. Setbacks distances are not the primary metric of IWT siting – target receptor sound levels are THE PRIMARY determinant. Setback distances from property are important as well and should be 2 times the total height of the turbine. It is unfortunate that IWTs currently deployed have such serious health consequences at previous utilized distances of 1500 feet. Indeed 3600 feet is the shortest distance listed in the Punch and James review article and that depends on a calculated target sound level likely not possible with such large IWTs. Realistically, 2 MW IWTs will have to be >1.25 miles to achieve safe home experienced emission levels. At that distance, annoyance will be minimal and serious AHEs and litigation will be likely non-existent. Utilizing unapproved ETSU-R-97 guidelines that employ "pseudo-science" considerations for nighttime sound levels in rural residential environments with background noise levels of about 25 dBA is absurd and presents "willful abuse and unethical actions" of an energy contractor. I would like to see a maximal permissible/worst case scenario resident sound level of Lmax of 40 dBA or a Leq of 30 dBA. These are concordant with textbook recommendations and countries who have responsibly responded

to the demands of health safety and property rights. In addition, separate Lmax regulation of ILFN emission using C-weighted values is strongly suggested.

Part – 15: Conclusions

Avoiding "Adverse Health Effects" is the focus of health care. "Doctoring" in early America (simplistically) revolved around fixing bones, sewing up lacerations and delivering babies. As our understanding of disease processes and normal and diseased human physiology has exploded in recent decades, we now see applications of endless technologies to address the physical and mental health needs of our suffering fellow human beings. Recognizing and attempting to encompass all "contributors to disease" in our desire to reach "optimal health" has broadened our focus from individual disease expression to include societal factors that can trigger and exacerbate disease and limit the high quality of life we all seek. Indeed, the Affordable Care Act (whether you like it or not) as well as competitive private health plans and Medicare services emphasize "prevention and wellness".

As stated, the WHO defines health as "a state of complete physical, mental and social wellbeing and not merely the absence of disease or infirmity". This model of health considers the physiological, psychological and social factors in health and illness, and interactions between those factors. The WHO definition links health explicitly with wellbeing and conceptualizes health as a human right requiring physical and social resources to achieve and maintain. "Wellbeing" refers to a positive rather than neutral state, framing health as a positive aspiration. Health is considered as "a resource for everyday life, not the object of living". Health is a means to living well, which highlights the link between health and participation in society.

Mental health and physical health are inextricably linked: with mental health influencing physical health and vice versa. Stress responses are known to affect physiological processes regulated by the autonomic nervous system including cardiovascular, respiratory, digestive, repair and defense functions.

While it is clear that physical ill-health can be accompanied by mental health problems such as anxiety and depression, the resulting psychological state may in turn impede the recovery or stabilization of medical conditions, thus producing a vicious circle in which wellbeing is difficult to attain. All this is said to emphasize that annoyance - at almost any level - can contribute to adverse health effects. This is particularly relevant when the source of annoyance is not wanted and cannot be eliminated and leaving one's home is the only remedy.

It is important to demonstrate past recognition of "annoyance as an adverse health effect". Please see the following citations:

The 2009 WHO Night Noise Guidelines for Europe created a flow diagram of (environmental) noise exposure with high sound levels directly activating "stress indicators" including the sympathetic limb of the autonomic nervous system. Moderate noise levels were pictured to follow an indirect pathway noting sound disturbances of activities, sleep, communication producing cognitive and emotional response - described as "annoyance".

The Council of Canadian Academies (4/9/15) described their review of supportive evidence for "annoyance" to be sufficient when referring to contributions to adverse health effects.

Data from the LARES study (2006) "confirmed, on an epidemiological level, an increased health risk from chronic noise annoyance. (further) The results of the LARES study in relation to severe annoyance by neighborhood noise demonstrate that neighborhood noise must be classified as a serious health endangerment for adults".

Pedersen and Persson Way in "Wind Turbine Noise, Annoyance and Self-reported Health and Well Being in Different Living Environments" (2007) stated: "Annoyance is an adverse health effect".

