

21/05/2026  
The Secretary  
Strategic Infrastructure Development Department  
An Coimisiún Pleanála  
64, Marlborough Street  
Dublin 1. D01 V902

AN COIMISIÚN PLEANÁLA	
LDG-	088092-26
ACP-	
25 MAY 2026	
Fee: €	50 type: PMO
Time:	9:13 By: Post

Please find enclosed my submission making observations for wind farm application PAX04. 324165.

To confirm my details:

Observer's name: Michael Thomas Colk.

Address: The Gathering, Gortnacowly, Bantry, P75 V065, County Cork.

Enclosures: Main submission. Appendices of the same. Community Survey.  
Postal order for 50 euros.

Could it please be noted that this application is one of a group of FOUR wind farm applications currently with An Coimisiún Pleanála for consideration. All four locations are within FOUR/FIVE kilometres of each other in this tiny area of West Cork, North of Bantry. The cumulative impacts of one on another and the receiving environment must be evaluated rigorously for the potential devastating effects they may cause.

Details of the applications are as follows:

Name	References	Potential Decision Date	Details
Curraglass	PL88.500665	25/05/2026	3 turbines, 156.5m tip height
Derreenacrinnig	PL-501243-WC-26	31/08/2026	3 turbines, 119.5m tip height.
Gortloughra	322743-25	Finfo by 05/05/2026	8 turbines, 175m tip height.
Maughanaclea (SID)	PAX04. 324165	29/04/2027	14 turbines, 169m Tip height.

Lastly, there are two submissions, one for myself and one for Mrs Teresa Colk Lynch. These has been written independently of each other so that we can cover more aspects - so they need to be read separately.

Thank you.

Michael Colk

**Submission Ref: PAX04.324165**

**Maughanaclea Ltd Wind Farm**

**Submission from:**

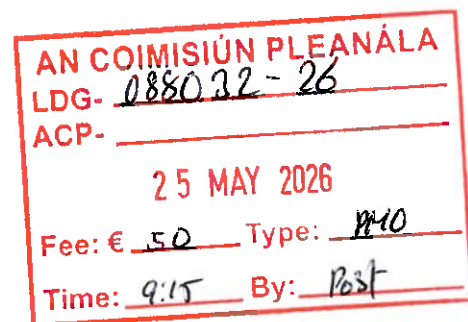
**Michael Colk**

**Gortnacowly**

**Bantry**

**P75 V065**

**County Cork**



**THERE ARE 2 FILES**

**Main Submission**

**Appendices**

**Ref: PAX04.324165**

The Secretary.  
An Coimisiún Pleanála  
64, Marlborough Street  
Dublin 1.  
D01 V902

15/05/2026

Council: Cork County Council.

Applicant: Maughanaclea Ltd: Enerco Energy Ltd, A member of the Craydel Group.  
Company Directors/Subscribers: Michael Murnane. David Murnane.

Agents/Consultants: MKO Planning and Environmental Consultants., Galway.

Location: Ardrah, Maughanaclea, Ballynamought, Gortloughra, Cousane, Coomclogh, Derragh, Glanycarney, Keenrath, Derrynacaheragh, Shiplough, Coolsnaghtig, Mallabracka, Derrylahan, Derreens, Demesne, Dunmanway North, Milleenanannig, and Ballyhalwick, Co. Cork. The surrounding area includes operating windfarms, such as Grousemount, 3.7km to north of Site, and Shehy More, 5.5km southeast of Site, and proposed sites, Curraglass, Gortloughra and Derreenacrinnig, which are currently in the planning process.

Description: Wind Energy Complex consisting of 14 no. wind turbines with an overall turbine tip height of 169 metres, a rotor blade diameter of 133 metres, and turbine hub height of 102.5 metres, and a meteorological mast with a height of 30 metres, and subsequent decommissioning of of site following a thirty five- year operational period from the date of full commissioning... Associated foundations and hardstanding areas. A 110kV substation compound, Underground electrical (110kV) and communications cabling from the proposed 110kV substation to the existing Dunmanway 110kV substation and associated works.

#### A Chara

My submission to An Coimisiún Pleanála is strictly grounded in planning law and policy. Its observations will demonstrate that the proposed wind energy complex materially contravenes multiple planning policies and legal requirements, and the documents presented in the application have significant substantive shortcomings.

SUBMISSION: The main part of my submission are a series of observations that examines, considers and assesses whether the proposed Maughanaclea sites are in a suitable and appropriate location for a wind energy complex. The task in such a short timescale, reading researching and then writing is an immerse task, and there are areas that I have not been able cover which are important. MKO presents us a massive amount of paper work to read , analysis and comment on.

This planning application breaks down all the implications of this proposal into neat little boxes to suggest it will not impact on the environment. However, what is important is not to forget the bigger picture, all these areas are interlinked, independent upon each. Each area added together supplies the overall picture, and it is the whole picture that should be considered before making a decision .

There are numerous inadequacies within the EIAR prepared by MKO. These shortcomings, and many more inherent in the EAIR, need to be carefully evaluated by the Inspectorate in the coming eleven months by carrying a full examination and analysis.

In reading this submission, others submitted, and professional reports, insurmountable problems are particularly apparent with the 'Maughanaclea' wind farm proposal, the correct decision may be confidently reached on the unsuitability of the sites, and a recommendation made for planning refusal to the Board members.

For ease, this submission is split into sections and appendices, which are as follows:

1. General Introduction
2. National and Regional Policies and Procedural Grounds
3. The Mealagh Valley
4. Landscape
  - History of previous planning
  - Scenic Route
  - Recreational Routes
  - Cumulative Effect
  - Scoping Exercise
5. Noise and Health
6. Tourism
7. Dark Skies
8. Biodiversity
9. Peat
10. Hydrology
11. Conclusion and Summary

### 1. GENERAL INTRODUCTION.

This local area lies adjacent to a part of the Wild Atlantic Way touring route, and is visible from the R585 S29 scenic route through the Cousane Gap and within reach of Gougane Barra. Previous planning permissions for wind farms, along with their sub-stations and ancillaries, have been refused in both the Mealagh Valley and the Shehy Mountains to protect the visual amenity of the area, and to curtail the likely environmental damage that construction of these industrial entities would cause. When writing in opposition to a wind farm at Shehy Beg, Failte Ireland recently warned that this scenic area, described as a 'calling card' enticing visitors to West Cork, could have its tourism base undermined by all the disruption during the construction for a wind-farm on these ridge lines. This Maughanaclea application submitted by Enerco would directly extend the number of turbines along the same ridges, and for the first time on the opposite side, appearing on the slopes and ridges of the Maughanaclea hills. These observations will clearly show that the application does not meet the requirements of National, Regional, and Council policies, in that all renewables development should be in 'Appropriate Locations'. It can be stated with utmost confidence that the sites proposed for a 'Maughanaclea' wind farm are not in suitable or appropriate locations: end of. To grant permission for this wind energy complex would be contrary to the proper planning and sustainable development of this beautiful area of West Cork.

## Introduction

### Legal and Procedural Grounds

- The Climate Action and Low Carbon Development (Amendment) Act 2021 is a landmark Irish law signed on July 23, 2021, that commits Ireland to a legally binding target of a 51% reduction in greenhouse gas emissions by 2030 (relative to 2018 levels) and net-zero emissions by 2050.
- Climate Action Plan 2025, Chapter 1, The Critical Nature of the Challenge: 1.5 Taking Action in Ireland states that under the 2021 CAP& LCD Act:

*'Ireland's national climate objective requires the State to pursue and achieve, by no later than the end of the year 2050, the transition to a climate resilient, biodiversity-rich, environmentally sustainable, and climate-neutral economy.'*<sup>1</sup>

- Project Ireland 2040: National Planning Framework: Policy Objective 70: Promote renewable energy use and generation at appropriate locations within the built and natural environment to meet national objectives towards achieving a climate neutral economy by 2050.

The regional policies and objectives within Project Ireland 2040: The Southern Regional and Spatial Economic Strategy, which contains the following

- RPO87:... increase the use of renewable energy sources across key sectors of electricity supply, heating, transport, and agriculture.
- RPO 95...to support implementation of the National Renewable Energy Action Plan (NREAP) and the Offshore Renewable Energy Plan...and leverage the Region as a leader and innovator in sustainable renewable energy generation.
- RPO 99. It is an objective to support the sustainable development of renewable wind energy (onshore and offshore) at appropriate locations and related grid structure in the Region in compliance with national wind energy guidelines.

County Cork Development Plan takes into account and puts into action the necessary Objectives to meet the policies contained in the Government policies and Directives, as well the Regional Policies and Objectives. It is the CCDP that sets the standards and guidance lines that Wind Farm developers and consultants need to meet.

A recent Supreme Court Judgement, *Coolglass v An Comisiun Pleanala*, on 04/02/2026, Mr Justice O'Donnell, concludes the following:

Ireland's planning is fundamentally plan-led not government-policy led.

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<sup>1</sup> p.22 Climate Action Plan 2025. Chapter 1 The Critical Nature of the Challenge. Prepared by the Department of the Environment, Climate and Communications. Government of Ireland.

Climate Objectives are already woven into the planning process to significant degree.

In their conclusion on the judgement, Mayes, Hayes and Curran LLP a leading Irish law firm based in Dublin states:

*'The Supreme Court [has] made it clear that section 15(1) of the Act does not mandate climate-led decision-making to the exclusion of all other considerations. Climate objectives must be considered and addressed, but they do not automatically override development plans or other statutory requirements.'*

The Supreme Court judgement also clarifies:

Supreme Court firmly endorsing the use of County Development Plans within the planning process for renewables and in many ways reasserted its authority within. The Court also confirmed that Ireland's planning is fundamentally plan-led not government-policy led. MKO's insert summarises part of the Climate Action and Low Carbon Development (Amendment) Act 2021, and its amendment of section 15(1) which states: 'a relevant body shall, in so far as practicable, perform its functions in a manner consistent with (a) the most recent climate action plan...',

- the inclusion of 'in so far as practicable' makes it clear that there may be circumstances in which a relevant body may not be required to perform its functions in a manner consistent with the s. 15 objectives.
- In the field of individual planning decisions, it is perhaps less likely that s.15(1) will have a decisive effect that in respect of the actions of other relevant bodies. This is because the pursuit and achievement of the climate objective is already woven into the planning process to a significant degree.<sup>2</sup>

In their conclusion on the judgement, Mayes, Hayes and Curran LLP a leading Irish law firm based in Dublin states:

*The Supreme Court [has] made it clear that section 15(1) of the Act does not mandate climate-led decision-making to the exclusion of all other considerations. Climate objectives must be considered and addressed, but they do not automatically override development plans or other statutory requirements.'*

All parties, including MKO, must accept that CCDP has taken into account national climate policies and objectives and adopted them into their development plans. However, MKO thought their submission have ignored the role and the importance of County Cork Development Plan 2022-2028.

This can clearly be seen in their scoping exercise, section 3.2.3

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<sup>2</sup> 2p.67, Ruling **118** (iv). p.68, Ruling **118** (x).

3.2.3. The process of identifying a suitable location for a development such as the Proposed Project is influenced by a number of factors. While wind speeds, the extent of suitable or available land, proximity to the grid connection point, and planning policy are all very important,

a wind farm project must be commercially viable/competitive, as otherwise it will not attract the necessary project finance required to see it built. The Site has been identified as having potential for a wind energy development as a result of a nationwide search of suitable lands.

County Cork Development Plan 2022-2028

Looking at MKO's planning report, there is an indication that the consultants are taking exception to something in the judgement possibly something to do the authority of county development plans and so their Wind Energy designations. This becomes fairly obvious looking at MKO attempt to impose their own Landscape Characteristics, something that are not I entitled to carry out.

#### 13-2. COUNTY DEVELOPMENT OBJECTIVE, RENEWABLE ENERGY

*(a) Support Ireland's renewable energy commitments as outlined in Government Energy and Climate Change policies by facilitating the development of renewable energy sources such as wind, solar, geothermal, hydro and bio-energy and energy storage at suitable locations within the county where such development has satisfactorily demonstrated that it will not have adverse impacts on the surrounding environment (including water quality), landscape, biodiversity or amenities.*

### An Introduction to The Mealagh Valley

The **Mealagh Valley** is located just outside the town of Bantry. It follows the course of the river Mealagh fed from the eastern end of the valley, ie The Maughanaclea Hills as well as others in the area.

There are around 260 households. People, both in the valley and Bantry town, see it as 'hidden gem' a quiet peaceful place to live, a place to walk through to enjoy the silence instilled by nature.

The valley is approximately 15 kilometres long with the Eastern end 3km wide as you towards Bantry it does widen out. The Eastern end is dominated by a number of well known hills. At the far eastern end, Nowen Hill (535 metre) closes the valley. The southern side at the eastern end are Derreenacrinnig West (402 metres) and Derreenacrinnig East (509 metres). On the west side of these hills is the more dominate Mullaghmesha at (494 metres). On the North side are the Maughanaclea Hills (452 to 470 m). The effect of these hills, or we can call them small mountains, is to enclose this part of the valley, although travelling towards Bantry the hills become less pronounced. The Mealagh Valley presents a curved shape, consequently the Maughanaclea Hills have a dominant effect on the surrounding areas, which can clearly be seen when driving along the southern side road from Bantry.

Geological studies have shown the formation of a prominent U-shaped valley with lakes created by a glacial ice retreat<sup>1</sup>. The Mealagh valley was formed thousands of years ago and has important geological features. Geological studies of the area indicate that the Mealagh Valley was part of a much larger 'Bantry Valley'. A number of glacial lakes were formed, studies suggest three distinct lakes. These lakes were termed Glacial Lakes Bantry, Ownbeg and Mealagh<sup>2</sup>.

The hills that dominant the eastern end of the valley are generally rounded, shaped due to the extensive erosion during the successive glaciation periods. In terms of the counties landscape definitions, they are; LCT 15a Ridged and Peaked, High Value and Sensitivity landscape, some areas of planted forestry and others display an open landscape.

Travelling toward Bantry the hills are less pronounced, however, the area has an array of drumlins, a form of glacial deposits composed of diamict, which comprises cobbles and boulders set within a matrix of stiff bluish grey clay. This area of the valley starts near Ardrah landscape definition HVL, LCT 4 Very high Value, Sensitivity and of National Importance.

The valleys geological formation, an enclosed valley, creates an extremely quiet, tranquil place to live. There is no constant background noise like traffic and very limited machinery use of one sort or another. The topography of this part of the valley traps the sound generated locally and thankfully there is very little noise generated in the valley, making it very quiet and a joy to live

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<sup>1</sup> see Holocene Lakes In Bantry- Appendice D

<sup>2</sup> see Holocene Lake in Bantry- Appendices D

here. However, on occasions farmers using a rock breaker in the fields can easily be heard, with resulting sound being trapped and swirling around in an echo chamber. Small noises can generate an also produce an amplified echo for example a dog barking, mainly due to the surrounding hills. Recent optical fibre was being fitted by engineers to the existing poles. It was noticeable when engineers were drilling to fix brackets, the reflected sound that came back was much greater.

Visitors always stand and listen to the quietness, and cannot believe how peaceful and tranquil the surrounding area are, as well as observing the surrounding natural beauty of the valley.

At night it is difficult to describe the quiet and stillness, all you can hear are the owls or the passing disturbance in the air as bat fly around you. After a heavy rain fall it is possible to hear the Mealagh river flowing quickly through the valley heading towards the Atlantic Ocean.

There is no light pollution in the night skies, resulting in wonderful dark night skies that is not in competition with man made lighting. Dark Sky Ireland stated that the valley has a 'near-pristine environment , close to the conditions of Kerrys Dark Sky Reserve and Mayo Dark Sky Park-Ireland accredited dark sky areas<sup>3</sup>. '

The formation of the valley also creates the conditions for the valleys own micro climate. It can be raining in the valley and dry in Bantry as well as in Kealkill the other side of the Maughanaclea Hills. We will often find ourselves surrounded by low clouds and mist creating an eerie feeling. One can watch the weather front coming from the Atlantic heading down the valley and know what to expect. Being a closed valley creates a tunnel effect resulting at times a much fiercer weather than normal.

### People

Many people in the valley feel connected to the landscape. There are families who have lived in the Mealagh Valley for generations, there are also many newcomers (commonly known as blown in's) who have settled in the valley, coming from all over the world, England, Holland, Germany, Spain, Luxembourg, Israel, all have stayed and become part of the community and have strong bonds with the valley.

### Valley Survey Report (There is a copy with this submission).

A recent survey of everyone, including children, living in the valley was carried out by the Mealagh Valley Community Centre Ltd in partnership with West Cork Development Partnership: published in the summer of 2024, a copy given to every household. There were 241 adult responses and 39 child responses.

It showed clearly that residents in the valley valued the quiet, peace, and tranquil nature of the whole valley. When asked what were their favourite locations: Mullaghamesha, Owen Hill, and the view of the hills.

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<sup>3</sup> See letter from Dark Skies Ireland

Comments taken from the survey:

*'Our communal appreciation of the environment we are living in is clear'.*

*'the stunning natural environment we share is clearly appreciated by the young people'.*

*'the peace and quiet, access to nature, the space, the valley is a hidden gem'.*

*'the peace and quiet'.*

*'Living in a beautiful place'.*

*'The sense of love for the valley'*

*'The peace and quiet and feeling safe'*

*'Its a beautiful place to live-full of beauty and walks, loving community'*

*'The natural environment and wild life'*

*'Lovely wild life and we are happy here'*

*'The Mealagh Valley is the most beautiful and peaceful place to have a home with gorgeous trees and shrubs and many wild birds and the butterflies and bees slowly coming back. Fuchsia growing along the sides of the roads gives the valley a special character. Let's keep it that way'.*

If Wind farms are referred to at all in the Community Survey- and this was pre-Enerco- it was always in the negative. Most people at this point in time would have thought we have seen the end attempts at Wind Farms construction in the valley.

*[What are your main 3 concerns for the community we live in?]*

*More renewable energy working around the valley.*

*Sustainable energy sources.*

*The possibility of wind-farms.*

*Having valley overlooked by windmills.*

*Potential for more sitka forests and any wind-farm proposals.*

*Wind turbines being built.*

*Building of wind turbines/farms.*

*Wind development.*

*Loss of rural setting.*

*Climate change: wind farms being built purely to fill peoples pockets. Our response to climate change requires proper joined-up thinking.*

*Climate Change: much heavier rain washing away the roads.*

*Erosion and impact of severe weather on roads, ditches and land.*

*The amount of surface water on our roads.*

Looking at the main concerns for the community, environmental issues came in a high third. It is clear many people feel connected to their environment, the landscape is not something disconnected from us. The landscape is more than a view, it is a valuable part of people lives.

This view is supported by the National Landscape Strategy for Ireland 2015-2025 vision statement

*'Our landscape reflects and embodies our cultural values and our shared natural heritage and contributes the well being of our society's environment and economy. We have an obligation to ourselves and to future generations to promote its sustainable protection, management and planning'.*

There is great interest in the local heritage. In summer 2024, and against year 2025, the community has held a Heritage Day, both of which were very successful. Last year members of the community interviewed older residents and produced a video, 'Voices of the Valley'. Another popular event at both days, was a talk about the archaeology of the valley by David Myles. He researched the area, and found sites that had not been registered, all can be found in his book, An Archaeological Survey of the Mealagh Valley.