The WHO Training Package states that adverse effects from noise exposure can include direct ear damage, indirect adverse effects (physiological and psychological effects) and impaired cognition....

Cognitive effects can include reading, concentration, memory and attention issues. Chronic noise exposure impairs cognitive function (reading comprehension and long-term memory) and that dose response relationships are supported by both laboratory and field studies and that "over 20 studies have reported that noise adversely effects children's academic performance".

Bakker, et al. in "Impact of wind turbine sound on annoyance, self-reported sleep disturbance and psychological distress" (2012) noted: "A dose-response relationship was found between emission levels of wind turbine sound and self-reported noise annoyance. Sound exposure was also related to sleep disturbance and psychological distress among those who reported that they could hear the sound, however not "directly" but with noise annoyance acting as a mediator. Respondents living in areas with other background sounds were less affected than respondents in quiet areas".

In 1991, Suter on "Noise and its Effects - Administrative Conference of the United States" stated: "noise has a significant impact on the quality of life, and in that sense, it is a health problem in accordance with the World Health Organization's definition of health....along those lines, a 1971 WHO working group stated: "Noise must be recognized as a major threat to human wellbeing....annoyance can connote more than a slight irritations; it can mean a significant degradation in the quality of life. ..... this represents a degradation of health..."

Michaud, et al "Noise Annoyance in Canada", Michaud is a staff member of Health Canada, Referring to the WHO definition of health, "under this broad definition, noise-induced annoyance is an adverse health effect".
(2010) Heath Canada document: "Health Canada considers the following noise-induced endpoints as health effects: noise-induced hearing loss, sleep disturbance, interference with speech comprehension, complaints and change in percent highly annoyed"
Jeffery, Krogh, Horner (2013) "Adverse health effects of industrial wind turbines", Canadian Family Physician, "noise-induced annoyance is acknowledged to be an adverse health effect. Chronic severe noise annoyance should be classified as a serious health risk".
General Purpose Standing Committee.... (2009, Australia): "...reputable research has shown that noise annoyance is an adverse health effect that can result from wind farms, as it can result in effects such as negative emotions and sleep disturbance.
Of great importance are comments from Wind Energy's principle thought-leader acoustician, G. H. Leventhall: Leventhall (2009) attributes these reported IWT symptoms as effects of 'annoyance by noise' stating, "I am happy to accept these symptoms, as they have been known to me for many years as the **symptoms of extreme psychological stress** from environmental noise, particularly low frequency noise". The effects of low-frequency noise-induced annoyance and stress from various sources have been researched".
Levanthall (2004), "Regulatory authorities must accept that annoyance by low frequency noise presents a real problem.... " and that "The claim that their 'lives have been ruined' by the noise is not an exaggeration..."
From Wind Farm Noise (textbook):
There is a considerable amount of anecdotal evidence and published research that suggests that wind farm noise does seriously and adversely affect a small but significant proportion of the population.
Nevertheless, many acoustic, social science and medical **professionals ignore this evidence by defining 'scientific evidence' in a very narrow way and then stating that there is no 'scientific evidence' available that proves beyond doubt that wind farm noise can harm anyone.**
(Writer comment: This is exactly the wording and precisely the tact that Wind Energy uses to dispute the magnitude of contrary data that I have summarized and presented here).
As pointed out by May and McMurtry (2015), there seems to be a tendency in the medical research discipline to interpret the lack of rigorous evidence of a causation link as proof that the link does not exist.
(Writer's comment: Previously, in part - 8 "Peer Review", I described the nine elements that Sir Austin Bradford Hill felt were critical in establishing causation are relevant and adequate to declare (in assessment of the data) that IWTs cause adverse health effects. Sir Hill noted that "all scientific work is incomplete - whether it be observational or experimental. All scientific work is liable to be upset or modified by advancing knowledge. But that does not confer upon us a freedom to ignore the knowledge we already have, or to postpone the action that it appears to demand at a given time. In other words, if it quacks like a duck, looks like duck and flies like a duck, (and 6 other features) ... then it is reasonable and appropriate to believe it is a duck).
There have been many hundreds of case studies that demonstrate that the health of a significant percentage of people has been affected by wind turbines. **Whether or not these adverse effects are directly caused by wind turbine noise or are indirectly caused by such things as sleep disturbance as a result of a nearby wind farm is a moot point, as either case results in the same conclusion: that is, wind turbines result in some people living in their vicinity suffering adverse health effects.**
Even further to support that wind turbines cause adverse health effects, it is remarkable (in light of the strong wording of implausibility Wind Energy carefully uses each time when proclaiming "non-causality") is that the literature that Wind Energy offers to support that phraseology, state that "IWT noise produces annoyance". Annoyance as a concept is well-established and used by both sides of the argument. The World Health Organization (and MANY other researchers) define annoyance as causing adverse health effects. Indeed, Wind Energy's "top acoustician", Dr. Leventhall, explains symptoms created by wind turbine noise exposure as consistent with his experience with low frequency noise effects he himself has experienced. Dr. Leventhall did some of the earliest evaluations of low frequency sound found in the evaluation of "noise-induced sick building syndrome". He helped to conduct the controlled tests needed to separate out the characteristics of HVAC sound associated with the reported symptoms and poor work performance (range of symptoms of HVAC were quite similar to later symptoms associated with low frequency wind turbine noise). These symptoms were linked to modulated low-frequency (and infrasound) HVAC noise.
Earlier, in 1982, Leventhall and Vasudevan published "A study of Annoyance Due to Low Frequency Noise in the Home". The abstract described annoyance leading to health problems in some cases. ... low frequencies were capable

of causing annoyance, especially when the noise fluctuated in level (Writer comment: "was modulated"). In his introduction he also commented "when the noise nuisance also involves low frequency noise, much evidence exists to suggest that the annoyance reaction to the low frequency noise is greater than that implied by the (measured) estimates of loudness of the noise. The A weighting scale... takes little account of the low frequency sound energy. This practice in industrial noise regulation often encourages machinery manufacturers to concentrate almost entirely on attenuating energy in the middle and high frequency ranges. As a consequence, modern plan and machinery - increasing in size all the time - may be making a growing contribution to the sound energy in the low frequency range. The noise could become subjectively louder although the dBA level is reduced". (These comments by Dr. Leventhall almost exactly express the current observations and concerns of industrial wind turbine noise. Again, Leventhall was a pioneer in our understanding of infra- and low-frequency environmental noise which then was "mirrored" by wind turbine noise.

Somewhere in the mid- 2000s decade he became aligned with Wind Energy- essentially becoming their acoustician scientist - and his concordance of opinion (with other peer acousticians) that IWT noise cause adverse health impacts essentially reversed without explanation).

Dr. Malcom Swinback, during his 2015 testimony before the Select Committee on wind Turbines in March, 2015, added his observation about health effects associated with wind turbine infrasound. "one of the reasons for confusion in the reporting of adverse health effects from wind turbines lies in the fact that permitted IWT sound levels in the USA are generally significantly higher than those in other countries. Whereas many countries now seek setbacks of typically 2 km, in the USA, setback of 300 - 400 meters are not uncommon, with corresponding permitted sound levels of 45-50 dBA or higher.

Consequently, there are considerably more complaints from affected residents, compared to other countries with more cautious standards. Worldwide discussion and assessment of such problems often does not make this distinction clear, with the result that there can be significant confusion as to which problems arise from these VERY CLOSE SETBACKS, and those which can still prevail at larger setbacks.

(Continuing from the "Wind Farm Noise" text): "It seems that the only type of scientific evidence that would be generally acceptable to those who do not believe that there are any adverse health effects results from wind farms, would be longitudinal epidemiological study of thousands of people with confounding factors removed, which is clearly an impossible task.... The situation is very similar to the debate on anthropogenic global warming. This too has not been proven beyond any reasonable doubt, but there is plenty of evidence that global warming is occurring and that it is a result of the activities of man. However, there are always those, who for whatever reason, will deny the patently obvious and continue to do so regardless of any evidence with which they are confronted".