The Mealagh Valley is a very special place to live. It is an inappropriate place to be dominated by 14x169.5m industrial size wind turbines. I will show in the small amount of time available and the immense task of studying and analysing information and data, to show that I am correct in the view that this development is inappropriate for this location and will destroy what is a very unique place not just affecting residents also the wider community of West cork.

In the Valley Survey Report 2024, Survey Analysis page 2,

' Our environment is not simply a product to be exploited or sold; we all value where we live, its nature, peacefulness, quietness and space. It is important that as a community, we respect, protect and improve the natural environment that we are all privileged to share together.

Since our out valley survey in 2024, the Maughanacela's Wind Farm was announced , there was Community Survey carried out, the results can be found in Appendix D.

One Quote sums up a lot of the feeling of the community,

*"We learnt recently that businesses (ie call centres, server farms) use more electricity than all of the homes in the country, yet electricity prices continue to rise. It seems clear that there is no benefit to the people of the country and it all feels like a continued exploitation of our natural resources. concerns."*

## LANDSCAPE

### Landscape and Visual Impact

It is important to consider the size of the proposed Wind Turbines before we can visualise their impact on the landscape at the proposed location. Over the two sites there will be 14 turbines, one is sited along the ridge line of the Maughanacleas Hills, over looking and dominating the Mealagh Valley with 8 turbines. The other 6 turbines will dominate the iconic gateway to the Wild Atlantic Way situated at the Cousane Gap.

The turbines themselves will have a tower of 102.5metres high, and three rotor blades with a diameter of 133metres, giving us the tip height of 169.5m. The steel and concrete bases requiring massive foundation support could measure 25 metres in diameter. and very deep. The Landscape and Visual Impact is far greater than ever anticipated in WEDG 2006 or the present guidelines being: not only because of the increasing height of the towers, but the three absolutely enormous blades being attached and sweeping over four acres of land below. We must not forget that the turbines are moving adding further to the visual disconnect of the landscape and then there is a major risk with the noise element.

Looking at the Mealagh Valley site on a OSI map, the Maughanaclea Hills vary in height, at their lowest 270m to a possible 450m. It is hard to be specific however, the proposal means adding 169.5m to the height of the hill. Using a local comparison, the tallest building in the City of Cork is the Elysian Tower at 70m and you cannot miss it. A 169.5m turbine will stand out, so I have no doubt that these turbines with moving blades will dominate the whole of the Mealagh Valley landscape from beginning to end. Looking at the Cousane Gap we have a very similar position. The view along the R585 going towards the Wild Atlantic Way at the Cousane Gapis stunning as you wind up the hill through the Gap. This area will also be dominated by the 169.5m turbines.

### Why is the Landscape so important?

Our Landscapes are valued by society, and the European Landscape Convention highlights its importance in society and forms the basis of Irelands Landscape Strategy for Ireland 2015-2025: Landscape Strategy Vision.

*'Our landscape reflects and embodies our cultural values and our shared national heritage and contributes to the well being of our society, environment and economy. We have an obligation to ourselves and to the future generation to promote its sustainable protection, management and planning'.*

As Natural England suggests, 'The European Landscape Convention reminds us that we need to achieve:'

*'sustainable development based on a balanced and harmonious relationship between social needs, economic activity and the environment'*

Ireland has signed up to the European Landscape Convention, which was introduced as a European wide concept centring on the quality of landscape protection, management and planning. Acknowledgement of this appears in Cork County Development Plan 2022-2028, under Chapter 14,14.7.3, which states

*Ireland ratified the European Landscape Convention in 2002 and must adopt national measures to promote landscape planning, protection and management. The European Landscape Convention defines landscape as 'an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors'. The Convention, in addition to the obvious environmental benefits from properly protecting, managing and planning landscape, highlights the economic and social benefits that accrue such as tourism potential, economic growth, employment and quality of life enhancement.*

Unfortunately the Wind Farm industry seems to ignore the need to protect Ireland's natural environment and landscape even though their EIARs are full of copious pages on the subject. First and foremost, they constantly inform us that we face a national emergency and this takes priority and overrides the environmental issues, pushing aside all present environmental protection and dismissing people's concerns. All they doing is making the situation even more perilous and destroying our diminishing natural environment.

I will show that MKO strategy is to override policies and objectives set out in the Cork County Development Plan 2022 -2028 by surreptitiously changing their wording and continually repeating their own definitions with the aim that their changes become the norm.

A good starting point for my observation would be to look at MKOs Landscape section.

Landscape Character Values, Value, Sensitivity and Importance found in the Landscape section.

MKO in their Landscape Character Assessment starts their proposal by producing a Landscape Character Area Table, they point out the LCT 15a Ridged and Peaked Upland applies to this area, and that is correct. However, by slight of hand in the column 'Development, overall' the designation for sensitivity is stated as Medium, and highlighted in bold.

This is actually their own sensitivity value designation, and it is important to point out at this stage that Cork County Development Plan states very clearly the characteristics of LCT15a, Ridged and Peaked Upland (Mullaghanish to Millstreet) is High Landscape Value and High Landscape Sensitivity.

MKO constantly changes the Sensitivity value of LCT15a to Medium, and elsewhere to moderate. This must raise the question for ACP Inspectors as to why are they doing this, and what gives them the authority to do it?

To answer this we only need to look at MKO's section 17.3 Sensitivity of Designated Landscape Character Area.

Their general argument is that in their opinion they are allowed to change the Cork County Landscape Designations, as there is no National standardised criteria for landscape sensitivity. MKO further state that generally County Development Plans are inconsistent in their approach and few include specific sensitivity characteristics to wind farm development. I doubt very much whether different consultants, such as MKO, have agreed an absolute standard for themselves. This opinion has little value in that Cork County does have sensitivity landscape values. Its very precise definition (see next section) for high sensitivity landscapes are those identified as only being able to accommodate limited development pressure. It is fair to say that a Wind Farm is undeniably far beyond a 'limited' development and will have a significant dramatic impact on the remote LCT15a landscape.

MKO further adds local LCTs are often highly incompatible with National direction. Not according to a recent Supreme Court judgement, *Coolglass v An Comisiun Pleanala*, on 04/02/2026. The Supreme Court firmly endorsing the use of County Development Plans within the planning process for renewables and in many ways reasserted its authority within.

MKO arguments involving landscape designations, overall values and sensitivity are at the heart of the consultant's submission by devaluing the landscape values that Cork County Council has assessed and agreed and are clearly incorporated into their County Development Plan. Even the current Variation1 of the CCDP, that will be adopted shortly, confirms that the County's Landscape Character Assessment remains unaltered. Rather than accepting and working with the sensitivity designations, MKO's strategy is to attempt to obstruct and change whole system of assessment. These particular landscape designations are there to restrict significant changes to the character of valuable sensitive landscapes of the Maughanaclea Hills, Mealagh Valley and the Cousane Gap.

It seems that MKO has not attempted to carry out a comprehensive scoping exercise to explore alternative sites within West Cork in order to find the most appropriate site for a major wind farm development. There are even twenty year old sites that could be considered as candidates for re-powering with more modern turbines. A full scoping exercise would have involved them looking at the 'Acceptable in Principle' and 'Open Consideration' areas and using the CCDP to find sites within these areas that are not considered 'High Landscape Value or High Landscape Sensitivity'. This does not appear to have been an option.

### Cork County Landscape Characteristics

The devaluing of our local landscape is so prolific in the EIAR's Landscape Chapter that it is worth considering CC Landscape characteristics in more detail. Cork County Council carried out their Landscape Character Assessment in 2007 which also included the preparation for the Landscape Strategy. This assessment used the government's guidance, that the results of the exercise were signed off at ministerial level.

It aimed to provide a better understanding and appreciation of the county's landscape and also the importance of managing development into the future, including wind energy development. Except for a few small changes (2014) the Landscape Characteristics have remained in place to the present time. They are very clear in terms of Landscape Value and Sensitivity:

**Landscape, CCDP, (GI)14.8.4** The Sensitivity of each character type is defined as the ability to accommodate change or intervention without suffering unacceptable effects to its character and values. Sensitivity is evaluated using criteria ranging from Very High to Low. A highly sensitive landscape is likely to be vulnerable to change whereas a landscape with a low sensitivity is likely to be less at risk to change.

**Landscape, CCDP, (GI)14.8.5 High Sensitivity** landscapes are vulnerable landscapes with the ability to accommodate limited development pressure. In this rank landscape quality is at high level, landscape elements are high sensitive to certain types of change, if pressure for development exceeds the landscapes limitations the character of the landscape may change.

Further in **CCDP (GI)14.8.11** it is clearly stated,

*'The capacity of each landscape character type to absorb new development will largely depend on the sensitivity of the landscape type. Developments which are likely to create a significant environmental and particularly visual impact will best be absorbed in areas where the landscape is robust, ie has the capacity to absorb development without significantly changing its character. All developments should be assessed on a site-by-site basis to avoid, minimise or mitigate any potential environmental or visual impact.'*

#### **CCDP (GI ) 14-9 Landscapes**

- a) *Protect the visual and scenic amenities of County Cork's built and natural environment.*
- b) *Landscape issues will be an important factor in all land-use proposals, ensuring that a pro-active view of development is undertaken while protecting the environment and heritage generally in line with the principle of sustainability.*
- d) *Protect skylines and ridge lines from development.*

There is no denying that the introduction of 14 x169m Wind Turbines will drastically impact on and change for this High value, High Sensitivity landscape.

#### Landscape Values and Sensitivity of the site of the Maughanaclea Wind Farm

The area for MKO/Enerco's proposed wind farm is of the Landscape Character: LCT15a Ridged and Peaked Upland, High Value Landscape, High Sensitivity. However, it is also important to point out the proposed wind farm's turbines are very close, less than 250 and 400<sup>1</sup> metres, to an area designated as LCT4: Rugged Ridge Peninsulas, with Very High Landscape Value and Very High Sensitivity. This LCT's very high landscape sensitivity, provided for the assessment this area to be one where wind farm development is 'normally discouraged'. This proximity is not explored in a meaningful way by MKO, and often simply left as a statement. I will be returned to later in this section.

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<sup>1</sup> MKO figure from their chart check is it 250 or 230? Also states 400 for another point

It is clear to see already that Landscape Sensitivity, is key to this proposal. It is only if the local area was of Low Sensitivity could it be classed as a robust landscape that would be tolerant to change, and so have the ability to accommodate significant development. Even MKO does not push their assertions that far, but it is obvious just how determined they are, by slight of hand and their own reasoning, to reduce the sensitivity value of LCT15a to be 'Moderate or Medium' as opposed to the CCDP's High Sensitivity.

To confuse the situation further MKO states that this LCT15a does not have the designation High Value Landscape (HVL), as in the CCDP. They are suggesting the local planning policy does not give it the highest landscape value, and it is only of local importance, allowing them to degrading its value. This is an attempt to further confuse the issue. The lack of HVL and a local designation does not change the landscape characteristics of High Landscape Value and High Landscape Sensitivity for LCT15a. Ridged and Peaked Upland. They utilise the fact that it is also classed as 'Open for Consideration,' as is 55% of the county, furthering their view that the overall landscape designation should be 'Medium'.

It is important at this stage to look at these statements in detail and unpack their arguments.

This High Value Landscape (HVL) designation causes confusion, and its worth clarifying why it is used at all for County Cork. CCDP 14.8.12 Seascape Assessment (or as the map indicates High Value Landscape) is an extension of landscape character assessment and includes 1,100km of coastline; seascape is a crucial element of the County's history, identity and culture. A number of changes have been occurring along coastlines including the need for coastal protection works, upgrading and proposals for new ports, marinas, proposals for aquaculture schemes and investigation of wind energy and other renewable energy projects offshore. In 2014, Cork County designated its Seascape Assessment as High Value Landscape, (HVL): it was introduced to protect the coastal areas of the county from over development. Within this term High Value Landscape(HVL) landscape designations remained the same with the designations for value and sensitivity they had before. At future date, once the National Landscape Characterisation has been completed, a comprehensive seascape survey will be carried out.

Within these High Value Landscape (HVL), areas , the County Landscape Strategy values still applies. For example, the western end of the proposed wind farm adjoins an area of High Value Landscape(HVL) of the coast line. Because of the local coastline's beautiful scenery it also has a designation of Very High Value and a Very High Sensitivity and it needs to be noted that not all parts of County Cork's coastline are assessed as highly.<sup>2</sup> So, it is a red herring for MKO to start postulating on LCT15a's lesser value because it isn't designated as High Value Landscape (HVL): it isn't because it is not counted as part of 1,00km of coastline.

The important point is that the the Landscape Character Map, High Value (Seascape) Map and areas for development all follow the same boundaries. The Landscape Character Areas and descriptions have not changed since 2007, except minor changes in 2014, This may not even

change in the next development plan, unless there is a review using national territory mapping exercise, and that would be designations not necessarily boundaries.

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<sup>2</sup> As said before, this Landscape is LCT4 Rugged Ridge Peninsula, Value is Very High, the Sensitivity is Very High and of National Importance.

### Magnitude of Landscape Change

Lets look at MKOs section 17.4 Magnitude of Landscape Change.

We have seen that MKO dismisses the CCDP and the standards it has set for planning applications including wind farm developments. They slip their own landscape designations, evaluations and tables into the void. A good example is their 'Magnitude of Landscape Change', where designations and values are used; however, how they are evaluated is a something of a mystery , part from assuming they make their judgements using GLVIA3. At this point it is worth pointing out that GLVIA3<sup>3</sup> is not specific to industrial size wind turbines: it provides guidelines for Landscape Consultants, for when there are no formally agreed landscape designations or guidelines in place, ie. opposite to County Cork.

### Local Designation Issue

Picking up on MKO's issue with LCT15a being of local importance, the consultants use this as a further justification for downgrading its High Sensitivity value. (MKO Ch.13.4.1.1.3). They infer constantly that 'local' dictates the other two aspects, so LCT15a cannot possibly be High Landscape Value or High Landscape Sensitivity. This is obviously their own view, with nothing that can prove this correlation. Each aspect is independent of the other, so LCTs have many combinations, such as low, medium, local or high, high, local or medium, medium, county etc etc. I would add that a recent wind farm at Gortloughra, with the same area characteristics was refused by CC planners and its with ACP.

### Supreme Court Rulings.

MKO uses the designation of local importance as a justification to virtually ignore once again that all need to be taken into account when making the necessary judgement. LCT 15A is High Landscape Value and High Sensitivity. These values are clearly set out in CCDP are not there to be changed by consultants like MKO for their client Enerco. County Cork's Development Plan was agreed by the elected councillors representing the people of County Cork. Further more the Supreme Court

*[has] made it clear that section15(1) of the Act does not mandate climate-led decision-making to the exclusion of all other considerations. Climate objectives must be considered and addressed, but they do not automatically override development plans or other statutory requirements.'*

The Supreme Court judgement also clarifies:

*'A planning authority is entitled to commence into consideration with a presumption that compliance with the development plan will itself be compliant with its s.15 duty.'*

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<sup>3</sup> in a response to a GLVA survey in 2021 only 26% of their members agreed that the GLVIA3 was fit for purpose, and 27% agreed that GLVIA3 requires a rewrite. This rewrite is in progress.

MKO constantly uses their own assessment of the landscape as 'medium', bringing this through to their LCA assessment summary and then the non-technical summary. It seems everywhere you turn there is their incorrect assessment of medium, giving them a moderate effect on the landscape, enticing the reader to accept it as correct. Yet, it is fair to point out even a moderate effect on the landscape would be highly visible. They continually add it is only of local importance, again trying to negate the areas is Highly Sensitive to dramatic change.

They further suggest that there is no classification criteria for landscape sensitivity of LCA with respect to wind energy. Well, there is no specific reference for any form of development: the issue is visual effect and visual impact on the area proposed. In terms of 14 x 169.5m industrial wind turbines, no one would deny that there will be a major impact on an area particularly characterised as Highly Sensitive to change.

MKO motives are perfectly clear: they must have the Sensitivity of LCT15a reduced to medium/moderate and decides to do this by discrediting CCDP's Landscape Character Designations. MKO suggest the 'proposed turbines are after all located within an area classified as Open to Consideration as is the majority of this LCT. They then start building their argument towards 'this is an ideal place to erect a Wind Farm'. Yes this is an area 'open for Consideration' however, permission is granted on a case by case basis and it has to be in an appropriate location, it is not an automatic agreement.

#### Reason for MKO changing the landscape character areas characteristics.

The attempt by MKO to change the landscape designation becomes very evident in the section, LCA Assessment Outcomes. This is where they assess the effects on the landscape. I may repeat myself, however, it is important to be very clear.

The location of the proposed wind farm is designated in CCDP as LCT15a Ridged and Peaked Upland, Landscape Value High, Sensitivity High, Importance Local. What sensitivity means I have written about earlier, along with Landscape Value. MKO calls the sensitivity medium: it is their evaluation obtained by carrying out verbal gymnastics to justify their change. Again MKO cannot change what is clearly stated in the CCDP. However, looking at CCDP definition of medium sensitivity, MKO still could not justify this wind farm proposal. Again MKO play on the local designation as if it affects the sensitivity or value, what I would suggest for ACP to carefully read the Archaeological Report from David : the local importance actually undervalues the importance of the Archaeological aspect of this landscape, though MKO makes no comment on this.

Another example of verbal gymnastics can be found in 13.7.3.: Landscape Effects (Operational Phase)

*'The landscape character of the proposed wind farm site will undergo major changes in landscape by the introduction of vertical man made structures.....there will be a substantial magnitude of change to the landscape...within the site.'*

MKO are suggesting that this substantial change only affects the proposed site, and seems to infer that by magic this introduction of 165m man made vertical structures with large moving turbine blades will immediately disappear from sight once leaving the site! Stranger and Stranger.

Closeness to an area with the HVL area designation within the Mealah Valley.

As stated before, a number (3) of the Wind Turbines in this proposal are situated in an area where a previous wind farm was refused. They sit very close to an area designated as HVL, with character designation of Very High Value, Very High Sensitivity, and of, note, not county but, National Importance. MKO's own charts shows turbine T014 at a distance of 250m from this protected area and in another table states a distance of 400m for a turbine. Like most large consultants, MKO thinks it is perfectly acceptable and correct to erect large Wind Turbines very close to an area 'Normally Discouraged', an HVL area of Very High Value and Sensitivity, as well as of National Importance. In their opinion, they will not have any significant effect as there will only be a slight visual impact on this valuable landscape. (In the next section it will be seen that a previous wind farm application in Ardrah turned down for its closeness to an area classed as HVL).

Previous Planning that is now part of the present proposal

The present application for the Maughanaclea Wind Farm includes the area of land that formed the earlier Ardrah Wind Farm. MKO's map shows that at least 3 turbines, T12,13 & 14 of the proposed Wind Farm are located in the area of the former application at Ardrah. The turbines may not be sited in quite the same places as before, due to their height and huge blades; however, they are in the self-same location which was turned down by ABP. (see Appendix A & B for full details)

These wind turbines will also sit very close, in one case 250m, from the area classed as HVL, with a Landscape Value of Very High value, Very High Sensitivity and of National Importance.

30/05/2011 There was an application was for a total 5 wind turbines with a height of 64 metres and rotor diameter of 71 metres, including all ancillaries. The planning reports are no longer available. The application was given approval by Cork County Council on the 15/03/2012 after receiving 40 submission letters.