In the "Wind Farm Noise" textbook, their conclusions continue...

It is time to stop debating whether or not a problem exists. It is well known that wind farm noise does result in sleep disturbance and adverse health effects for some people and the time has come to decide what to do about it. However, further research is needed to determine whether the problem is inaudible infrasound (writer's comment: or perceivable infrasound - particularly as infrasound noise levels rise as IWT power generating capacity increase) or low-level, audible low-frequency noise. (Writer comment: the textbook continued with reminding us of a "normal" (associated with a bellshaped response curve) distribution of hearing sensitivities which permits 2.5% of the population to have hearing sensitivities up to 12 dB lower than published sound "limits" and that some people have become "sensitized" over time to wind turbine infrasound. Low-frequency noise rather than infrasound may generate adverse health effects through a stress response as a result of the audible noise being annoying or depriving sensitive people of sleep. The low-frequency noise from wind farms is particularly prominent in rural residences where the ambient noise level is low - especially at night).

The Wind Farm Noise textbook continued: "Affected people find wind farm noise to be very annoying and, as time goes on, they become more and more sensitized to it, (Writer comment: rather than habituated or that their "negative attitude softens or accepts" as Wind Energy may suggest), so they become more stressed and also suffer from insomnia and /or sleep disruption. Whether the problem is infrasound or low-frequency noise is not the most important issue. The fact remains that some people are so affected by wind farm noise that their health suffers and some are forced to leave their home in order to achieve an acceptable quality of life. Thus, it is important to begin work on new noise guidelines for new wind farm developments based on maximum acceptable levels of A-weighted noise as well as acceptable levels of low frequency noise. Existing allowable levels (even the lowest of 35dBA) are too high for a significant proportion of the population who live in quiet rural area: the levels of 40 or 45 dBA allowed in some jurisdictions are well over what would be considered acceptable by most people. In addition, all jurisdictions should determine what would be a fair offer of compensation for those who have suffered ill effects, which would at a

minimum include the offer to purchase their residence at the price it would have realized prior to construction of the wind farm.

An almost identical set of concluding responses are included in the Punch and James (2016) article:

Wind Turbine Noise and Human Health in their response to Wind Energy's "blanket statement that there is no evidence in the literature to support a causative link between wind turbine noise and adverse health effects. The authors responded to this statement which is cited as factual by wind industry advocates in the literature and in legal proceedings. (In stark contrast) ... "there is an abundant literature, much of its peer-reviewed and authored by highly reputable researchers, indicating that audible and inaudible noise emitted by IWTS adversely impact the health and well-being of substantial numbers of people who are regularly exposed to wind turbines. It is clear that the literature review and papers claiming no AHEs **fail** to include important studies, international standards, guidance from the WHO, and research conducted on wind turbine noise and other sources of infra- and low-frequency sound. Whether this is through oversight or calculation, only reports that cite scientifically credible references should be considered legitimate sources of information. Our review has shown that it is unacceptable simply to state that the literature contains little or no evidence of a causal link between wind turbine noise and adverse health effects. At a minimum, those effects have been shown to be regularly correlated to living in proximity to IWTS, and there is sufficient evidence that those effects are highly associated with objective measurements of audible noise and infrasound".

The extensive Punch and James, 72-page article that included 180 references, finished with a needed "goal" of refocusing as described below: "Based on all the evidence presented, our fundamental view is that the controversy surrounding adverse health effects should not be polarized into two groups consisting of either 'pro-wind' or 'anti-wind' factions, but rather one in which there is room for a third, 'pro-health' perspective. Essentially, the pro-wind view is that IWTs should be installed wherever feasible, that definitive scientific research is lacking to indicate that turbines cause AHEs and that if you can't hear it, you can't feel it. The antiwind view is that IWTS should not be installed anywhere because wind is not an economically viable source of renewable energy, that all government subsidies and development efforts should end and that what we can't hear can hurt us. A pro-health view is that there is enough anecdotal and scientific evidence to indicate that ILFN from IWTs cause annoyance, sleep disturbance, stress and a variety of other AHEs to warrant siting the turbines at distances sufficient to avoid such harmful effects, which, without proper siting, occur in a substantial percentage of the population. That view holds that what we can't hear can hurt some of us and that the precautionary principle must be followed in siting IWTs if such health risks are to be avoided. Industrial-scale wind turbines should not be located near people's homes, educational and recreational facilities and workplaces. It is our belief that the bulk of the available evidence justifies a pro-health perspective. It is unacceptable to consider people living near wind turbines as acceptable collateral damage while this debate continues."

I too, have pursued an entire life's career to "Pro-Health" goals - in the treatment of my patients as well as my neighbors and the community that I live in. Believing that IWTs placed "in harmful proximity to places where people live and work" to represent the answer to our world's energy production is like a discovering a bottle on the beach and expecting to find a genie inside that will provide answers to our wishes. When you look at the whole picture of wind-sourced energy to be clean and renewable and provide a clear pathway to environmentally-safe energy production, you realize that there is a misdirected faith in its supposed benefits. Instead we have to look toward other answers - rapid escalation of regenerative agricultural practices to sequester (ongoing) massive quantities of CO2 back into the soil, safe nuclear energy production, tolerable placement and recyclable photovoltaic electric production, much higher standards of efficiencies of heating and (particularly) cooling and many others and always...living "within our means". Afterall, we are sharing this planet with more than 3 times as many people than is reasonably sustainable given the finite resources of our natural world.

Mathias Basner, MD, PhD, attempted to frame the latest information about potential physical harm with environmental noise in a 2019 medical journal editorial. Dr. Basner is an Associate Professor of Sleep and Chronobiology in Psychiatry. He is the President of the International Commission of Biological Effects of Noise who personally reviewed and helped to summarize the data for the Oct, 2018 World Health Organization Environmental Noise Report. In the editorial, he acknowledged the problem of smaller populations in currently available studies which make statistical powering of conclusions difficult. He has stressed that NONE of the wind noise guidelines data from the 2018 WHO raised found an "absence of risk". He finished his comments with **"the fact that more studies are needed should NOT lead us to postpone the urgently needed protection of the population from noise. The knowledge we have acquired so far IS SUFFICIENT to take preventive actions and substantiate them with respective legal noise regulation."**

Bullets:
With the possibility of adverse health effects and industrial wind turbines it comes down to:
1) We have to accept that operating IWTs do produce noise that is harmful to an important percentage of those nearby; they are not harmless "pinwheels spinning in the distance".
2) Industrial Wind Turbines have never been shown to be safe for human health with respect to developing adverse health effects - particularly with long-term exposure to turbine noise. Accepting Wind Energy's proclamation that there is no credible evidence of a causal relationship between IWT noise and adverse health effects is to deny the existence of an enormous amount of information that link adverse health effects to exposure to IWT noise.
3) There is a range of human sensitivity to hearing or perceiving wind turbine noise. This means that some people will have serious adverse health effects while some may experience none. This variance in experienced health effects, after review of the bulk of literature (per Punch, James), are the physical stimuli themselves and the physiological reaction they induce.
4) Sleep disturbance is the most frequent of the most serious adverse health effects. It is not only related to excessive audible noise level but also to amplitude modulation in lower frequencies and audible and perceivable portions of the infrasound noise spectrum. Significant disturbed sleep will lead to mild to severe annoyance suffering and may promote serious cardiovascular disease.
5) We need to recognize the heightened susceptibility of adverse health effects in vulnerable populations that live within the range of wind turbine noise emissions. Providing quiet home and learning environments for children is essential for normal brain development.
6) As recommended by a wide range of supportive literature, World Health data and recommendations, textbooks that have very thoroughly researched all aspects of IWTs including health effects, greater scientific understanding of the importance of restorative sleep and strong confirmation of a need for a precautionary approach to avoid AHEs and likely serious health outcomes, we need to act NOW to implement protective ordinances for our citizens. Such adequacy of an ordinance is judged by the resultant absence of resident complaints and initiated legal action. To knowingly inflict resident oppression that compromises health is immoral. Continued optional IWT close-siting practices done solely to generate increased financial gains for wind contractors represents a failure of leadership by both parties and intentional disregard of voluminous concordant scientific data.