The ABP decision to refuse permission for the Ardrah site in July 2014 was based on the following reasons and considerations (first part in précis):

- *....The proposed development, which is not located within a "Strategic Search Area", is located immediately adjacent to areas designated as "Strategically Unsuitable Areas", would be unsuitable for wind energy projects and where such projects would normally be discouraged.*

[NB. for 'Strategically Unsuitable Areas' post 2014, this area became designated as: 'normally discouraged' / 'High Value Landscape'. Its character assessment remained unchanged: 'Very High Value, Very High Sensitivity, National Importance.']

- *The proposed development, which would by itself be visible over a wide area, would in conjunction with permitted and proposed development in the area, give rise to an undue concentration of wind energy development with significant negative impacts on the character and visual amenities of the area, and in particular the Mealagh Valley, and its amenity, tourism and recreational potential. The proposed development would, therefore, seriously injure the visual amenities of the area and be contrary to the proper planning and sustainable development of the area.'*<sup>4</sup>

## **INTRODUCING THE MEALAGH VALLEY**

(Mealagh Valley description previous chapter, what its like to live in the valley)

This section is absolutely vital to highlight how the Mealagh Valley sits centrally in Enerco's plans and yet barely has a mention as an entity. It has become mere slopes and ridge lines on which to erect their turbines, and there just happens to be sensitive receptors that may be significantly affected - but they are 'sparse' in number. This completely negates its visual beauty, its unique geological history, its climate and also its people and community. It also disrespects the previous planning history of the Mealagh Valley where developers have tried to gain planning permissions for wind farms, and also disregards the many protections that are afforded its landscape by County Cork Development Plans, both past and present. Each of these points are explored within this section.

### Cork County Development Plan 2022-2028

This extract covers just a few of the many objectives contained in the present plan, that look to protect what is here in the valley.

(ET) 13.6.3 (precis) Cork County Council developed a wind energy strategy using the 2006 [Planning for Wind Energy Development] Guidelines which included a methodology for a sieve mapping analysis of the key environmental, landscape, technical and economic criteria. A number of key policy considerations included the location of all existing and proposed wind energy developments and their cumulative impacts, and also to protect Important or high value landscapes.

*ET 13-7: County Development Plan Objective: Open to Consideration.*

*Commercial wind energy development is open to consideration in these areas where proposals can avoid adverse impacts on:-*

*Residential amenity particular in respect to noise, shadow flicker and visual impact;  
...sites and locations of significant ecological value; Architectural and archaeological*

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<sup>4</sup> Decision 08/07/2014, held on An Bord Pleanála web site. Ref PL.88.240461.

*heritage; Visual quality of the landscape and the degree to which impacts are highly visible over wider areas.*

*In planning such development, consideration should also be given to the cumulative impacts of such proposals.*

*GI 14.9. County Development Plan Objective: Landscape.*

*a) Protect the visual and scenic amenities of County Cork's built and natural environment. b) Landscape issues will be an important factor in all land-use proposals, ensuring that a pro-active view of development is undertaken while protecting the environment and heritage generally in line with the principle of sustainability. c) Ensure that new development meets high standards of siting and design. d) Protect skylines and ridge lines from development.*

*(GI) 14.9 Landscape Views and Prospects*

*The County contains many vantage points from which views and prospects of great natural beauty may be obtained over both seascape and rural landscape. This scenery and landscape are of enormous amenity value to residents and tourists and constitutes a valuable economic asset. The protection of this asset is therefore of primary importance in developing the potential of the County...*

*14.9.2 ...Scenic routes highlight the quality of the overall environment and landscape experienced within Cork County. It is important to protect the character and quality of those particular stretches of scenic routes that have special views and prospects particularly those associated with High Value Landscapes.*

*14.9.3 All proposals should be assessed on their merits taking into account the overall character of the scenic route ...and the Landscape Character Type through which the route passes.*

Adhering to policies and objectives in the CCDP 2022-2028, and previous similar CCDPs, applications have been refused on many grounds that would protect fully the visual value and avoid negative impact on the 'receiving' landscape. Bear in mind yet again, these applications at the time would have been for much smaller wind turbines, with hub heights at 50-70 metres.

As stated at no point in MKO's EIAR is the Mealagh Valley mentioned as an entity, and certainly no previous planning applications are listed. The previous wind farm application for Ardrah is nowhere to be found in the documentation, which is inexcusable as part of the 'Maughanaclea' proposal sits on the same site. Further, there is no mention of the effects this proposal will have on the valley as whole: even in their cumulative effect section the Mealagh Valley is missing? MKO have completely ignored the past planning history for the valley even though is a history of wind farm planning applications going back to the late 1990's. However, I am sure that they are well aware of the past applications: appendix A and B provides a list of wind farm applications and outcomes just for the Mealagh Valley, and at 29 pages this is only a précis of the reports, orders and decisions many of which are available in the public domain.

### Previous Planning History of wind farm proposals in the valley.

For ACP robustly to assess Enerco's proposed development called 'Maughanaclea', it would be helpful here to provide just a small part of the past history of wind farm proposals and show how the history impacts severely on these present proposals.

#### **Mullaghamesha.**

Let's start with proposals for a wind farm on the hills the opposite side to the Maughanaclea Hills, on the Mullaghamesha Hills. These are the highest and longest hills of the Mealagh Valley, situated on the South side, and directly opposite the Maughanaclea Hills.<sup>5</sup> Permission was refused at Cork CC level in 1998, and so the company appealed. In the following year, An Bord Pleanála refused to grant permission to Green Power Ltd of Macroom for a wind farm comprising of 20 turbines. The Order read:

*'it is considered that the proposed large scale wind farm development would be visually obtrusive and out of character in the rural scenic landscape, and would seriously injure the visual amenities and natural beauty of the area'.....'The proposed development would, therefore, be contrary to the proper planning and development of the area'.*

#### **Coomleigh East**

Another planning application was received during the same years for Coomleagh East and West townlands, situated on the eastern ridges of the Maughanaclea Hills. In June 1999, planning permission was refused by Cork County Council for this wind farm which also comprised of 20 turbines. Later in the November, permission again was refused again by Cork County Council, this time for 7 turbines with a hub height 40m, rotor 48m, and tip height of 64m.

*'Having regard to the location of the site in a remote, elevated and unspoilt exposed upland area in a rural scenic landscape of amenity/tourism/ recreational potential and visible from a public road which is a designated Scenic Route in the current Cork County Development Plan, it is considered that the proposed large scale wind farm development would be visually obtrusive and out of character in the rural scenic landscape, and would seriously injure the visual amenities and natural beauty of the area. It is considered that the proposed development would be contrary to the objective of the Planning Authority as set out in the current Development Plan to preserve the views from such roads and would be visually obtrusive and conflict with this objective, which is considered to be reasonable. The proposed development would, therefore, be contrary to the proper planning and development of the area'.*

*'The proposed development, in conjunction with existing and proposed wind farm development would constitute an unacceptable density of this type of large scale development in a sensitive and scenic area. Proposed development would, therefore, be contrary to the proper planning and development of the area'.*

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<sup>5</sup> CCC 98/1166, PL 04.108995. Permission refused by CCC on 01/10/1998, and by ABP on 25/05/1999,

The Council's decision was of course appealed and in June 2000 this proposal was refused by An Bord Pleanála concurring with the reasons to Cork County Council. (More details in appendix A and B.)

### **Goulacullin & Barrboy**

This site has a true history of try, and try again, by George O'Mahony, a farmer from Drimoleague.

1998 (97/4390) George O'Mahony applied for permission for a windfarm at Goulacullin (site1) comprising of 12 no. 660 kw wind turbines with ancillary equipment for generation of electricity

& control building. Permission refused by Cork County Council. Refused by An Bord Pleanála, on appeal [04.108973] on 25/05/1999. The Board Direction/reason was given as follows: Having regard to the Guidelines for the Wind Farm Development as issued by the DoE and the location of the site in a remote, elevated and unspoilt exposed upland area in a rural scenic landscape of amenity, tourism, and recreational potential and visible from a public road which is a designated Scenic Route in the current CCDP, it is considered that the proposed large scale wind farm development would be visually obtrusive and out of character in the rural scenic landscape and would seriously injure the visual amenities and natural beauty of the area.... The proposed development would, therefore, be contrary to the proper planning and development of the area.

22/10/2003. Permission granted on the same site as above for five years, this time for a wind farm of 5 no. turbines, ( height of 76 metres not stated in Order) + ancillary: control buildings, substation & 40m wind monitoring mast . There were two subsequent revisions to the plans.

After not starting this project and a number of extended permissions, eventually planing permission was refused.

### **Goulacullin again**

This Wind Farm development by Statkraft was never in the public domain. Fehily Timoney Consultants applied to An Bord for a pre-application meeting re a proposed development of 9 turbines with a tip height of 167 m. (Case 317478-lodged 30.06.2023) These would be located at the western end of the Mealagh Valley, next to Derrenacrinnig West and Maughanacleas Wind Farm closely on the northern side. The application for the pre-application meeting was withdrawn 19.03.2024.

History and recent experience tells us that Statkraft will come back at some time in the future. This part of West and particularly the Mealagh valley have been earmarked by Wind Farm companies as area an area for development at the expense of the people of this community.

### **Ardrah Wind Farm**

The last Mealagh Valley application spanned over three years up to 2014, and is still well remembered by the people who live here. This was for a wind farm in the Ardrah townland, immediately on the West of the Maughanaclea Hills. It is so important to note that these same

lands have now been gathered into the present Enerco Maughanaclea proposal, but this history of this previous application is left out entirely, and is without even a mention in MKO's

application. Please refer to Appendix A & B which provides a longer precis highlighting the landscape issues that resulted in its final refusal by An Bord Pleanála in 2014 .

The Ardrah history begins in May 2011. The application was for a total 5 wind turbines with a height of 64 metres and rotor diameter of 71 metres, including all ancillaries. The planning reports are no longer available; however, it is note that application was given approval by Cork County Council in March 2012, after receiving 40 submissions offering observations objecting to the application. In the April, Unhappy with County Cork Planners' approval, residents from this East part of the Mealagh Valley appealed to An Bord Pleanala. A first report in the July, from

ABP Inspectorate raised a number of points that are very relevant in regards to the present proposal mainly about the effects on the visual amenity in the area. (For more details from his lengthy report, please see Appendix B.) His conclusions raised a number of points, including,

*'I consider that there are fundamental issues in the consideration of this proposal, relating particularly to the landscape and visual impacts of the development. The Mealagh Valley comprises a distinct landscape element, recognised in the county landscape character assessment as being of high sensitivity'.*

*'The site is exposed to views from a relatively wide area to the south and west, notwithstanding its relatively low elevation. Notwithstanding its relative scale, I consider that the proposed development, by reason of its overall exposure and cumulative impact on the character and amenities of the Mealagh Valley, would have significant negative impacts on the landscape and visual amenities of the area and its potential as a tourism and recreational resource.'*

The ABP Board decided at that time to request further information from the consultants, to be sure of their final decision. Atkins provided additional information to ABP in Oct 2013 and the same ABP Inspector wrote a supplementary report:, stating

*I have previously raised concerns with regard to the overall landscape and visual impacts of the proposed development, particularly on the character of the Mealagh Valley, when taken in conjunction with other permitted developments in the area. I do not consider that the submissions received have addressed there concerns and remain of the opinion that permission should be refused ...*

In July 2014, An Bord Pleanala gave their decision to Refuse permission. The refusal was due to 'significant negative impacts on the landscape and visual amenities of the area and its potential as tourism and recreational resource.' There was no appeal/ application for a Judicial Review.

The lands that would have been for the earlier Ardrah Wind Farm, have now come back to the fore of people's minds because the same landowners have now joined forces with Enerco to produce present application for a 'Maughanaclea' wind farm. It can be clearly seen on the consultants maps at least 3 of the proposed Wind Turbines are located in the area of the former application at Ardrah. Yet, all the lessons that could be gleaned from the ABP Inspector's

reports on the land's biodiversity, wildlife, soil etc, as well as noise report and considerations of visual impact, is not being considered at all.

These wind turbines will sit very close, in one case 250m, from the area classed as HVL, with a Landscape Value of Very higher value, Very High Sensitivity and of National Importance. The

previous application of 2012 for 7 Wind Turbine at Ardrah had been rejected by An Bord Pleanala on due to its the closeness to this HVL, area. The proposed wind turbines of 175 m, higher than those previously planned with will dominant this end of the Mealagh Valley.

### SCENIC ROUTES, RECREATIONAL ROUTES,

#### **Scenic Routes**

The MKO documentation works its way through various West Cork's scenic routes without really acknowledging why they are called such, and their value to the County and to Ireland. This is set out quite clearly in within GI14-9 CCDP 2022-28 in that they are identified as such to protect the 'asset' of views and prospects of great natural beauty for both residents and tourists. It states further:

*Each of the scenic routes was examined individually and their location related to the landscape character type traversed and some of the features lending themselves to the attractive nature of these particular routes identified. Scenic routes highlight the quality of the overall environment and landscape experienced within Cork County. It is important to protect the character and quality of those particular stretches of scenic routes that have special views and prospects particularly those associated with High Value Landscapes.*

*(GI)14.9.3 All proposals should be assessed on their merits taking into account the overall character of the scenic route...*

#### *GI 14-12: General Views and Prospects CCDP Objective*

*Preserve the character of all important views and prospects, particularly sea views, river or lake views, views of unspoilt mountains, upland or coastal landscapes, views of historical or cultural significance (including buildings and townscapes) and views of natural beauty as recognised in the Draft Landscape Strategy.*

#### *GI 14-13: Scenic Routes CCDP Objective*

*Protect the character of those views and prospects obtainable from scenic routes and in particular stretches of scenic routes that have very special views and prospects identified in this Plan. The scenic routes identified in this Plan are shown on the scenic amenity maps in the CDP Map Browser and are listed in Volume 2 Heritage and Amenity Chapter 5 Scenic Routes of this Plan.*

*GI 14-14: Development on Scenic Routes*

- a) *Require those seeking to carry out development in the environs of a scenic route and/or an area with important views and prospects, to demonstrate that there will be no adverse obstruction or degradation of the views towards and from vulnerable landscape features. In such areas, the appropriateness of the design, site layout, and landscaping of the proposed development must be demonstrated along with*
- b) *mitigation measures to prevent significant alterations to the appearance or character of the area.*
- b) *Encourage appropriate landscaping and screen planting of developments along scenic routes.*

*So Scenic Routes were first and foremost identified in order essentially to protect that which can be seen and already there. This is above any assessment as to potential changes to the landscape, which comes later under landscape sensitivity. There also seems to be a implicate precautionary principle here as to how proposals for any change or development may be viewed. MKO oddly evaluates 32 scenic routes in their report; however, hidden within the data two main Scenic routes, which affected by their proposal, seemingly treated the same as all the others. This section considers MKO views on Scenic Route 28 and 29 to illustrate just how far short they fall of the objectives set out in CCDP 2022-28.*

**Scenic route 29**

To be honest, after reading MKO's report regarding Scenic Route I had to shake my head in disbelief. The evaluation is very odd, giving an account of how a receptor (person) travelling along this route would experience varying extents of both the northern and southern turbine clusters. MKO's instant solution to any difficulties is this: *'Generally, a receptor (person) would have to turn their head to see either cluster' (WTs)*. Does this not instantly negate the whole purpose of a scenic route, in that people look around to enjoy the views and the scenery'? This solution is not just stated once, for travelling the centre of the route again, *'one would have to turn their head in either direction to perceive either cluster when travelling along this route'*. Basically if someone looks straight ahead, or possibly wear blinkers like a horse, they will not see the turbines. This is just bizarre, and if this was not so serious it would be funny.

Again with the centre section of the route, *'the proposed turbines have a significant visual impact but do not significantly impact the key scenic attributes of the designated scenic route'*. The sentence does not make a lot of sense, but breaking this down, MKO has accepted that the turbines will make a significant visual impact, and that is fairly obvious if you travel the route. Part of this significant impact is of course the reality of absolutely huge blades rotating high above the landscape of hills and mountains. These constantly attract the eye, and as you travel your eyes go from one turbine to another. This is a constant distraction away from scenic attributes and so is a significant change to the landscape.

Given that all scenes routes were designation was based on their landscape character type, it is important to note that it passes through the landscape of LCT4, which is Rugged and Ridged Peninsula and 15a Rugged and Peaked Uplands. There are views being remote landscape, with

a sense of remoteness as you travel the route, Prevalent and of rural character. The key attributes<sup>6</sup> of CCDP Scenic Route 29, also describes the route as travelling through High Value Landscape, the attributes of which I covered earlier.

MKO constantly suggests the trees and hedging and vegetation will hide the wind turbines from people view. They seem to forget trees, hedges and vegetation lose their leaves part of the year,

and in West Cork, trees, hedges and vegetation are cut back in the Autumn. Whilst, GI14.14 might *encourage appropriate landscaping and screen planting of developments along scenic routes* - houses and farm buildings are partially hidden - there is no appropriate landscaping

that could mitigate or hide a 169m turbine on a ridgeline! Again, the fact that MKO resorts to particular odd ways of seeing things all has one purpose - that of gaining planning permission.

The reality is clear the erection of 14 x 169m wind turbines is introducing an alien technology along this scenic route. It has a dramatic impact at many places along the route especially in the section drives past the two wind farm sites.

The SR29 is one of the main routes into this part of the Wild Atlantic Way, and the Cousane Gap is seen the 'Gateway', or as Failite Ireland says the 'Calling card'. For MKO, they envisage Visitors and tourists travelling this route to be welcomed by 14x169m operating wind turbines, which for most people will add to a major corridor of wind turbines along the R585. People purposely choose to travel a Scenic Route, because it has been assessed and advertised as such, and they would assuredly find contradictory to then be told not to turn to look to the side if they did not want to see what's on the hillsides. This is of course, if they are travelling during the day, because as night there is no choice but to see rows of bright red lights. Even as we travel now on the route of the R585, once past Coppeen many wind turbines can be seen and at night there is a bright red glow to the sky. Further wind farm applications are being planned along this route: and MKO make the point a number of times in their EIAR that this area is ideal for further wind farm energy developments. The effects of this are too hard to contemplate for the people who live here and the people who visit.

### **Scenic Route 28**

MKO agrees that a section of Scenic Route 28 will have full visibility: the section from Kealkill to the Keimaneigh Pass, and looking at an OS map this is fairly obvious. However, they state the negative visual impact will range from 'Imperceptable to Not Significant'. It's Double speak once again, as merely having full visibility strongly suggests that the turbines will clearly impact the very nature of landscape. In reality, many visitors to Googane Barra travel this route and will clearly see the turbines perched, and dominating on the Maughanaclea Hills. Again perhaps MKO's answer would be not to look.

### **Recreational Routes.**

MKO points out Recreational Routes are sensitive receptors as people are likely to be using them in a recreational capacity, so value is likely to be placed upon views and the scenic

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<sup>6</sup> Table 2.5.1 Scenic Routes-Views and Propects and Scenic Routes Profile Part 2 CCDP 2022-2028

amenities of the landscape. These routes are popular and draw many visitors to the area. Using MKO's own data there are 70 RRs within 25km of the proposed wind farm. Each route has the visibility assessed, possibly by AI, and certainly sitting at a desk top. MKO uses desk top searches to evaluate 'theoretical visibility' and Google Maps to assess the visual impact, which has its limitations.

There are a number of Recreational Routes (RRs) close to this proposal, and particularly close to the Maughanaclea Hills. MKO strategy here is not dissimilar to their approach to landscape values, by playing down the actual visual impact on the surrounding area they can give the impression that there will be little visual deterioration. As there are so many RRs, let's start by looking at one that is very close to the Maughanaclea Hills, that of RR 24: The Mullaghmesha

Loop. Importantly, this is part of the Sheeps Head Way, which is a national Recreational Route. The highest point on the loop is at the top of Mullaghmesha at 494m. Mullaghmesha is on the

Southern side of the Mealagh Valley, directly opposite the proposed Wind Farm sitting on the Maughanaclea Hills.

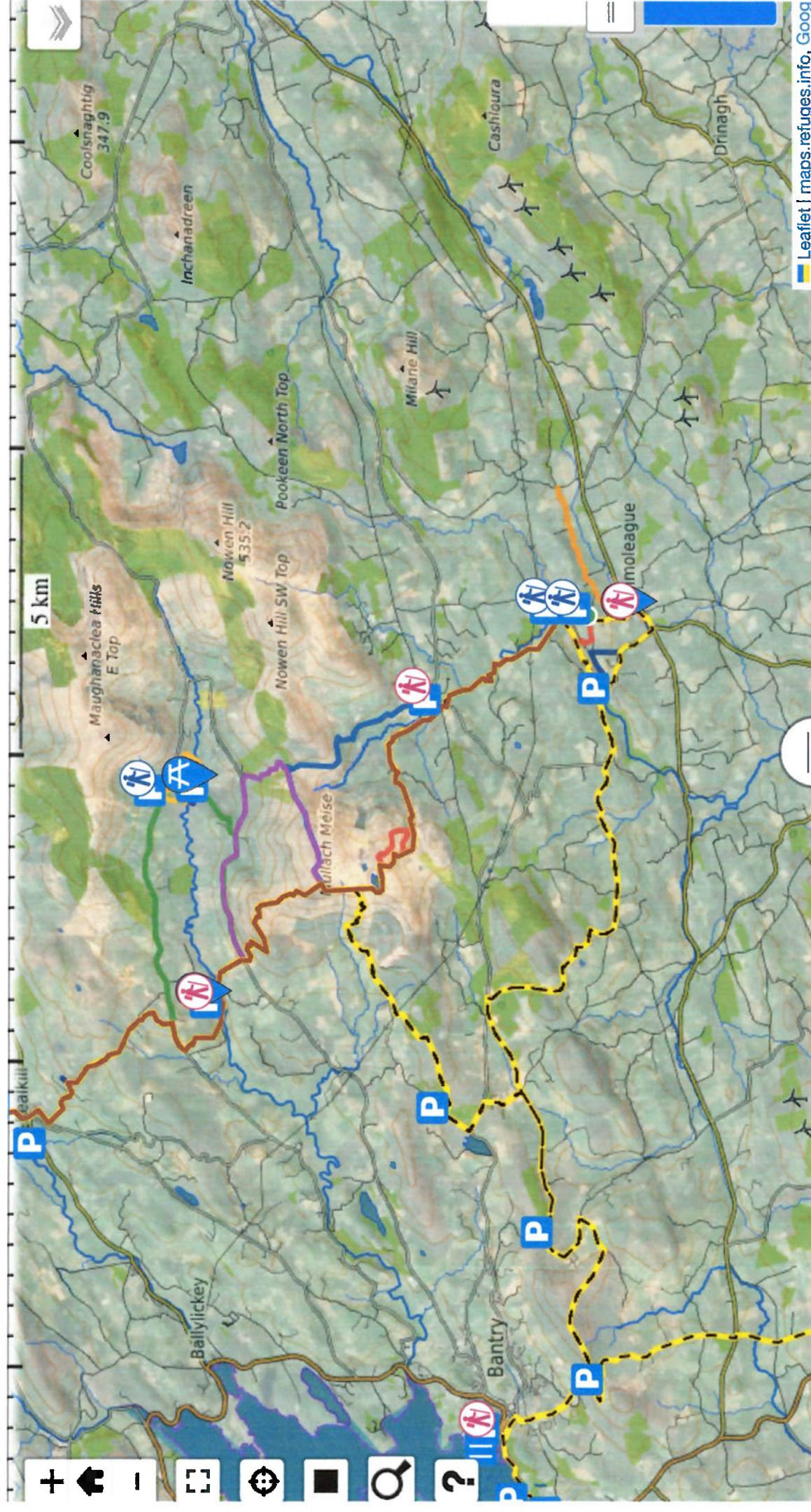
MKO using their theoretical visibility software, Actual Visibility says significant visual effects are not likely to occur. Well....this may be the case when there is low cloud. Having walked this route myself on a number of occasions, I have been trying to imagine eight 169metre high wind turbines with huge rotating blades sitting opposite on the Maughanaclea Hills at a hill height of 450metres. Walking on a hill at 494m, I can assure anyone that even the cranes and paraphilia of construction would have a significant visual impact on the landscape opposite, and will dominate the area for a considerable distance. When finished, and the turbines are operating, with their blades a-turning, the visual impact will be far greater still.

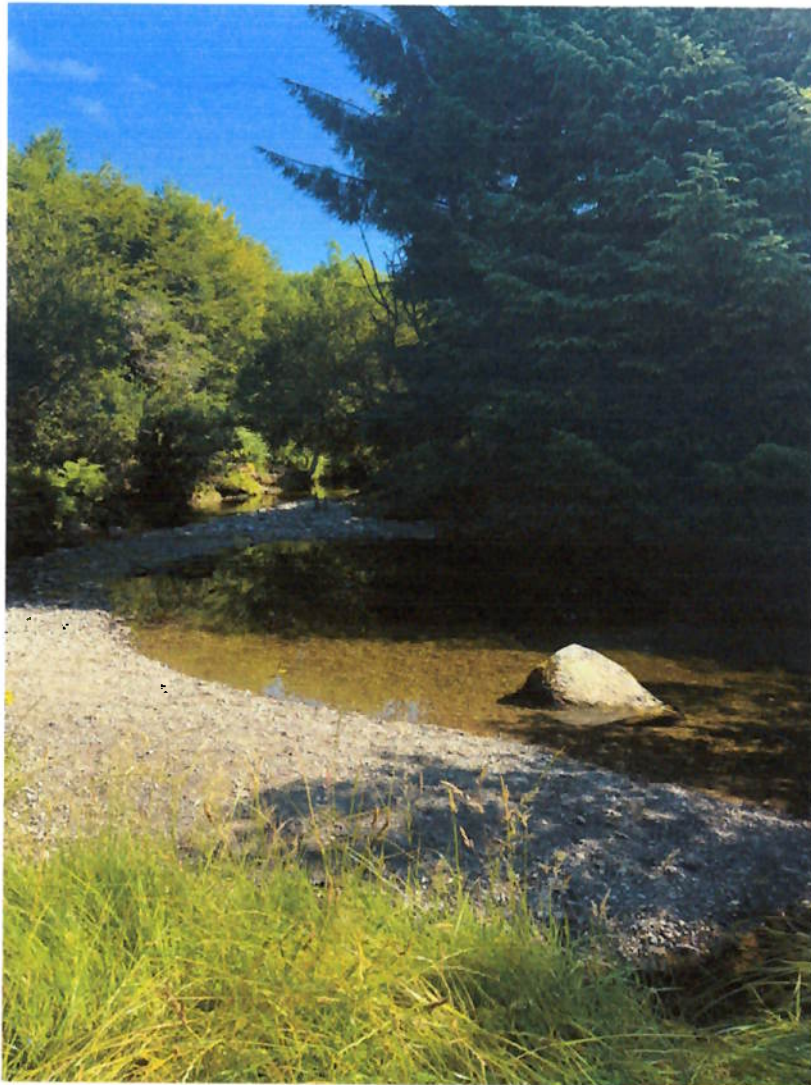
To say significant effects are unlikely to occur just ignores reality. Anyone with common sense would realise that this cannot be the situation. MKO have greatly down-played what will be seen by continually stating '*no significant effects*'. It is a clear precise strategy of down-grading the visible effect of the 8 wind turbines sighted on the Maughanaclea Hills. This is also setting a low-bench mark which MKO uses to judge the visibility of this wind farm along all the RRs.

All the other Recreation Routes' visibility and impacts have been judged against this low benchmark. Of the 70 recreational routes that MKO have evaluated, 40 of them will be impacted by this wind farm. MKO makes numerous judgements, *limited visibly, seen at a distance, unlikely to have a clear view, may occur*, and finally - *miniature*. What these all mean I have no idea as there are no definitions provided. To repeat, the strategy is to down-play the visual impact by using the same set of judgements. Using these terms constantly leads almost to believing that the assessments made by MKO are correct, and of course this is the intention. According to MKO, 6 and 8x169m turbines will not effect the visual amenity of this part of West Cork.

But we must not forget the most important Recreational Route: the nationally acclaimed Wild Atlantic Way. This time MKO pronounces a conclusion that these turbines will likely be seen along the coastlines. So, there is an acceptance that there are negative impacts, but 'only 11 km of the entire WAW exhibits full or partial theoretical visibility'. This does confirm that they have

it climbs the Shehy Mountains before ending at Gougane Barra. It is very strenuous in places, and need appropriate footwear and clothing. The route is marked with the Slá Bharra marker, and comprises a two day journey of outstanding scenic and spiritual reward. [Link to more information](#)





(Aside) Our natural swimming pool in Quinten's Mealagh woods.

Below: St Finbar's Pilgrim's Path from Drimoleague to Gougane Barra.

A cloudy day in the Mealagh



never visited and have made judgements sitting at a PC, using ZTV and Google Maps to make their judgements. According to MKO the turbines simply appear as small elements relative to the landscape, and its magnitude of change is deemed Negligible and Slight, resulting in residual visual effects of Not Significant and Moderate. The consultants appear to be adhering to the MKO mantra in respect of visual impact, it is 'Not Significant' and 'Moderate'. Somehow the landscape will accommodate the proposed turbines. What is very worrying is they add a little this time to the sentence, '*accommodate the proposed turbines....as well as other wind energy developments.*' Yet another example of a MKO mantra of saying it enough times and it becomes true.

The consultants have actually left out some recreational routes which are close by, One such is an important and popular walk of the Sheeps Head Way which takes in the Mullaghmesha Hills, which has two forks, one route heading to Bantry and the other route across the Mealagh Valley towards Kealkill and eventually to Googane Barra. Along this route the wind turbines of the Maughanaclea Hill would certainly be seen at numerous locations. They have admitted to another Route, that of Saint Finbarr's Pilgrim Walk, which also follows part of the Sheep's Head Way. The route has been opened up with the good will and hard work of local landowners. It takes Pilgrims and walkers over three mountain systems and four valleys, the Illen, Mealagh, Ovane and Lee Valley. The spectacular views of each part, a rich archaeological landscape, interesting folklore and characters ,make this an experience to be remembered. The proposed wind farm at numerous points will negatively impact on this experience by having a damaging visual effect.

In terms of the visual impact of these turbines there is an effect on Bantry Bay itself. Every summer cruise ships stop in Bantry Bay for a few days. It is a growing element in the tourism of the area, this year there will be 12 cruise ships Bantry Bay and they would clearly see the proposed wind turbines.

I have followed the Sheeps Head Way, especially along the top of Mullaghmesha on a number of occasions believe me the 8x169.5m operating wind turbines will clearly be seen the dramatically dominating not just the Mealagh Valley but wider afield, right to the coast line and the Atlantic. MKO evaluation of significant visual effects are not to occur, this evaluation must have ben carried out sitting at a desk top. MKO have set this assessment very low using it as a guideline for other RRs.

Clearly reality has been ignored again. You have to at an OSI map see the reality. Standing at the Mullaghmesha directly opposite the Maughanacela , nothing will stop you being the turbines. But it will detract from the stunning panoramic views of this beautiful area.

#### Cumulative Effect of this Industrial Size Wind Farm

Further, the 2006 WEDG describes an cumulative effect as;

*'the perceived effect on the landscape of two or more wind energy developments visible from any one place.'*

*'In terms of landscape character, additional wind energy developments might contribute to an increasing sense of proliferation. A new wind farm might also contribute to a sense of being surrounded by turbines with little relief from the view of them.'*

It is worth adding that 20 years have passed since the 2006 guideline were issued, subsequently turbines have grown exponentially in height raising concern about the impact on the receiving landscape and environment. It would be useful to look at the recent planning history in regards to cumulative effects on the area around the proposal at Maughanaclea project.

There has been several planning applications recently in the area, at Gortloughra situated on the R585 close to the Cousane Gap. 8x175m, refused by Cork County planners now on appeal with ACP. In the submission to CCC Planners it was pointed out, in terms of cumulative effect, that as far back as 2012/3 there were grave concerns regards the cumulative effect of the number of

wind farms in this localised area. When planning consent was given to Shehy More. (next to Gortloughra) The inspector's report raised the issue of a concentration of Wind Farms in the area:

*'The main concern I would have is the cumulative impact of so many existing wind farms in this one area...'*

*'While in many respects the area is ideal for wind farms, like any landscape it has its limits before the number of turbines fundamentally alters the landscape qualities in an unacceptably negative way. To a large extent this is a subjective judgement as there is no clear guidance nationally as to when it can be concluded that enough is enough. Clearly the appellants believe that they have been asked to accept too many turbines in one area, and I have a lot of sympathy for their concerns. .... I would conclude that for this appeal, the landscape has not yet reached its limits for capacity for windfarm developments, although it is quite close to a reasonable limit for what it can take before any further developments result in a strongly negative impact.'*

In addition to Shehy More, which is now operational, there are no less than four wind farm currently being proposed. Apart from 'Maughanaclea', within a few kilometres there is Curraglass (Enerco/ MKO) 3x150metres, after a long and chequered history it is presently on appeal with ACP. Recently at Derreenacrinnig 3x 119.2metres was given permission by Cork Planners, and is now on appeal to ACP. This is located on the south side of the Mealagh Valley opposite proposed Maughanaclea WF. Let's not also forget the proposal for Goulacullin for 8 turbines, situated just in the next townlands to the present proposal at the eastern end of the Mealagh Valley: this has been withdrawn for the present, but is likely to return.

The cumulative effect of these wind farms in such a tiny area will have a dramatic visual effect, and greatly affect the lives of people resident here. We are not a sparsely populated area in Ireland's terms, MKO states quite clearly there are 275 sensitive receptors (homes) in a 2km radius of the MKO/Enerco's project. This cumulation of wind turbines completely surrounding us is unacceptable in anyone's terms. As pointed out earlier, there have been other wind farm proposals in the past, and wind farm companies have apparently returned to target these areas

once again. It is interesting to note the 2023 survey of the Irish Wind Energy Association, that states:

*'Access to good quality sites for renewable energy generation is becoming increasingly challenging for developers as the most "optimum" sites are already secured'.*

This seems to be saying that the 'low-lying' quality fruit (Land) has all but gone. Does this explain why developers are considering sites previously refused?

### Scoping Exercises

We have here an accumulation of proposed wind farms in a very small area. Added to this, MKO constantly suggests in their EIAR that this location can take further wind energy projects, even though it is fair to say they already have a concentration of wind farms in West cork that are either operational, permitted or proposed.

*MKO 13.7.3.1 'the proposed turbines will be adding to the cumulative turbines in this LCT, as detailed in Appendix 13-2, an overall 'Moderate' residual landscape effect'.*

This shows once again the reasons for MKO attempting to change both the landscape value and sensitivity from High to an overall moderate. Yet again MKO are dismissing the agreed Landscape Characteristic and Values, as per the CCDP 20222-2028 which is not in their remit to do and not part of the requirements for an EIAR. Rather than working with these designations, they bring in their own.

To repeat, the Landscape Characteristic is LCT15a, Ridged and Peaked Upland, with a character area within, 72 Mealagh Valley, 18 & 76 Cousane Gap, 73 Ownane Valley. Within 250m of the proposed development is an character area LCT4, Rugged Ridge Peninsula, Very High Value and Sensitivity. Two thirds of the Valley from Bantry to Ardhard sit in the Very High Value and Very High Sensitivity area.

Looking at MKO's Maps of the Zone of Theoretical Visibility -13 and 14-, the significant negative impact of their proposal is clearly shown. It shows Curraglass 3, Gortloughra, 8 Dereenacreenig 3, then 14 Turbines for 'Maughanaclea' and we have a total of 28 Turbines already in this tiny area. Let's not forget the possibility of an additional Wind Farm at Goulacullin for 8 Turbines not yet in the equation, as this gives us a possible 36 turbines with 3-4km of each other. To quote again MKO states that the area can accommodate further wind energy projects. This cumulative situation will clearly cause a dramatic change in the landscape due to a concentration of extremely tall wind turbines in a very confined area. This significant impact will also be seen in areas of HVL status, as well wider afield.

Looking at map Figure 13-16 we get a fuller picture of the cumulative affect and impact within West Cork. There is approaching 300 turbines within a radius of 25km (just 15 miles) of a

'Maughanaclea' wind farm. I would add, this map is based on MKO own evaluations of the wind farms' significant impact on the landscape. MKO are making plain for all to see that this is the start of flooding this location with even more wind turbines with little consideration of the effects on the people who live here.

Studying the same two maps it become very clear the 'Maughanaclea' WF and the other proposals will be clearly seen from Landscape areas designated Very High Value, Sensitivity and of National importance. The proposed and surrounding area cannot accommodate 'Maughanaclea's 14 x169m high turbines without damaging the surrounding landscape and so is totally inappropriate for location proposed.

MKO's attitude and opinion to this dramatic change in our West Cork Landscapes is simple: it is not a problem because there are so many Wind Turbines in the area that people are normalised to them. However, this ignores other implications for the area regarding the environment , biodiversity, tourism and the health of residents in this part of West Cork. It is also a classic example of 'Shifting Baseline Syndrome' the greatest threat to biodiversity for years to come.

The consultants make wide sweeping statements without any foundations or evidence. In chapter and chapter, appendix after appendix there are direct or implicit statements that the 'large scale, expansive landscape is effectively capable of accommodating the proposed wind farm, as well as other wind energy developments'. I find this rather bizarre: how can fourteen x 169metre high turbines, with moving blades of a huge diameter, blend in with a remote, landscape with some elements of forest and farming. They negatively impact not just the visual aspect of the landscape but the entire environment as whole. It's an alien industrial technology clashing with a receiving environment that has nature in its very core .

The ACP Inspectorate now has the role of addressing all of this, and perhaps it is best to start with simple essentials in noting that, despite MKO's propositions to the contrary, that the objectives for County Cork's 'Open for Consideration' areas must first be met. The Application, Planning Report and EIAR must demonstrate clearly that its proposals can avoid adverse impacts, one of which is

- *Visual quality of the landscape and the degree to which impacts are highly visible over wider areas.*
- The documentation must also demonstrate its due consideration of the cumulative impacts of such proposals.

This is only the first hurdle the consultants have to clear to convince the ACP that the Maughanaclea hills and Shehy Mountains are 'appropriate locations', taking into account CCDP 2022-2028, which of course they clearly are not.

In their misinterpretations, MKO are clearly advocating a free for all, this attitude is bourne out by their mis-interpretation of the Supreme Court ruling.

Conclusion.

The Maughanaclea Hill dominant the two valleys differently. On the Kealkill along the side the valley is followed by the R585, incorporating the scenic route 29. It travels through a wide vista of widespread and expansive views. On the Mealagh Valley side totally ignored by MKO. The Mealagh valley is unique in the area. It is a U shaped valley, at the western with high hills on three sides that form an enclosed area only 3km across. The eastern side of this part of the valley is open with views Atlantic Ocean. This part of the valley will be totally dominated by the proposed 8x169m turbines. Looking westwards two thirds of the valley are designated HVL, and will clearly be dominated by this development.