Editorial

Noise: What is to be Done?

Mathias Basner

Editorial to accompany the articles
"Aircraft Noise and the Risk of Stroke: A Systematic Review and Meta-Analysis"
and
"The Cardiovascular Effects of Noise"
in this Issue of Deutsches Ärzteblatt International

Hearing loss is one of the most severe health effects of noise with 1.3 billion affected people worldwide (1). However, health effects of noise go far beyond hearing. The so-called non-auditory effects of noise include annoyance reactions of the exposed population, sleep disturbance, school children's learning impairment, and cardiovascular disease like an increased risk for hypertension and myocardial infarction (2). According to the World Health Organization (WHO), circa 1.6 Million healthy life years are lost annually due to non-auditory effects of environmental noise in the Western European member states alone (3).

Noise is defined as „unwanted sound". While the auditory effects are predominantly determined by noise level and exposure time, the circumstances of the noise exposure play a crucial role for the non-auditory noise effects. For example, patrons of a rock concert do not perceive the music as noise despite high sound pressure levels. In contrast, a person living three blocks away from the concert hall, who cannot fall asleep because of the music perceives the music as noise despite much lower sound pressure levels. Sound is often perceived as noise if one has little control over it and feels at somebody else's mercy (4).

Little doubt: Noise is an important risk factor for cardiovascular disease

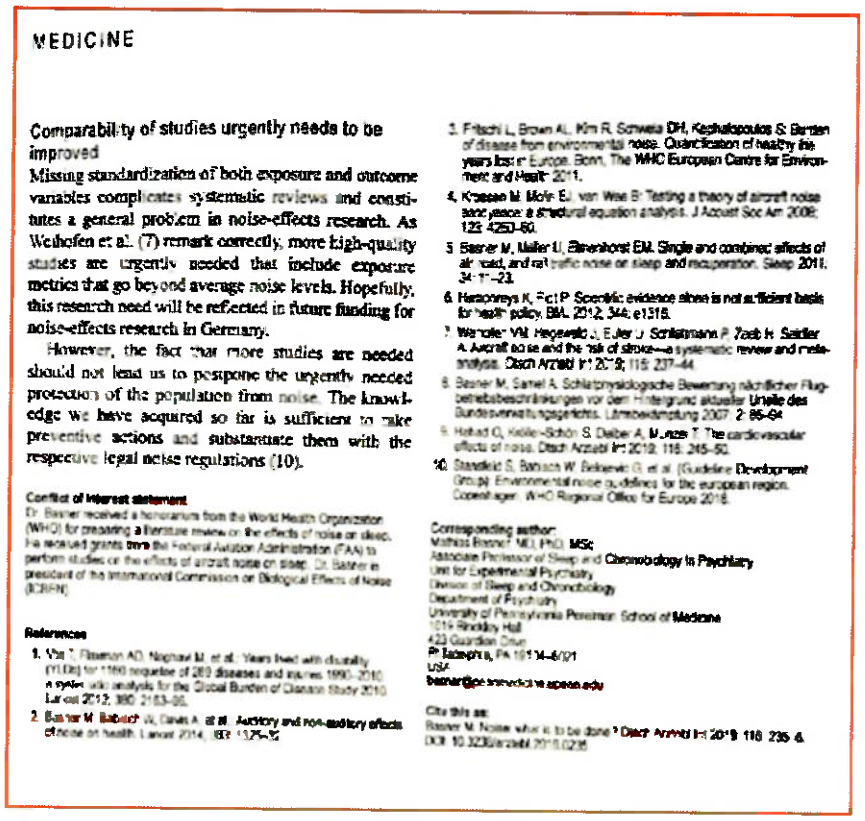
The number of studies on the health effects of noise has increased considerably over the past few years. Even if high-quality studies are still missing for many noise sources and disease endpoints, there is little doubt among noise effects researchers that noise is an important risk factor for cardiovascular disease. One may thus ask why the prevention of noise-induced health effects does not play a more important role in politics. Several reasons may be responsible.