That's remind ourselves of the issues that MKO has tried very hard to ignore and change the CCDP 2022 to 2028, to gain planning permission for their project. In their scoping exercise,

MKO would have been aware of the previous planning history, but decided to totally ignore the past rulings regards to wind farms.

MKO has used their own interpretation of the recent Supreme Courts Judgement to suggest that the CCDP 2022-2028 has been overruled allowing them to dismiss the county planning objectives. The fact is the Supreme Court reaffirmed the role of Countries Development Plan, they ruled that that the National Climate Action Plan has been incorporated into county development plans, in our case County Cork Development Plan 2022-2028.

The basis of MKO application also rests on them changing elements of CCDP 2022-2028. Which is not in their remit . The 2020-2028 CCDP clearly states that he the proposed Wind Farm at Maughanaclea sits well within a Character Area, Type 15a: Ridged and Peaked Upland, (Mullaghanish to Millstreet) . Landscape Value High, and Landscape Sensitivity High. High Sensitivity landscapes are vulnerable landscapes with the ability to accommodate limited development pressure. In this rank, landscape quality is at a high level with landscape elements which are highly sensitive to certain types of change. The proposal for 14x 169m Wind Turbines fits the description of highly significant change to the landscape.

MKO makes the point, 'the overall landscape value and sensitivity of the site is deemed to be medium'. I have not been able to find this statement in CCDP its obviously its MKO own opinion, they further add 'residual effects are deemed to be moderate'. Throughout the Landscape Section of their EIAR MKO continually sets a different landscape sensitivity value that is stated clearly in in the CCDP 2022-2028 as High. A recent planning application nearby at Gortoughra , where the location had exactly the same landscape designation, a refusal was given. MKOs strategy is clear, if we repeat our own sensitivity values median/moderate, eventual the whole landscape will be seen differiatey.

The visual effects of this Wind Farm will dominate much wider expanse than the Mealagh Valley and will add to an overwhelming cumulative effect, in this part of West Cork. Not for the first time MKO suggest the visual impact will be slight or not significant. Again we MKO continually repeating these words or similar to change what people think they can see. It is clear that there is no ending in sight as in the MKO's EIAR they suggest that this area of the Mealagh valley and wider landscape is ripe for further Wind Farms. To quote MKO again, there are so many wind turbines in this area that people accept them and do not see them anymore.

The reality is clear, this location cannot accommodate or absorb such a large industrial proposal 14x 169.5 m turbines without radical changing the remote landscape which is designated as High Sensitivity.

#### What Next ?

This proposal is not appropriate for this location which is bourne out by MKOs rewriting elements go the County Cork Development Plan 2022-2028. Why di they do the, simpleMKO know that this is an unsuitable site. They have ignored the existence of the Mealalag as well the previous planing history.

The only way forward is for the ACP to refuse this planning application as it clearly it is a unsuitable location. ACP decision also need to consider the previous history as a precent in regards to wind farm has been set by previous BaP decisions.

### Wind Turbine Noise and Health

Wind turbine noise and its resulting nuisance along with the health problems have been ignored by wind energy industry. Enerco and MKO follow that same line, ignoring the most up-to-date evidence available. They continue to use what many see as outdated regulations WEDG 2006 and ESTU-R-97 which are no longer fit for purpose. MKO in their conclusion on Noise Chapter 12: Table 12-30 clearly refers to just these.

Recent High Court Judgements have not prevented developers and consultants, such as Enerco and MKO, carrying on regardless ignoring a growing body of evidence and High Court rulings. The professional way forward would be to take a more precautionary approach to wind farm development. However, in the case of Maughanaclea's wind farm they continue as nothing has happened and general ignore the barriers to their proposal.

### High Court Court Judgments.

Recent cases in the High Court has supported the view that Wind Turbines can cause a noise nuisance and raises questions over the use and validity of WEDG 2006 and ETSU-R-97 guidelines. The court cases arise from the failure to properly assess and deal with wind turbine noise nuisance: the High Court found in the cases of Webster and Rollo, and Shorten and Carry v Meenacloghspar Wind Ltd, that the WEDG 2006 and ETSU-R-97 noise criteria and noise limits do not protect residents from noise nuisance.

This means MKO's assertion in using WEDG 2006 and ETSU-R-3 is incorrect in thinking that residents being surrounded by the proposed wind farm will not be affected by noise from the turbines. MKO and Enerco would be well aware of the Courts' rulings but have decided to ignore the implications. Further, MKO had been asked in the pre-application consultation meeting to include any available up-to date research (and reviews on health impacts) post 2015, and it is apparent from the EIAR Chapter 12 on Noise and Vibration and its appendices, that they have failed to do this in any meaningful way. <sup>1</sup>

In the case of Byrne and Moorhead v ABO Energy Ireland Ltd it was established that noise nuisance of a profoundly disturbing nature can be experienced in a home over one kilometre from the wind turbines. Again, this challenges the assumption that MKO makes that no one will be affected by turbine noise.

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<sup>1</sup>p.5 of 6. Record of Meeting ABP-321826-25. Case type: Pre-Application Consultation.

Participants included Alan Clancy MKO, Ciaran McKenna MKO, Ciaran Fitzgerald MKO, Susan Doyle MKO, Sean McCarthy MKO, etc plus William O'Connor and Niall Galvin: Maughanaclea/Enerco.

In the High Court case of Webster/Rollo, the Court travelled to the properties to hear for itself. The Court heard recordings, from different times, differing conditions, and different times of the day. The Court concluded that the method of noise assessment had been deficient and that noise conditions were purely based on the use of simple decibel limits. The noise was of a character, volume and frequency of occurrence that it interfered with the ordinary use and enjoyment of the two sets of plaintiffs in their homes.

### Wind Turbine Noise

Let's begin by having a closer look at the noise generated by wind turbines.

The World Health Organisation recognises that the noise emitted from wind turbines has a number of characteristics, the repetitive nature of the sound of the rotating blades, and atmospheric influence leading to a variability of AM, which can be a source of above average annoyance. Separating this out:

#### Acoustic Characteristics

'Acoustic characteristics are those features of noise that contribute to its perception by people in addition to the noise level', WEDG 2006. There are no provisions in WEDG 2006 for any acoustic characteristics, such as Amplitude Modulation. There again, there are no penalties in ETSU-R-97, which supports WEDG 2006, for AM.

#### Amplitude Modulation

Amplitude modulation is becoming more of an important issue for those living close to wind turbines. Two categories of wind turbine AM have been identified.

In the context of wind turbine sound, amplitude modulation usually refers to the periodic fluctuation of the broadband aerodynamic sound emitted from the interaction of the rotating blades with the surrounding air.

This characteristic of wind turbine sound may be described as 'swishing', 'whoomphing', 'lashing' etc, depending on the sound frequencies that exhibit the largest fluctuations<sup>2</sup>. This often referred to as 'Normal AM.'

Lower frequencies from a wind turbine will produce a sound character called a 'whoomph or thump sound, often referred to as 'abnormal AM'.

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<sup>2</sup> WSP Department for business, energy and industrial, Project Report 2023, UK.

Wind turbines react to the power of the wind, which is not constant and it has its ups and downs. AM reacts in a similar way to the wind power: the AM wave changes in frequency, raising a number of problems for those living close by. AM from industrial wind turbines can be variable, it is not constant in its tone, its power and the frequency changes with the wind. It is these characteristics that causes what the courts define as nuisance. The changeable nature of AM attracts a person's attention and it becomes a very strong source of distraction and nuisance.

There are many other sources of AM, such as the hum from a fridge which is constant. Humans can easily adjust to this form of AM, eventually we accept it as part of the present background noise. However, the World Health Organisation (WHO) points out that noise from wind turbines has other characteristics, including the repetitive nature of the sound of the rotating blades and atmospheric influence leading to a variability amplitude modulation, which can be a source of above average annoyance. *'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'*<sup>3</sup>. It should also be noted that relying on specific decibel limits does not address the problem of AM. The approach of imposing decibel limits alone when seeking to provide protection for a residential amenity, from the adverse effects of noise coming from a wind turbine noise, has been tried and found wanting.

It is now accepted that wind turbines produce AM which it can penetrate into peoples homes. however, the wind farm industry appears to still deny that it is a problem and hide behind outdated thinking and evidence as well as using the 2006 guidelines.

There was a review of AM carried out in 2018, by WSP on behalf of the UK government. The review concluded *'that there is sufficient robust evidence that excessive AM leads to increased annoyance from wind turbine noise'*<sup>4</sup>. A further review of noise guidance for onshore wind turbines was carried again by WSP in 2023,<sup>5</sup> *'it has been demonstrated that annoyance responses are influenced by AM characteristics in wind turbine sound, and that AM may be the most annoying characteristic of wind turbine sound'*. Noise annoyance thresholds were similarly reviewed: *'the evidence reviewed suggests that there is greater quality and quantity of international evidence on noise annoyance associated with exposure to wind turbine sound than was available at the time of the WHO review in 2018'*<sup>6</sup>

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<sup>3</sup>WHO Environmental Noise Guideline for European Region, 2018

<sup>4</sup> Wind Turbine AM Review Department of Energy & Climate Change, UK 2018.

<sup>5</sup>A Review of Noise Guidance for On Wind Turbines, Department for Business& Industrial Strategy UK 2023 shore

<sup>6</sup> A Review of Noise Guidance for Onshore Wind Turbines, Department for Business& Industrial Strategy UK 2023

The review confirmed that there is more than one form of AM and a range of complex interacting factors can influence its generation and character and annoyance responses are influenced by AM characteristics in wind turbine sound.

Despite this 2023 review, MKO go to great lengths to explain their assessment and rating of noise from their proposed wind farm by using guidance ETSU-R-97 (ETSU 1996) and IOA GPG (IOA 2013). They state that their noise assessment is based on guidance contained in Guidelines (DoEHLG 2006) guidance, adding that using ETSU 1996 supplements Guidelines 2006. This is now considered well out of date and not fit for purpose. WSP's evidence review has identified a substantial body of evidence published since ETSU-R-97 and IOA GPG that could inform and update the agent's assessment at will, but MKO does not avail itself of the following findings.

WSP's 2023 noise guidance points out that since the ETSU-R-97 was published, there is increased understanding of the range of physical and operational factors that influence wind turbine sound. Amplitude modulation, AM, has been reported as impacting on people beyond the extent that was considered acceptable at the time of ETSU-R-97. The research indicates that the underlying basis for the ETSU-R-97 limits are firmly outdated. The common application of the ETSU-R-97 noise limits as a binary test of acceptability is considered inconsistent with wider policy frames. Additionally research suggest that the assumptions about AM adopted in ETSU-R-97 do not adequately represent the nature of AM as experience and measured.<sup>7</sup>

Clearly current guidance does not fully address the the impact of AM produced by wind turbines. Assumptions about AM adopted in ETSU-R-97 do not adequately represent the nature of AM as experienced and measured. But, MKO constantly ignores the accepted issue of wind farm AM annoyance. Even the draft 2019 Guidelines state, ' while AM can occur over extended periods of time it tends to vary in intensity adding to the annoyance. Adding in the WSP, AM review, it has been established there is a clear link between the overall turbine noise level and annoyance.

It also confirmed that the sensitive period for wind farm neighbours to AM coincides with operational conditions (between sunset and sunrise) where the prevalence of AM occurs. This raises the question about whether the noise limits in ETSU-R-97, which are generally higher at night will produce significant adverse noise impacts on the surrounding area. The World Health Organisation Guidelines 2000 in respect of Noise in general, states:

*'The most important factor affecting a persons reaction is the time of exposure . The results of an international field study show that people wish most of all to have peace*

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<sup>7</sup> WSP Brief non technical summary

*during nights, evening and weekends. The annoyance caused by noise increases if the exposure is not only during the daybed during the evening and night.*

Further, WSPs research suggests that the most apparent difference between ETSU-R-97 and overseas national or regional guidance and regulations, is that the ETSU-R-97 night-time minimum noise limit is less stringent (lower) than the daytime. This study has found that this situation appears to be unique to the UK and Ireland. In 2019, the Government of Ireland published draft revised guidelines these will hopefully be revised further in the 'new' guidelines due in 2026. There is every indication that the Government is proposing to replace the existing noise limits with a regime that would effectively ensure that night-time limits are lower (more stringent) than the daytime.

But presently, even with Ireland's 2019 draft guidelines, they clearly state that the maximum noise limit of 43 dB(A) (being consistent with WHO) should be applied to new wind farms. As MKO constantly states that they are following best practice, why do they then ignore the 2019 Guidelines? Yes, they may be in draft form and at present under review, but new guidelines are not likely to increase the noise level above 43dB. It appears that this statement by MKO contradicts the Governments proposed noise guidelines, that follow the recommendation of WHO. This leaves me with the question why not at least accept and follow the 2019 noise level recommendation?

The World Health Organisation produced Noise Guidelines for European Region 2018. The difficulty WHO faced was the lack of quality data and evidence regarding wind turbine noise and its effects, even though the issue of wind turbine noise was well known. However, wind turbine noise exists, therefore WHO applied a series of 'conditional recommendations' regarding noise levels. To counter negative health effects wind turbine noise, the 'conditional recommendations' are to reduce noise exposure from wind turbines to below 45dB, as wind turbine noise above this level is associated with adverse health risks. MKO, based on a review, not quoted or cited, states that this recommendation, of below 45dB, should not currently be applied as a target for existing or proposed wind turbines in Ireland. They give no reason for this statement, and it seems that MKO are again blocking any positive recommendation to reduce noise nuisance for sensitive receptors that will suffer the consequences.

#### Considering MKOs conclusions.

At 12.6.3.1.1, MKO states again that *'the predicted noise levels associated with the proposed turbines are within best practice'*. This statement is incorrect as already pointed out. Knowing that extensive research into wind turbine noise has shown a significant negative effect on people, I would have thought that MKO would act more professionally and at least adopt the

Draft 2019 guidelines in the respect of noise, a maximum limit of 43dB, even though they are presently subject to review. MKO certainly does not work to the 'precautionary principle' which advocates noise should be reduced to the lowest levels achievable in a particular situation. Where there is more than a possibility that public health will be damaged, action must be taken to protect public health without awaiting full scientific proof.

MKO's answer to any likelihood of noise and nuisance problems is always that it rarely happens, and the difficulty is that it cannot be anticipated or assessed in the 'planning process'. This is not acceptable or good enough. Companies like Enerco and consultants such as MKO have been planning, erecting and running wind farms for at least 20 years, if not more. When turbines are upgraded or replaced it is always explained that the new models are quieter than the old, so the industry is well aware of this - from the manufacturer to the developers to the operators. They know from their experience and the complaints received what turbines, what layouts, what landscape topography and other conditions causes AM. The problem of AM can be resolved at the planning stage if there is the will to do so, rather than showing off a complaint procedure that they simply will put in place. The issue is the constant denial of the AM problem by the onshore wind energy industry and the large development companies in particular.

If MKO wishes to actually follow best practice, I suggest that this means following the precautionary approach to protect residents from foreseeable problems. MKO's assessment simply states, with very little evidence, *'the operational noise from the development is therefore rated as negative but not significant'*. A common case of verbal gymnastics in regards to their constant evaluation of *not significant* used by MKO throughout the entire EIAR.

Before leaving this section it is worth looking at the Acoustics Consultant's report that has been commissioned. My own views concur with his, and I just include two quotes that encapsulate my thoughts.

*'What this development will do is introduce an alien noise into a predominantly rural area. The statement that the predicted levels "will remain low" is merely an assertion and I suggest that many people would not consider a turbine level of 40dB in an otherwise quiet rural area as low.'*

*The development is more likely to meet the definition of Significant Effect, which is defined as, 'An effect, which by its character, magnitude, duration or intensity alters a sensitive aspect of the environment'. This is a 'better description of the new alien turbine noise coming into a quiet rural area'<sup>8</sup>.*

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<sup>8</sup> Dick Bowdler, Acoustic Consultant, p12, Independent Report Submitted.

## Infrasound

It is important to investigate the emerging issue in terms of noise: the production of infrasound. It is suggested by wind farm developers and their consultants, that as humans, 'we cannot hear it so it cannot harm us'. A rather disconcerting comment from supposed professionals, and reminds me of a piece of history when it was once said that radiation cannot kill you as we cannot see it. We now know differently. However, it is also a strategy that some industries have used on purpose, for instance the tobacco industry stood proud for decades saying: smoking can't kill. Clearly there is a strategy being used by MKO and the wind energy industry in general to dismiss peoples' concerns about the impact on their lives and health. 'It's all in the mind', is the latest suggestion promoted by wind farm industry. We all know differently.

There are major concerns regarding wind turbines generating Infrasound. Infrasounds are sound waves below 20 Hz frequency, which the human ear cannot typically detect, although many animal species can hear these sounds. Infrasound can travel long distances and have a lot of energy, sufficient to pass through some materials. Whilst we cannot consciously hear infrasound, it can create and trigger physical sensations like pressure in the ears, nausea, dizziness, or even anxiety as well as sleep disturbance. The World Health Organisation (WHO) agrees that wind turbines generate more infrasound or lower frequencies of sound than traffic sources. However, few studies relating the effect of such noise from wind turbines to human health are available.

Evidence suggests that infrasound is a hidden danger in terms of its effect on humans. It is out of the range of normal human hearing. The wind energy industry seems simply dismisses this as a problem and similarly, peoples' concerns are set aside and even if they are provable, given potential legal costs of higher courts tend to protect wind farm companies from challenges. The dismissal of infrasound happens even when Infrasound research has shown, *'that under specific atmospheric conditions, especially during the night time hours, sound generated from wind farms can propagate distances of several tens of kilometres'*<sup>9</sup>.

Infrasound remains a blind spot in Regulations that govern sound, as the noise is measured in A-weighted decibels dBs. This weighting is not suitable for frequencies below 125 Hz. The basis of dismissing Infrasound is the use of A-rating which is used to measure environmental sound. The A-rating process emphasises the frequencies to which the human ear is most sensitive which filters out below 20Hz.

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<sup>9</sup> Journal of Geophysical Research: Infrasound generated by wind farms, 2015.

David Ecotièrre, the Deputy Director of the Environmental Acoustics,<sup>10</sup> *'We researchers measure infrasound in unweighted dBs<sup>11</sup>'*. He believes another weakness is that variability is not sufficiently accounted for in preliminary assessments for new industrial installations, wind farms in particular.

*'We know how much the topography of the site—as well as local atmospheric conditions such as wind, temperature gradient, and the nature of the soil -(hard or soft, wet or dry)- impact the level of noise perceived by local residents.....'Headwinds tend to deflect sound waves towards the sky, while a tailwind will push them toward the ground and increase the noise level'.*

*'The temperature gradient, or the difference in temperature between the ground and the air, will also deflect the sound wave, or on the contrary push it downward'*, elaborates Ecotièrre. For instance, at night time, when there are thermal inversions between the ground and the air, sound generally tends to be pushed toward the ground, thereby increasing the noise level around the sound source. This is true for both high frequencies and infrasound.

Ecotièrre concludes that infrasound, *'has an impact on health, and therefore the legislation governing noise and applicable standards should therefor change considerably'*. It is worth noting that the set back distance in France is 1.5Km, and not 500m or 4 times tip height.