- We habituate to many things—including noise. However, habituation is rarely complete, i.e., pathophysiological processes are still at work even if we no longer perceive noise as such (5). Similar to the genesis of many other diseases, noise effects are also the result of cumulative processes. I.e., health impairment is the result of relevant exposure over long periods of time. Humans are markedly bad at connecting our present behavior with future outcomes. All these are possible reasons for why the strain imposed by suffering from noise does not exceed a critical level in the population, and why only some affected people actively fight those responsible for the noise. Even if scientific studies constitute an important foundation for political decision processes considerable pressure from the affected population is often a prerequisite for political change (6).
- The risk increases found in epidemiological studies are often comparatively moderate. Accordingly, in the meta-analysis of Weihofen et al. (7) the point estimate for an increased risk for stroke was 1.013 per 10 dB L_{night} increase in aircraft noise exposure. Due to the large number of relevantly exposed persons even this small risk increase has public health relevance. However, the strength of an association is one of the classical epidemiological criteria for causality. The weaker the association, the greater the concern that unobserved confounders or other systematic biases could account for the observed effect. Accordingly, it is easy for those responsible for the noise emission to dismiss the epidemiologic evidence as insufficient.
- We also have a noise equity problem. Noisy areas are less attractive, less expensive, and therefore attract low-income residents with equally low political influence. This assures that noisy areas stay noisy and quiet areas stay quiet.
- Last are probably most important—noise not only produces victims: Patrons of a rock concert enjoy the music and do not want to miss out. Bikers love their loud exhaust systems. An airport is an important economic factor for a region and generates many jobs. It also brings many amenities for those who live close to it but not under the flight tracks. Thus, for each resident affected by noise another resident in favor of the noise source is quickly identified. This is why noise regulations always have to strike a fair balance (8).

At what point is loud too loud? Critical role of noise effects research

The critical question is: When is loud too loud, i.e., at what noise exposure level are the basic rights for physical and psychological well-being violated? Noise-effects research plays an important role here. Reviews like the ones on the following pages can help evaluate the results of multiple studies. The review of Hahad et al. (9) shows that, despite some limitations, our knowledge on the cardiovascular health effects of noise has increased substantially since 2007. However, the quality of the studies could often be better. Accordingly, Weihofen et al. (7) assessed the quality of the studies contributing to their state-of-the-art meta-analysis as average to low.

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MEDICINE

Comparability of studies urgently needs to be improved

Missing standardization of both exposure and outcome variables complicates systematic reviews and constitutes a general problem in noise-effects research. As Weihofen et al. (7) remark correctly, more high-quality studies are urgently needed that include exposure metrics that go beyond average noise levels. Hopefully, this research need will be reflected in future funding for noise-effects research in Germany.

However, 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 the respective legal noise regulations (10).

Conflict of interest statement

Dr. Basner received a honorarium from the World Health Organization (WHO) for preparing a literature review on the effects of noise on sleep. He received grants from the Federal Aviation Administration (FAA) to perform studies on the effects of aircraft noise on sleep. Dr. Basner is president of the International Commission on Biological Effects of Noise (ICBEN).

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Cite this as:
Basner M. Noise: what is to be done? Dtsch Arztebl Int 2018; 115: 235–6.
DOI: 10.3238/arztebl.2018.0235

Tipperary

Wind farm company challenges planning permission for Tipperary woman's home

Katie O'Donovan

Tue 11 Nov 2025 at 16:00

A renewable energy company has appealed a Tipperary County Council decision to grant planning permission for a home for a local woman and her family.

Brenda Campion applied to the local authority for planning permission to build a single-storey detached home in Rossestown, just outside Thurles.