#### Residents' Distances from Wind Farms- Set Back Distances.

Since the early days of wind turbine development, the wind energy industry has continued to deny that there are any health risks for people living close to wind turbines. Returning to current regulations for Ireland, WEDG 2006, a sensitive receptor can be as close as 500 metres to a turbine, and this can feel closer depending on the location and the geological features of the location. The wind farm industry uses very dated research, commissioned by themselves, in order to dismiss evidence of the damage being done to peoples health living close by.

The distance from a wind farm has been used as a proxy to determine audible noise exposure. However, in addition to the distance, other variables - such as type, size and number of wind turbines, wind direction and speed, location of the residence up-wind or downwind from the turbines and so on - can contribute to the resulting noise level assessed at a residence. Further, using distance from a wind farm as a proxy for noise from wind turbines in health studies is associated with high uncertainty. Looking at MKOs/ Enerco proposal it ignores the varied environments, taking for example the topographical formation of the Mealagh Valley and the

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<sup>10</sup> David Ecotièrre, Deputy Director UMRAE, France, (taken from article-Infrasound, Laurie Cailloce 2024

<sup>11</sup> Infrasound, sound waves that nothing can stop. Laurie Cailloce 2024

unpredictable weather flowing down the valley from the Atlantic. The plan is for Eight 165 m turbines in a row situation along the ridge of the Mealagh Valley, overlooking and overpowering a numerous number of homes. Many of these are downwind and west of these turbines, creating the possibility of serious noise nuisance and possible ill health due to poor sleep and stress. Yes the turbines are a little over the 1Km point; however, as pointed out earlier the High Court said that noise nuisance goes beyond that distance.

Certainly, WHO suggest there are serious issues with noise exposure assessment related to wind turbines setback distances. They state that there is no clear evidence on an acceptable and uniform distance between wind turbines and residential areas, as the sound propagation depends on many aspects of wind turbine construction and installation. In many many instances the distance from a wind farm has been used as a proxy to determine audible noise exposure.

### Construction Noise

Moving on, this section of the EIAR is a prime example of MKO/ Enerco's attitude towards the residents surrounding this construction site. It is worth being reminded that this area is not sparsely populated; according to MKO themselves, there are 275 homes within 3Km of the wind farm there, and within 2Km, 225 homes. Therefore using the government's own average household of 2.75: within 2 Km there are 618 residents, within 3Km there are 756 residents. Essentially not a small number at all, and it is plain to see that MKO tries to hide this by using their own much wider study area.

MKO uses the strategy of denying there will be any '*significant noise*' from the construction phase. Looking at 12.5.2.1.1 Noise, the first point is their statement '*foundation works are anticipated at a significant distance from the closest noise sensitive receptors*', another typical MKO example of verbal gymnastics. They know how close the proposed foundations will be from the nearest sensitive receptor, it is not a significant distance, in some cases it is less than 1000m. Their assessment considers the worst case and construction noise levels will be lower at properties located further from the works. Really, what an insight, it is obvious the further away you are from the noise source it will not be as loud!

At the end of their Noise section 12.5.2.1.1 the last paragraph says, '*it is concluded that there will be no significant noise impact associated with the construction of the proposed turbines, hardstanding*' .....'*no specific mitigation measures are required*'. A very bold statement to make considering there is no evidence presented. How do they come to this conclusion? Again the statement is not supported by any tangible proof: it seems we must rely on their simple statements of denying construction noise, and accept the fact that there is no mitigation method to be adopted - not even this time a complaint process.

#### 12.5.2.1.2 Vibration

Let's look at their assessment concerning vibration, *'likely level of vibration from this activity (breaking and exploding rocky ground) is expected to be substantially below the vibration criteria for building damage'*. The important point to consider is that it is not even building damage that is the issue, it is about the damaging effect on peoples' lives for up to two years of heavy construction works. A simple question for An Coimisiún Pleanála to ask: where is the data and evidence to prove this statement? As usual, MKO make a very vague statement at the end of the paragraph regarding vibration, by saying *'will be no substantial effect'*, to convince us again to accept all that they say without question. MKO continually repeats, without any evidence, its own particular phrases such as, *'no significant effect'*, so that eventually every one will accept it as the norm, such as at 15.2.3.2 saying, *'there will be no significant vibration impacts....no specific mitigation method will be required'*. Over and over again, MKO repeats their unsupported claims.

#### 12.5.2.4 Borrow Pits

The developer's contractors will be using machinery and explosives to create large holes in rock to take the foundations for the turbine. Lets not forget the large borrow pits, especially the one located high up along the ridges, and above the heads of people in the Mealagh Valley only 1000m away. This sudden very loud blasting and constant pile driving will have a dramatic effect on the lives of anyone living below this area. It is a totally inappropriate place to excavate a burrow pit, being so close to people.

The final example of MKO's total dismissal of the residents is their hours of working. They state with authority that the hours of working *'will be limited to avoid unsociable hours, where possible. Construction operations will be restricted to 7:00hrs to 19.00 hours, six days a week'*. That is 12 hours a day 6 days a week - and this according to MKO is avoiding *unsocial hours*. It means that we will wake up to heavy construction noise at 7.00am and have to put up with it until 7.00am at night, and they have not mentioned the delivery of turbines at night. MKO also fail to mention when the weather is good the working day may be longer. They dare to call this situation *'not working unsocial hours'*, perhaps it is for the High Courts to decide whether this situation is sociably acceptable?

Using MKO's own figures there are 45.5% of retired people, and 10.7% unable to work This is well over 50% of the population of affected areas, who spend at lot of time at home: what awful days we are going to have. We cannot go out every day, equally bearing in mind we are in our mid70s, two years of very heavy construction work is a long time. Talking to people who have

experienced this situation, they had one word to describe a similar construction period: 'HELL.'

Just one more point about construction noise I do not suppose for one minute MKO has ever monitored the effect of machinery noise and explosions on the wildlife in the area who are susceptible to noise and sudden blasts. More damaging effects on wild life and biodiversity in general.

Throughout this section of the EIAR, MKO make repeating statements without any real evidence such as there are *no significant effects/ impacts*. They supplement this statement by stating they will be using best practice. The very beginning of a best practice would be a precautionary approach to construction and to consider the effect on the large number of people who be affected by this large construction site.

#### Conclusion of this section on Noise.

It is now recognised by the High Court as well as other bodies, ie WHO, that wind turbines can generate a noise, AM, which can have a significantly negative impact on its surrounding residents. MKOs/ Enerco proposals for Maughanaclea include 225 homes with 2 Km increasing to 275 homes at 3Km, around 756 residents. If MKO studies its own maps, the company can see clearly the numbers of households that will be affected. The lead consultants know that they are building up falsehood after falsehood in continually stating throughout their EIAR, that this is a sparsely populated area.

Equally MKO have ignored the quietness of many of the areas surrounding the sites. They have not given due regard to the noise issues and have failed to consider the implications to the surrounding residents. Instead, they just made a blanket statement that 'there is no significant noise problem', whilst providing little evidence to support their claim.

MKO's entire noise report is not fit for purpose, it is simply a case of denying up to date evidence, and the High Courts' rulings that wind turbine noise such as AM can at least cause a recognised nuisance. Due to the strong possibility of noise nuisance and the possible resulting health effects this proposal is not acceptable and is inappropriate for the proposed Maughanaclea sites. MKO have shown a complete lack of professionalism by not accepting clear evidence that there are negative implications for the hundreds of residents surrounding this proposal.

The noise report submitted by MKO is significantly lacking in its assessment and conclusion, and therefore the Inspectorate in carrying out the EIA should reject the EIAR presented.

My own Concerns

I live on the edge of the 1km, boundary (1000 metres), at HO75. However, looking at MKO map, the road follows the 1km line and other households will be equally effected by turbine noise such as AM at some point. I can include HO66, HO87, HO82, HO81, H108, HO78, HO64, HO62, HO38, HO47, HO21, HO43, HO58, HO28, HO41, HO26, HO59, HO32, HO56, HO42, HO46, HO56, HO42, HO57, HO71, HO61, HO69, HO71, HO84, H104, HO89, H205, H126.

My property (HO75) sits below many of the turbines, in particular T12, T13 and T14 which are down wind of the prevailing westly wind. I and many of my neighbours am in a similar position experienced at Wexford, which will be the source of any possible noise nuisance.

Where we and our neighbours live: Gortnacowly in the Mealagh Valley, seemsto be the very sister of the valley described in the Rollo & Webster High Court Case:

*(504) (48)...a quiet rural valley close to the Sliabh Bhui mountains in County Wexford. Ms Webster's evidence is that, absent of the Ballyduff turbines, ambient noise is generally characterised by the sound of nature. The rear elevations of HH and NF are shelters from the prevailing SW winds by a high hill on which the turbines are placed...(50) [they thought] that because of their location in a sheltered valley HH would be shielded from impact. It was the opposite..... (51) the wind turbine noise is annoying and ever changing: varying with the wind speed: the faster the rotors turn, the worse the noise... the time of day and the weather impacts on the intensity of the wind turbine noise.*

To be clear, the offending Ballyduff turbine is over a 1Km away and up on a hill, higher than Ms Webster's house and the house is in a south westerly direction from the turbine. The turbine is much shorter than the 169.5m planned for the Mealagh Valley, and this noise nuisance of thumping and whoomphing was from only the one turbine. In contrast, MKO/Enerco plans to erect 8x169.5m turbines in the Mealagh Valley. These turbine would be situated on high hills and ridges and above receptors to the North and South. With strong winds blowing form a Westerly direction form the Atlanta the same noise nuisance would be heard. Even if winds turn and blow from the East, as they do occasionally, again the effects will be similar, just from different turbines.

This already proven vulnerability from the High Courts shows that T11, T10, T9, T8, T7, as well as those for Ardrah, would not be in appropriate or acceptable locations. An Coimisiún Pleanála, in following the precautionary principle, has firm grounds for refusing permission due to the turbines being a potential noise nuisance to the 'receptors' at a lower level on the Maughanaclea hills.

It is not just the operating noise and AM that causes me great concern, it is also the two years of construction. It is clear that MKO constant use of 'no significant effect' throughout their construction pages that immediately adds to any anxiety I may already have. How you can carry

out a project of this size on high uplands without creating significant noise problems? There is no evidence to support their claim. I would suggest, from my own common sense and talking to people who have experienced a similar situation, the proposal will have a significant impact in regards to noise nuisance during the construction period of two years. Being in my mid-seventies two years is a long time. A few years ago some of the forest on the hills behind us were ready to harvest and so were taken down. Just one tree felling machine was used and that was easily heard, especially at night, outside and inside our house.

MKO's answer to noise problems, AM in particular, is to simply investigate for both construction and operating noise. Reading the experience of those who complained in the recent High Court case, says this investigations never happen. The only recourse we have is take the wind farm company through the courts. It is very expensive and takes years of legal battles to gain success as the recent court cases show. However, perhaps the recent High Court judgements may change that situation.

From my own view, my house, now called HO75, sits in the Eastern end of the Mealagh Valley which is an exceptionally quiet area: there are no background noises, It is tranquil and peaceful. The only noise tends be natural, mainly birdsong, and the only regular man made noises tends to be the odd passing car or a farmer's tractor. The valley's topography is a U shaped valley which encloses the eastern part, which is dominated by a number of hills including the Maughanaclea Hills. The effect is to enclose us in a very quiet location that can easily be disturbed by noise, particularly if it was from the construction and operating wind turbines. The physical formation of the valley results in any generated noise becoming trapped that then echos and is amplified. You can hear residents cutting their grass the other side of the valley, 3km away. Thankfully the quietness may be broken occasionally by farmers working in their fields or moving livestock. We know that these sounds are part of living in the valley and will be occasional and not last long. The first comment visitors make, 'it's so quiet here', they will usually stand for a few moments just enjoying the silence and stillness. In the 'Valley Survey Report you will read many comments about the stillness, peacefulness and quietness of the Mealagh Valley.

Whereas some of Ireland's people may value wind energy; certainly, many of its people living in the vicinity of wind turbines evaluate them negatively. Wind turbines are not a recent phenomenon, but their quantity, size and type have increased significantly over recent years. As they are often built in the middle of otherwise quiet and natural areas, like the ridges of valleys, and they can adversely affect the integrity of a location. Further, residents living in these areas have in effect chosen to live without urban noise, and so have greater expectations of the quietness of their surroundings and a heightened awareness of noise disturbance.

When considering the valley's quietness, the lack of back-ground noise has been ignored in the EIAR and only one sound monitoring position was set up in a noise sensitive location. The appendices contains many theoretical charts of predicted noise levels. However, they are no noise reports, only assessments measuring noise as decibels, which has already been found lacking in regard to AM. Likewise the noise monitoring follows WEDG2006 and ETSU-R-97, again somewhat lacking.

It needs to be noted that the World Health Organisation(WHO) takes a much more reasoned approach than the wind farm industry in regards to people's reasons to oppose wind turbines. They do not dismiss or ridicule people's concerns. WHO points out that the health effects of people living in the vicinity of wind turbines can be related not only to long-term noise exposure but also to the disruption of the construction phase. MKO/Enerco are well aware of peoples concerns and issues concerning the noise impact, they have experienced this with all their proposals, and they have become very skilled at constantly chanting 'no significant or substantial effects'. When the Enerco Community Officer visited in the autumn 2024, we ask him to stand still and listen: he responded in an exasperated tone, 'I can't hear anything' : that was our point and he just dismissed it and added that we will not hear the turbine 1 km away. Evidence from a high court case clearly shows it will not be the case.

All in all, the Noise report element of MKOs EIAR, tells us little. The agents have taken the easy option rather than a more precautionary approach which would be appropriate. MKOs Noise section is of such a poor standard, using theoretical predictions, ignoring evidence that could be easily gleaned as well as the recent High Court Judgements. For the reasons alone, this proposal should be refused.

### The Impact of Wind Farm Generated Noise on Public Health

This section takes all that has been said so far regarding Noise Nuisance and brings it into the area of Public Health. The World Health Organisation(WHO) made a simple but profound statement in 1948, which is still a guiding principle,

*'Health is state of complete physical, mental and social well being'*

Noise nuisance from AM and Infrasound and the resulting health issues from wind turbines have continually been denied by the the Wind Farm industry. The industry constantly likes to point out that they are meeting all the the recent regulations. However, many are very dated and not kept up to increasing size of turbines: we all are aware that Irelands 2006 guidelines have not kept pace with change, and even the Draft 2019 guideline are now wanting. Numerous reports and studies may continue to be produced to show that there is no health risk to people or animals or

birds. However, when we look closely at these it is often pointed out that this is due to the lack of research and poor data. The findings of NMRC of 2015 are often quoted, as it offers a conclusion to say *'that there is currently no consistent evidence the wind farms cause adverse health in humans'*. What is never pointed out is the second point the organisation made: *'Given the poor quality of current direct evidence ....high quality research into possible health effects... within 1500 metres is warranted.'*

The other studies that suggest there is a link between wind turbines and health issues are often ignored. Back in 2014, Professor Salt of Washington University states, *'The current highly-polarised situation has arisen because our understanding of long term infrasound stimulation remains very primitive level. Based on well-established principles of the physiology of the ear and how it responds to very low frequency sounds, there is ample justification to take this problem more seriously than it has been to date.'*<sup>12</sup>

This issue of up to date independent research is constant issue up to the present time.

#### MKO response to Health Issues

MKO follows a strategy of dismissing health concerns of people living close to proposed Wind Farm projects. Looking at MKO's statement of Authority regarding Human Health, no-one who was involved in the writing of this section has any Health Qualifications or experience of working in the health field, yet they consider themselves experts? They state quite clearly that there is *'some anecdotal reports'* of negative health on people living by wind turbines, but *'there is no credible scientific evidence to the adverse health effects of wind turbines'*. Their statement still relies upon a study carried out in 2009, and though there may have been no evidence at the time, it is now 2026.

MKO constantly dismisses concerns, stating that symptoms are the same as seen in the general population. They recognise that there is an issue but just dismiss the problems, by referring to *'wind turbine syndrome'* - not a very intelligent comment about health concerns.

Some of MKO's supporting evidence, of no health risks existing, is rather strange and bizarre. It provides a review of a controversial book written in 2009 called *'Wind Turbine Syndrome'* by Dr Pierpont. They relate that an *'expert body'* concluded a year later that the book was completely false and there was no evidence to support her claims regard wind energy. I suppose that MKO is trying to suggest that that opposition to *'wind energy'* is actually a conspiracy against wind farms. However, they say that the review of this book proves that, *'the consistent and*

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<sup>12</sup> Acoustics Today, Winter 2014, p20-28.

*scientifically robust conclusion remains that there is no evidence to demonstrate any significant health effects.* A somewhat dramatic comment supporting a review of a book written in 2009 that was simply questioning Wind Farm technology. MKO also use a study by CAHA 2010, to debunk the same book. Is this not simply regurgitating old history that is relevant any more? In a further paragraph, MKO quote the HSE in that in 2017 the data regarding Health implications of wind turbine noise in particular is weak. The question regarding the lack of data, has to be why - is the industry not investing enough to find the answer?

### The other side of the story.

The issue of wind farms and health effects has been going on for a number of years, since the early wind farms installations. There are a number of studies raising concerns regarding the effect and impact on the health of people living close to Wind Turbines. As far back as 2011, in The Problem with Noise Numbers for Wind, Thorne concludes, *'noise numbers and sound character analyses are meaningless if they are not firmly linked to human perception and risk of adverse effects.'*<sup>13</sup> He adds in his conclusion,

*'There are clear and definable markers for adverse health effects before and after the establishment of a wind farm and clear and agreed health effects due to stress after a wind farm has started operation'. '... serious harm to health occurs when a susceptible individual is so beset by the noise in question that he or she suffered recurring sleep disturbance, anxiety and stress.'*

In writing 'How Does Wind Turbine Noise affect People?' the author points out, all the statements that say, *'if you can't hear it, it cannot harm you'* are incorrect. He feels that this type of statement assumes,

*'that hearing driven from low frequency IHC (Inner Ear Cells) response, is the only mechanism by which low frequency sound can affect the body'. We know this assumption is false due to the lack of understanding of the physiology of the ear.'*<sup>14</sup>

One of the major health effects is the negative and disturbance of people sleep patterns. WHO 2000 Guidelines to local Authorities considers the interrelationship between sleep and noise:

*'noise deteriorates the course of sleep in different levels. Long term or repeated noise exposure during sleep causes nervous and endocrine activation...intermittent noise results in fragmentation in the course of sleep; while continuous noise results in a shallow sleep. Both kinds of noise ruin deep sleep and dream sleep (REM).'*

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<sup>13</sup>The problem with noise numbers for wind farm noise assessment, Bob Thorne, Bulletin Science, Technology & Society, Sage, 2011.

<sup>14</sup> How does the wind turbine noise affect people, Alec Salt, Washington School of Medicine Acoustics Today 2014.

In addition, falling asleep is more difficult and after awakening the mood is affected, and quite often during the day people feel tired and have headaches.

We must not forget the emerging health hazards due to noise from AM. WHO 'amplitude modulation .. can be the source of above average annoyance'. They point out that the standard methods of measuring sounds, most commonly A-weighting may not capture low-frequency sound and AM characteristics of wind turbine noise.

An interesting study explored why some families living in proximity to wind farms vacated their homes in Ontario, Canada. A target of 25 participants was established; however, this was then increased to 67 participants. Due to noise and the subsequent health issues, 28 abandoned their homes, 31 were contemplating to do so; 4 preemptively vacated their homes before work started.

We now come to different aspect of the Environmental Noise Guidelines for European Region: World Health Organisation of 2018. The WHO report states '*Noise is one of the most environmental risks to health and continues to be growing concern among policymakers and the public alike.*' Their guiding principles are to '*reduce exposure to noise, whilst conserving quiet areas, promote interventions to reduce exposure to noise and improve health*'.

The WHO studied current research into wind turbine noise, and generally found it inadequate. It looked at the current 45 dB level and suggested even below this level there might be increased risk of annoyance and increased risk of other health outcomes, however, '*the evidence on the adverse effects of wind turbine noise was rated low quality*'. Looking at night noise exposure to wind turbine noise and its effect on sleep disturbances similar picture was found, the low quality and heterogeneous nature of the evidence, they were not able to give guidelines.

They also looked for evidence about the effectiveness of interventions of wind turbine noise exposure, '*Owing to the lack of research, however, no studies were available on existing interventions and associated costs to reduce wind turbine noise*'.<sup>15</sup>

The WHO noise guidelines have indicated that there '*are serious issues with noise exposure assessment related to wind turbines*' and that further work is needed to

*'assess fully the benefits and harms of exposure to environmental noise from wind turbines and to clarify whether the potential benefits associated with reducing exposure to environmental noise for individuals living in the vicinity of wind turbines outweigh the impact on the development of renewable energy policies in the WHO European Region.'*

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<sup>15</sup> p.77-78. WHO , Environmental Noise Guideline for the European Region 2018

It is worth looking at WHO's finding and recommendations in regards to wind farms.

'For average noise exposure, the GDG (WHO) conditionally recommends reducing noise levels produced by wind farms below 45db as wind farm noise above this level is associated with adverse health effects'.<sup>16</sup>

Even though the data is poor and of low quality, the World Health Organisation (WHO) has taken a very precautionary approach to the issue of human health. They recognise the possibility that there is a danger to human health and provide a conditional recommendation to policy makers that they implement suitable measures to reduce noise exposure from wind turbines in populations exposed to levels above the guideline values.

The important point is that MKO slants the findings to be more favourable to their client developer. They state quite clearly that the WHO recommends reducing noise levels produced by wind farms below 45db, but later in their Noise and Vibration section, concludes the conditional recommendation of the exposure level of 45db should not be applied in Ireland? Obviously MKO will only follow WHO recommendations when it suits them.

MKO translates the WHO's comment concerning lack of evidence, as meaning that there is no health risk so we can carry on as before, again not a very professional approach, and certainly not an independent view. The wind farm industry in general has used the lack of clearer and updated guidelines, by continually reverting to the 2006 WEDG and ETSU-R-97 to continue erect larger and larger wind turbines, rather than take a far more precautionary approach to planning the next generation of Wind Turbines.

### Infrasound and Health

In regards to infrasound, as said before the wind farm industry denies it is a problem and their mantra is simple, 'If you cannot hear it then it cannot harm you'. That is, it cannot affect your health. However there are growing concerns and data to show that they have a negative effect on people's health living close by. Many professional researchers are taking a more guarded approach to health issues related to wind turbine noise, rather than simply dismissing it on the grounds of poor research, which is lacking in evidence and not fit for purpose.

The general acknowledged major concern about wind turbine disturbance and health centres around the low frequency noise projected from wind turbines.

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<sup>16</sup> WHO, Environmental Noise Guideline for the European Region 2018

'Clearly no infrasound problem could exist without a biological response to it. The explanation for the biological response has not received much consideration in terms of research, other than dismissing it as a 'nocebo' effect or by product of assorted socio-economic factors.<sup>17</sup>

However, evidence and acceptance is growing that noise from wind farms is not only a nuisance it has a consequential and detrimental effect on the health of people as well as other living species. So, whilst MKO may still assert that infrasound does not exist, outside of the wind farm industry bubble, the voice of caution opposing this stance grows louder.

Recent research is showing exposure to high level of infrasound (more than 100 dBz) negatively interferes with cardiac function, even as soon as one hour after exposure. Numerous independent laboratory researches from around the globe has been performed, resulting in similar findings supporting this conclusion. The effect of infrasound goes obviously beyond the direct mechanical effect in increasing the cross-bridge breakage and involves a wide range of metabolic processes. 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.<sup>18</sup> These results should be considered when looking at all environmental regulations. It is the recommendation of the leading research group to set the level of infrasound no higher than 80dBz as the maximally tolerated limit for chronic exposure.

(dBZ measures sound pressure across the entire frequency spectrum (20 Hz to 20,000 Hz) without applying frequency weighting. It reflects the true energy of the sound, capturing low, mid, and high frequencies equally)

Some evidence suggests that even inaudible sound may affect the delicate structure of the ear and the vestibular organ. A recent review of several animal studies demonstrated that small physiological changes could be detected in the cochlear outer hair cells when these animals were exposed to infrasound. The outer hair cells of the cochlea were more sensitive to infrasound compared to the inner hair cells. There exists as yet no human data comparable to that of these animal studies, so it is therefore still unclear if such theoretical affections of the inner ear structures can explain why some individuals have symptoms like tinnitus, vertigo and Meniere's disease.

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<sup>17</sup> Wind turbine infrasound: Phenomenology and effect on people, Claire Flemmer, Sustainable Cities and Society, 2023.

<sup>18</sup> Infra sound and Human Health: Mechanisms, Effects, and Applications, Maram Dastan, MDPI, Applied Science 2026

This independent research and conclusions can be easily linked in with the studies that directly relate to Wind farms/ Wind turbines. A 2021 <sup>19</sup>study on adverse health effects of wind turbine noise concluded 'that there is a high probability that emissions from IWTs (Industrial Wind Turbines) including infrasound and LFN, result in serious harm to health in susceptible individuals living/ or working in their proximity. These events can be attributed to IWT-related events such as recurring sleep disturbance, anxiety and stress, and likely others. Again the WHO study 2018 points out that,

*'Assessment of population exposure to noise from a particular source is essential for setting health based guideline values. Wind turbine noise is characterised by a variety of potential moderators, which can be challenging to assess and have not necessarily been addressed in detail in health studies. As a result, there are serious issues with noise exposure assessment related to wind turbines.'*

So, this takes us right up to the current year, with a study: Infrasound and Human Health, which states 'exposure to infrasound is an important environmental stressor that has received little attention and can have a significant biological impacts on various body systems'. The voice of caution is growing louder, and really post 2015 research and study papers should have been presented as part of the EIAR, as requested by ACP in the pre-application consultation phase.

#### Harm to Wild life and domestic animals

Before concluding this section, it is worth also considering the effect of AM and Infrasound has on species other than ourselves. It is a well known fact that many species can hear sound that humans cannot hear. Research in 2022, looked into the effects of wind turbine generated noise ,such as infrasound, on wild life and domestic animals in close locations to wind farms. A growing body of evidence suggests that anthropogenic noise may detrimentally affect wildlife populations, communities and ecosystems'.<sup>20</sup> and concludes that the effects on wildlife remains insufficiently explored. Other research in Ontario Canada found, 'Birds and bats, domestic animals and wildlife, are reported to be affected by noise. *'It is not just the blades of wind turbines that harm birds, but also noise'*. A US Geological Survey notes, there is a real '*potential for turbines to adversely affect wild animals directly via collisions, and indirectly due to noise pollution.*'<sup>21</sup> Lastly, another study in 2021 states,

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<sup>19</sup> Wind turbines and adverse health effects:applying Bradford Hill's criteria for causation, Anne Dumbrille, Environmental Disease 2021, Medknow.

<sup>20</sup> See, Renewable and Sustainable Energy Reviews.

<sup>21</sup> Wind Turbines:Vacated/abandoned homes study, Exploring research participants descriptions of observed effects on their pets, animals and well water, Environmental Disease, 2024.

*'there is experimental evidence that exposure to LFN/infrasound can lead to adverse effects in animals as well as people. Animal studies have demonstrated serious health effects from the proximity to IWF'.<sup>22</sup>*

The effect of infrasound on wild life, can not be dismissed as it will only add to Irelands biodiversity crisis.

### Conclusion

It is becoming absolutely clear that noise generated by wind turbines can now be considered as a 'nuisance', an 'annoyance' affecting peoples health and well-being, after the recent High Court case. The High Court found in favour of the complainants, that they were the subjects of annoyance in terms of noise from a wind turbine.

Due to the increased height and sizes of turbines, the 'noise emitted from them is becoming more and more of an issue. For years the wind farm industry has dismissed that wind turbine noise is a nuisance that can have a harmful health effect on some people. Evidence is now suggesting AM and Infrasound can affect people's health and possibly wild life and domestic animals. Rather than taking a precautionary approach of at least using the 2019 Guidelines, MKO has reverted to the outdated WEDG 2006 and ETSU-R -97 guidance in regards to turbine noise.

In conclusion, there are serious adverse health effects associated with noise pollution generated by wind turbines. It is essential that separation distances between human habitation and wind turbines are increased. There is an international consensus emerging for a separation distance of 2km, indeed some countries are opting for 3km. The current guidelines on separation distance is based on ETSU-R-97 and is manifestly out of date. It is only relevant to the small turbines of the previous era. The vastly increased scale of today's turbines, and their blades, means that the current recommendation on turbine separation is grossly inadequate.

Good professional, best planning practice must take into account a precautionary approach to proposed Wind Farms, in particular in regards to the effects of AM and Infrasound. Consultants such as MKO and developers continually revert to using 2006 WEDG and ETSU-R-96 guideline snalone, which are now recognised as out of date, and ignoring the more up to date guidance and regulations. The 2006 regulations only offer the minimum basic standard.. The wind farm industry must take more responsibility and take a serious precautionary approach as there are now more variables to be considered due to a greater understanding of wind turbine noise and the consequences for human health and the wider natural environment.

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<sup>22</sup>Wind turbines and adverse health effects:applying Bradford Hill's criteria for causation, Anne Dumbrille, Enviromental Disease 2021, Medknow

The presenting strategy of MKO is to simply dismiss noise and health concerns using very dated and specific research to dismiss noise and its consequences. They cannot demonstrate that their development will not have a significant negative impact on the lives of people who live near to their proposed development. The Noise Section of the EIAR is wanting and fails to give evidence that the wind turbine will not negatively impact the lives of people in the vicinity. Their final conclusion reads like all the other assessments in sections of this EIAR. In regards to noise, they state *'In summary, the noise and vibration impact of the Proposed Development is not significant'*.

This leads me to one final comment, the Draft Guidelines 5.7.15, state that the developer and its consultants, that they should;

*'Ensure the general public has maximum confidence in the reliability of the accuracy of the noise predictions'*,

This is something that it is sadly lacking in this planning application and EIAR. This has not happened.

ACP must assess the noise predictions made by MKO, considering the number and size of the turbines. The data collection was very limited in terms of sound monitoring points, there was only one in the Mealagh Valley, an exceptionally quiet location, as highlighted in the our Community Survey Booklet.

ACP must ask the questions, when evaluating the Noise and Health sections, is it realistic that that construction and operating noise is only slight? Where is the evidence? How MKO come to this conclusion?

Unlike MKO/Enerco, ACP cannot ignore the possibility of health risks due to AM or even Infrasound. MKO need to provide more data to back up their claims, that there will be no noise nuisance because we are using WEDG 2006, which does not give guidance on AM. To suggest that AM cannot be predicted at the planning is not acceptable, rather than solve the problem they just deny AM.

## The impact of light on the Dark Skies

Why do dark skies and the nocturnal environment need conservation?

Conservation is the care and protection of precious resources so that they can persist for future generations. We need to recognise that the night sky is a natural, cultural, and historic resource that closely intertwines humankind with the nocturnal environment.

The County Cork Development Plan 2022-2028 recognises the value of dark skies.

*15.11.3 the Council recognises the impacts light pollution ( glare, shadow, light trespass, clutter and spillage) can have on the visual, wildlife, and residential amenities...*

*Objective BE15-13 Seek the minimisation and control of light pollution associated with activities of development, having regard to relevant standards, published guidance and the receiving environment and Dark Sky principles.*

*Objective 10.6.3 It is also important to recognise the night sky as a tourism asset for the county and should be protected from night pollution...*

The topography of the Mealagh Valley, is U shaped with high hills around, giving us the opportunity to see the night sky directly, without other lighting polluting the view of the sky. Consequently the night skies in the Mealagh Valley are spectacular, when I first moved here I was amazed by the night sky and and the celestial displays still am to this day.

*According to Dark Sky Ireland, the 'Mealagh Valley has near-pristine environment, close to the conditions in Kerry Dark Sky Reserve and Mayo Dark Sky Park, Ireland international accredited dark sky area'<sup>1</sup>.*

*Night Skies are important in so many ways, 'The nightscape is an essential element of the human experience, whose cultural, social, scientific, and aesthetic values are assets of the intangible heritage of humankind '<sup>2</sup>*

The protection of dark skies through both reducing light pollution and protecting existing dark areas such as that in the Mealagh Valley is an important part of policy on artificial light. This new environmental problem of light pollution has started to be recognised and be defined as every form of artificial light in the wrong place at the wrong time. Light pollution creates a sky glow, glare, nuisance, and other relevant causes of environmental degradation.

You can see from the map that the Dark Skies in Ireland were once very common in 1997, in 2015<sup>3</sup> they have been severely lost only remaining in the Western areas of Ireland. Today there may be even less Dark Skies to experience, making the Mealagh Valley very unique. Light

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<sup>1</sup> Letter Dark Sky Ireland, Brian Espey Chairperson,

<sup>2</sup> Quantifying the visual impact of wind farm lights on the nocturnal landscape, Salvador Bara, Journal of Quantitative Spectroscopy, 2024.

<sup>3</sup> See maps

pollution is one of the most fast-growing forms of environmental degradation that is caused by the increased amount of artificial light at night.

Some would say wind turbines navigation lights are not a main sources of light pollution, but nonetheless, they introduce additional light that can affect local environments, causing further alteration of species behaviour and ecosystems. Various bird species along with bats are attracted to light emitted from wind turbines consequencely, such night time lighting influences the risk of mortality due to collisions with these energy structures. Wind turbine lighting also contributes to the disorientation of different migratory species and the disturbance of habitats.

The Night Skies of the Mealagh Valley are now under threat from Wind Turbines sited high on ridges with their red aviation lights making it impossible to see the Dark Sky. The nightscape becomes polluted because the artificial light can obscure the natural beauty of the night sky.

*'The fraction of territory within the visual range from which the wind farm lights can be seen depends on the local topography and on the height of the lights above ground level. However, since wind farms tend to be located on the highest elevations of mountain ridges, this fraction is generally very large'<sup>4</sup>.*

It can be said the light pollution issues by themselves are not the reason to refuse this wind farm application. Although, if we link it to the major negative visual effect on the sensitive landscape during the day, and the possible effect on the growing interest in Dark Skies tourism, then this area is not appropriate for this development. Looking at the cumulative effect of the proliferation of Wind Farms and the subsequent increase in turbines envisaged by MKO then the night sky of West Cork would be under threat. The consequent damage to the overall landscape and natural environment would be immense. Travelling along the R585 passing Coppeen, the red glow of wind turbines can now be seen when travelling towards Kealkill. The Maughanaclea wind farm will add to the loss of the Dark Sky not just in the Mealagh Valley but also along the scenic Route 29.

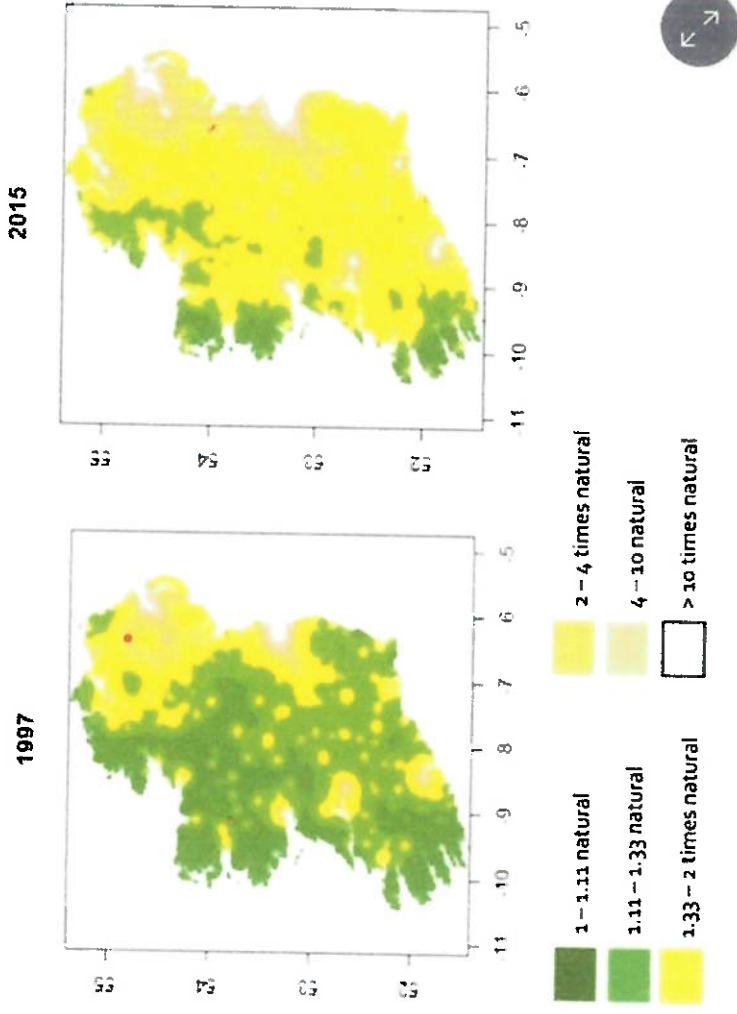
The issue of the loss of the Dark Sky can not be seen in isolation as it links to the visual impact of wind turbines on the landscape as a whole, and people's enjoyment of the Night Skies and in particular tourists, we must not forget the threat to wild life.

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<sup>4</sup>Quantifying the visual impact of wind farm lights on the nocturnal landscape, Salvador Bara, Journal of Quantitative Spectroscopy, 2024.

## Shifting Baseline Syndrome

Ireland's Atlantic edge sits at the last frontier of natural darkness in Europe, but we are losing this resource at an alarming pace, and it is happening while we are sleeping. Over the past few decades, light pollution has spread across Ireland, leaving few places with a view of a naturally dark sky overhead.



The growth of light pollution in Ireland. Source: Prof Brian Espey, Trinity College Dublin



**DARK SKY**  
IRELAND

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25<sup>th</sup> June 2025

Dear Terrie & Michael,

Thank you for bringing the potential impact of windfarm lighting to your local area to our attention. The Meallagh Valley has a near-pristine environment, close to the conditions in Kerry Dark Sky Reserve and Mayo Dark Sky Park – Ireland’s internationally accredited dark sky areas. Indeed, Ireland has the only such Gold Tier (highest quality) Dark Sky Reserve in Europe, maximising its tourist potential and leading to promotion by Failte Ireland, Discover Ireland and Wild Atlantic Way advertising, amongst others. Dark sky areas have been shown to provide a significant boost to local economies, providing an extra strand to environmental holidays and leading to extra income in shoulder and off-season for local B&Bs and guesthouses. As such, the area should be protected for future tourism development.