Last month, Tipperary County Council granted permission to Ms Campion, subject to 14 conditions, including that the house be Ms Campion's place of permanent residence for at least seven years, that all cables for electricity, TV and internet be routed underground, and that hedgerows around the land be maintained at all times.

However, renewable energy company Orsted Onshore have appealed the grant of permission to An Coimisiún Pleanála, questioning Ms Campion's eligibility to build a home in a rural area.

In a letter to the planning appeals board, an agent on behalf of Orsted said that as the applicant had previously owned a home, she should not be considered eligible under the council's 'local need' rules.

Local need rules set out a strict set of criteria that a person must fulfil in order to get planning permission to build a home in a rural area. Included in this are that the applicant has a significant tie to the area for at least 10 years, and that they can't already own a property.

The agent for Orsted said that "the planners report for this application acknowledges that the applicant has previously owned a home. This is contrary to the clear intent of the development plan which restricts rural housing in these areas to applicants who are building their first home".

"The proposal does not comply with the rural housing policy objectives," the agent added.

The agent for Orsted also raised concerns about traffic on the Rossestown Road, and the access point for the new house.

"The access is frequently used by farm vehicles and contractors operating large machinery. It is unclear from the current application how the farmland will continue to be accessed should the dwelling proceed".

Orsted also said that the house design didn't comply with the Rural Housing Design Guide, that it doesn't make as much use as possible of the sun, and that no details of any renewable energy measures have been added, apart from the inclusion of solar PV panels.

Wind farm company wins appeal against planning permission for Tipperary home

Katie O'Donovan
Mon 11 May 2026 at 11:00

A renewable energy company has successfully appealed a decision to grant planning permission for a rural home in Tipperary, after arguing the applicant did not meet local housing need criteria.
Breda Campion was granted planning permission by Tipperary County Council to build a single-storey detached home in Rossestown, just outside Thurles.
Tipperary County Council granted permission to Ms Campion, subject to 14 conditions, including that the house be Ms Campion's place of permanent residence for at least seven years, that all cables for electricity, TV and internet be routed underground, and that hedgerows around the land be maintained at all times.
However, renewable energy company Orsted Onshore appealed the grant of permission to An Coimisiún Pleanála, questioning Ms Campion's eligibility to build a home in a rural area.
In a letter to the planning appeals board, an agent on behalf of Orsted said that as the applicant had previously owned a home, she should not be considered eligible under the council's 'local need' rules.
Local need rules set out a strict set of criteria that a person must fulfil in order to get planning permission to build a home in a rural area. Applicants must demonstrate a significant connection to the area over at least 10 years and must not already own a property.
The agent for Orsted said that "the planners report for this application acknowledges that the applicant has previously owned a home. This is contrary to the clear intent of the development plan which restricts rural housing in these areas to applicants who are building their first home".
"The proposal does not comply with the rural housing policy objectives," the agent added.
The agent for Orsted also raised concerns about traffic on the Rossestown Road, and the access point for the new house.
Ms Campion stated that she had grown up in the Rossestown area, and while she did previously own a house outside county Tipperary, she no longer owned one.
She said her elderly parents still live in Rossestown and require round-the-clock care, making it necessary for her to live nearby.
However, an inspector with An Coimisiún Pleanála agreed with the renewable company, and has overturned Ms Campion's grant of planning permission.
In their report, they said that "by virtue of previously owning a dwelling in a rural area," Ms Campion doesn't comply with the local need aspect of the Tipperary county development plan.
"I consider that the social need provision does not apply in this instance and the applicant cannot comply with… the Tipperary County Development Plan and has not established a sufficient housing need," the inspector noted.
"The criteria of this policy requires that the applicant does not or has never owned a house in the open countryside, the wording of this requirement is not specific to the local rural area," they added.
The inspector also said that restricted visibility from the proposed entrance to the house would "endanger public safety by reason of a traffic hazard or obstruction."
The planning appeals board were also not satisfied that the new home could accommodate a wastewater treatment system in line with Environmental Protection Agency (EPA) standards.