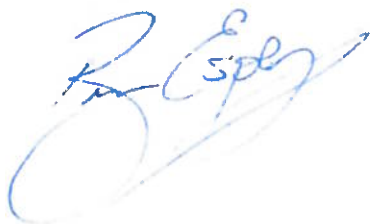
Research shows that even a single aviation warning light can impact on the visual amenity of the surrounding area, particularly given their siting on wind turbines over 100 metres tall. Calculations show that medium intensity lighting can appear brighter than Venus – the brightest planet – out to distances of 4 km or so and, against a dark sky, such lights can be seen up to distances of tens of kilometres. The visual effect is, of course, multiplied by the combined effect of all the lights of the entire farm, including those sited on high ground 400 metres high.

Unless the lights are very directional, light falling on the ground (horizontal illuminance) has been shown to raise light levels above the natural background in dark locations such as the Meallagh Valley to kilometre distances, with the potential to affect ground-dwelling species. While the impact as seen from ground level is one aspect, these lights are obviously intended to be visible from the air where they can also impact migratory birds who depend on their vision in the red part of the spectrum for navigation and can cause more harm in overcast or foggy conditions. We are endeavouring to engage with the Irish Aviation Authority on the topic of windfarm lighting and note that representatives have taken part in European meetings regarding the environmental impact.

Dark Sky Ireland notes that preservation of biodiversity as required by recent EU actions. Although the night-time environment has been given insufficient attention to date, this is changing as it is becoming more recognised as being important for the well-being of all species – terrestrial, airborne and aquatic. This has also been recognised in the current Programme for Government’s plans to “Promote and encourage an expansion of Dark Sky Ireland national parks and reserves” under the “Protecting Heritage and Nature” section of the document.

I hope that this is of use to you. Please let us know if we can be of further assistance.

With best regards,



Brian Espey  
Chairperson, Dark Sky Ireland

**References**

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Programme for Government 2025 – Securing Ireland's Future <https://7358484.fs1.hubspotusercontent-na1.net/hubfs/7358484/Programme%20for%20Government%20-%20New.pdf>

Nature Scot Information note - The Effect of Aviation Obstruction Lighting on Birds at Wind Turbines, Communication Towers and Other Structures <https://www.nature.scot/doc/information-note-effect-aviation-obstruction-lighting-birds-wind-turbines-communication-towers-and>

### The Impact of the Maughanacneas Wind Farm on Biodiversity

Due to the massive amount of paperwork within this EIAR and the time constraints it is impossible to cover every area. Biodiversity is one area that I would have liked to question, however, due to shortage of time I just concentrate on a small part with the help of my wife's submission. .

#### Biodiversity and Wild Life Impact.

The application falls short of the Biodiversity Action Plan 2023-2030 and the National Biodiversity Plan which recognises that wetlands are of special importance to biodiversity in Ireland.

When the ACP Inspector is assessing this EIAR they need to consider the drastic effects that will be forced on to the naturally abundant biodiversity at the proposed site.

*'In terms of the amount of land for wildlife, 'We left only 3% for wildlife.....The situation is very serious, but it's also something that can be turned around quite quickly with the right action. Nature can grow back quickly if we stop doing things that are harming it, and then start doing the right things by restoring our environment and treating it with the respect it deserves'.*

Leo Varadkar Taoiseach's, Forward, Ireland 4th Biodiversity Action Plan, 2023-2028

*'The idea that the next generation will not experience these things because of decisions we make today is unconscionable and an impoverishment of the most basic wonders of childhood'.*

Michael Martin, Tanaiste, Forward, Ireland 4th Biodiversity Action Plan, 2023-2028

*'There is a multitude of reasons to value, conserve, restore and sustainably use biodiversity in Ireland. But the simple fact that our children want us too is the only reason we need'.*

Michael Martin, Tanaiste, Forward, Ireland 4th Biodiversity Action Plan, 2023-2028

Michael Martin has captured what is happening to the environment which is a very good example of 'Shifting Baseline Syndrome'.

'Shifting Baseline Syndrome' is insidious due to its invisibility. By making people more habituated and tolerant of environmental degradation, it does not just contribute to the loss of wildlife, it makes a fundamental obstacle to addressing a wide range of global environmental issues. It fuels the degradation of entire ecosystems, while skewing perceptions of climate change, natural resource depletion and pollution.

Looking at MKO's biodiversity section, all they do is gather sightings of birds, and again eventually suggest that the construction and running of 14x 169 m wind turbines will have no significant affect or something similar, on the bird populations they can fly elsewhere. Birds pick a nesting site for a reason, anyway, where else can they go with so many wind farms in the area, ie approaching 300 possible within 25 Km of this site, using MKOs figure. Picking up dead birds achieves nothing, what happens when there are too many being killed, who decides what to do?

The main danger to birds is collisions, direct collision between birds and turbines are the most obvious cause of bird deaths. Rotating blades cause motion smear. This makes them appear as transparent blurs that birds can not perceive causing fatal collisions.

It is not just collisions that affect birds. Wind Farm cover a huge amount of land, especially 169.5 m one. This can disrupt migration routes, as well as essential roosting and breeding sites, harming biodiversity. Developers like MKO count numbers of dead birds, not overall environmental impact on birds, for now or the future.

Sadly, time only allows a covering of Birds and a particular bird species: Choughs. Fortunately my wife has covered the MKO survey on this bird exceptionally well. It strikes me that this bird is very special and we are lucky to have so many nesting here. It is protected under Annex 1 of Birds EU Directive. This location seems to have become an important breeding ground for them and they need protecting from out of place development such as wind farms.

- CHOUGHS. (*Pyrrhocorax pyrrhocorax*)

In carrying out their EIA function, the Inspectorate will need to continue to test the robustness of the 'Maughanaclea' Monitoring Programme and subsequent reporting, by considering the many sightings of Red-billed Choughs which have been recorded in the MKO surveys.

This bird species is listed as a protected species on Annex I of the EU Birds Directive. In Ireland this Bird Species is listed as Amber (medium conservation concern) as they are in decline in many areas and their Amber Status is considered to be 'vulnerable'. At the moment, these highly acrobatic fliers are likely to be soaring around the rock coasts of Ireland, especially of Cork and Kerry. The fact that Choughs have been listed on all four WF bird surveys shows that this local area is unique in this protected bird species being found this far inland. The Gortloughra EIAR concurs with this, stating:

*The regional Chough populations in West Cork has demonstrated a recent tendency to colonise inland upland ares, moving beyond their traditional habitat preference in Ireland for rock coastlands with short open grassland foraging areas....*

According to MKO, there needs only to be a regularly breeding population of two(2) pairs for a classification of County Importance. Both MKO and JoD consultants leave the classification there. However, given breeding pairs are recorded in all four sets of surveys: Maughanaclea, Gortloughra, Curraglass and Derreenacrinnig, the requirement for six(6) pairs can be easily substantiated and so qualifies this area of West Cork to be one of National Importance for Choughs, protected as an Annex I species.

If one only focuses on the proposed 'Maughanaclea' sites, Choughs were observed 186 times during the three years of vantage point surveys alone, and it must be noted that sometimes the birds were well within 300metres of proposed sites for turbines. Choughs have been recorded mainly from viewpoints in townlands of Ardrah and Maughanaclea: their behaviours are noted as flying, calling, foraging, roosting, clustering in numbers up to twenty five, and breeding pairs with young chicks. Twenty five is not the largest flock recorded: with Gortloughra, there was one recorded comprising of 59 individuals, both adults and juveniles, feeding.

MKO confirmed that a KOR was required for Choughs, assessing direct habitat loss, disturbance/displacement and collision risk; however, as soon as the tables are produced, everything begins to dissipate into very little or nothing:

*Construction phase: direct habitat loss, Disturbance, low effect significance.*

*Operational phase: direct habitat loss: No effect, low effect significance.*

*Collision Risk: Breeding, Winter: very low effect significance.*

Nothing is said of, or quoted from, the informative Bird Watch Ireland report of 2015, which makes two very salient points, out of many:<sup>1</sup>

*19.7 Site Fidelity:*

*Choughs will remain in the same nesting site throughout their reproductive life, likely around 10 years though in some instances lasting up to 20. Indeed, some nests have remained active across multiple generations (Trewby, Carroll, Mугan, et al. 2010). A study on the habitat use of individual pairs also suggested that fidelity to areas may vary between breeding pairs (Robertson et al. 1995).*

*19.8 Sensitivity to development of wind energy:*

*This species is vulnerable to disturbance during feeding. For example, population viability on a French island was found to be compromised by relatively minor human induced disturbance (Kerbiriou et al. 2009). In this example, the location of paths for tourists was recommended to be kept at least 150m away from feeding areas. In addition, given this species' relatively narrow range along coastlines, its high site fidelity and the decreasing availability of suitable feeding ground, this species is also vulnerable to habitat loss.*

Even in the 2003 Percival 'Bible'<sup>2</sup>, Choughs are deemed to be an ecologically sensitive species. With the 'Maughanaclea' sites, it may not be the risk of colliding with turbines that would decimate our local population of Choughs.<sup>3</sup> Instead it would be from the dramatic loss of habitat and disturbance whilst feeding, during the construction period and then beyond with maintenance crews. This is not tolerable for a protected bird species, listed in Annex I the EU Birds Directive, Amber-listed as of conservation concern and of National Importance for the area. One can only conclude that a genuine requirement exists once again for the Inspectorate to assess the actual data, and come to very cautious conclusions rather than merely accepting entries from MKO's desk-top study.

The Bird Ireland report of 2015, and subsequent research, needs to be assessed constructively and the findings adopted. MKO's Bird Tables must be reassessed as to whether they are based on sound precautionary principles, if they are robust or complete enough, and if the stated magnitude/significance of the effects are accurate. At the moment, there are so many entries

<sup>1</sup> Guidance Document, February 2015, Bird Sensitivity Mapping for Wind Energy Developments and Associated Infrastructure in the Republic of Ireland. Mc Guinness, S., Muldoon, C., Tierney, N., Cummins, S., Murray, A., Egan, S., & Crowe, O.

<sup>2</sup> All the reports submitted to ACP for ornithology refer to 'Percival 2003': Birds and Wind Farms in Ireland: A review of potential issues and impact assessment. Dr s.M. Percival. It is often cited to evaluate the sensitivity of species. It has actually been superseded by more recent guidance, such as McGuinness et al, 2015.

<sup>3</sup> Ireland holds a significant portion of the European population (~60%), specifically along the west coast, making their protection crucial.

that state the effects of turbines on various bird species will be no effect, very low, low, slight, negligible, and all below a threshold of 'not significant'. Disturbance and direct habitat loss seems to gain even less attention. More importantly, where is the precautionary principle that must be present within such modelling to inform a correct assessment?

The assessments above for Choughs, leads one to being fearful for other bird species on the Red and Amber Lists and the Annex I of the EU Birds Directive, as computer modelling and AI appears to fail them badly. Two other birds that are in danger due to this proposal, the Kestrel (*Falco tinnunculus*) and the successfully reintroduced White Tailed Eagle (*Haliaeetus albicilla*), both of whom are now in danger. Whatever MKO states, all birds are in danger due to this development, MKO gives the answer, they will go elsewhere.

Birds in particular those mentioned pick particular sites to nest and hunt in. The problem facing wildlife in general is that else where is becoming less of an option due to the cumulative effect of spreading wind turbines takes away the option of elsewhere.

This is an area of special value in terms of the number of protected birds that can be found, the Choughs, Kestrels and of course the recent reintroduced White Tailed Eagle. We cannot afford to lose a site of this significant and importance not just to protect the bird population, it is the whole area of biodiversity that is at risk. ACP needs to give full regard to the impact of this proposal considering the impact on the biodiversity within the area.

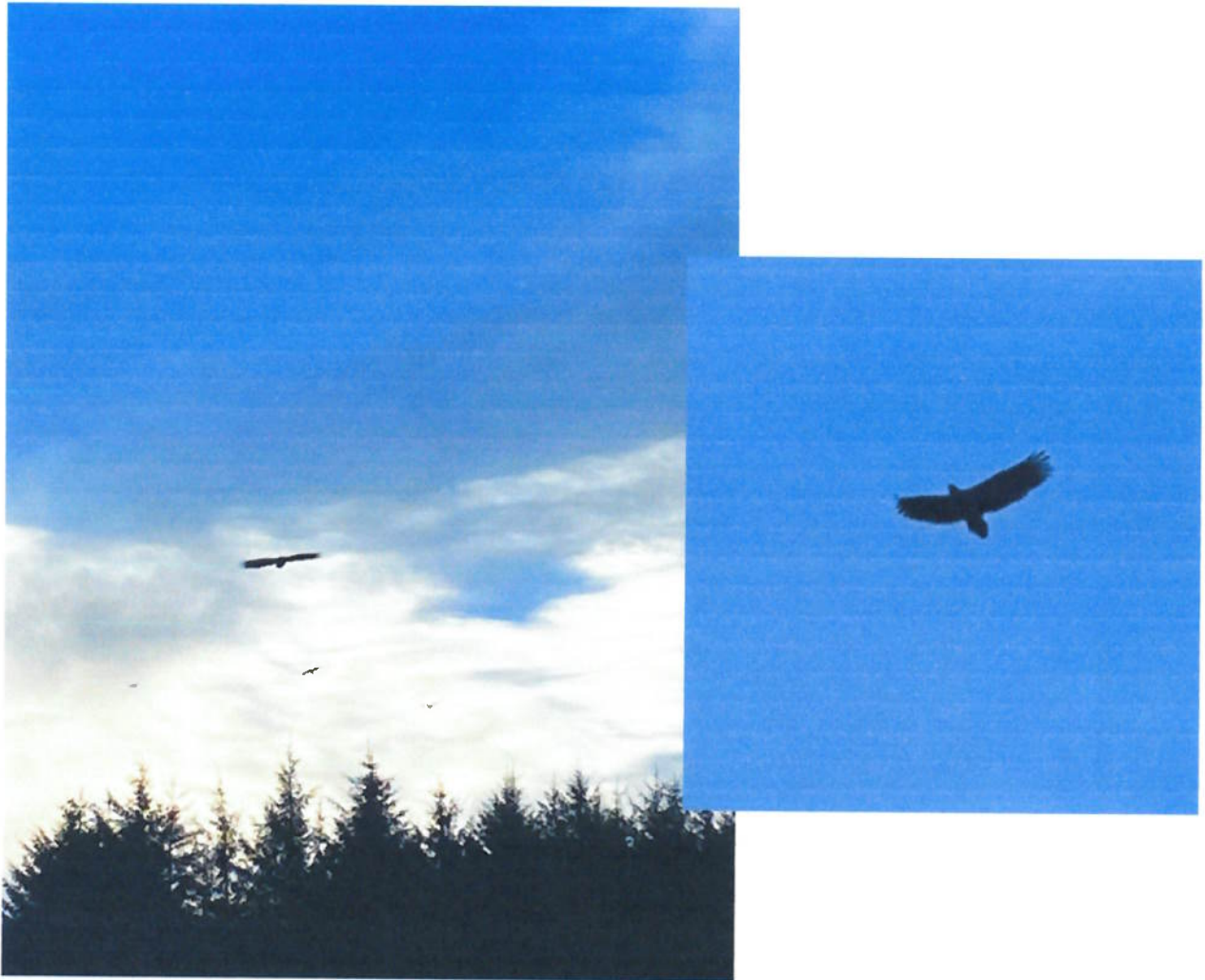
Lets remember the quote from Michael Martin

*'There is a multitude of reasons to value, conserve, restore and sustainably use biodiversity in Ireland. But the simple fact that our children want us too is the only reason we need'.*

At this point let us just look at where we are in terms of Biodiversity loss in Ireland. A recent study involving Biodiversity Depletion of 14 counties in Europe was surveyed including Ireland. At number 13 was Ireland which highlights the poor condition of our Biodiversity.

Yes, at the end of the day the issue of wind farm development and the move to green energy and restore biodiversity is a balancing act. At the present time the scales of the balance fall in the direction of wind farm construction at the expense of the destructive effect on biodiversity. Wind Farm Developers cannot choose sites where it will adversely damage Biodiversity. Planning law and County Development Plans should say where this type of development is not appropriate.

Biodiversity Loss sits on a level with the Climate Crisis, something possibly the wind farm industry disputes. However, the Supreme court has made it abundantly clear that this is not the case. There has to be a rebalance between the need for Green Energy and Biodiversity Depletion. Up to now the loud voices of the wind farms industry has it all its way, and that needs to stop. It is in the power of planners and ACP to start to reverse that trend, by effective and robust assessment using the EIA to assess consultant's EIAR. Due to all the other negative impacts to the landscape and the natural environment at this site the balance need to swing in the direction of the planning permission being refused.



White Tailed Sea Eagles, flying over our neighbouring properties: H013, and H19, H031, 800metres away from proposed T10, T09 sites.

Lough Naibree in Ardrah townland, right in the middle of the sites for T14, T13, T12. These turbines will sit in a triangle around this Lough. In the distance you can see the 'Derrenacrinnig West' poles and wires that have remained even after the ABP refusal in 2024.



Loss of Peat on the Site of the Maughanaclea Wind Farm

Looking at MKOs data spread sheets concerning the removal of peat there are lots of zeros, no details of where the peat is lost from or removed from. Where is the data?

However, it is important we know, as peat stores carbon, and its removal returns the carbon to the atmosphere. How long will it take for this wind farm to be effective, in other words long does it take to pay back the carbon that was released?

Looking at MKO figures they show that up to 92,950 cubic metres of peat will be lost, due to the lack of detail it does not show from which part of the development the peat is removed. I would guess it would come from the foundations for the wind turbine towers, and the borrow pits.

To make the figure more meaningful, I decided to compare this Wind Farms Peat Loss with another recent and close-by Wind Farm proposal.

I choose Gortloughra WF ABP-322743-25, situated just a few Km from the Maughanacleas site along the R585 close to the Cousane Gap. Jennings O'Donovan the consultants for Gortloughra applied for planning permission March/ April for eight turbines hub height 100m and tip height of 175m, Ref : 25/142.

The Cork County planners refused the planning permission, partly due to the high levels of peat that was to be removed. Jennings O'Donovan appealed to ABP October 20025, case number ABP-322743-25.

Jennings O'Donovan proposed wind farm was refused on the ground of extensive Peat Loss, using their spread sheet there would be 22249.8 cubic metres of peat removed due to the wind farm construction.

Now let's look at MKOs calculations for Peat Lost for the Maughanacleas wind farm; using their spread sheet, I found that 92950 cubic metres of Peat will be lost due to the wind farm construction.

Yes, you could say the Maughanacleas is 14 turbines, although slightly smaller turbines, the project is not quite double the size. However, if we half the figure of peat loss for the Maughanacela proposal we will have 46,475 cubic metres of Peat lost due to the construction. The Peat loss still represents over double that of Gortloughra wind farm. Looking through MKOs EIAR the recovered peat is going to be spread around the site, hardly what I would have expected.

Is not for me to explain the reasons for the large amount of Peat being removed, but it does suggest that the peat at this site is much deeper. The loss is much more significant and would suggest that that MKOs project, in terms of Peat Loss alone, planning permission should be refused.

As a side issue MKO estimate of land lost is 126416 square metres, I doubt very much that they proposed biodiversity enhancement area will come anyway near this figure.

Why is it so important to save peat, simple, it is a natural carbon mechanism, however, all the stored carbon will be released back into the atmosphere, and it will take years to balance that loss using wind energy. What needs to be considered is that this loss is front loaded, and will initially add carbon into atmosphere, which will not be recovered until after 2030. MKO in a bid to gain planning consent pushes the need to fulfil Ireland target of 80% renewable energy by 2030, but they will be paying in carbon terms for the loss of Peat long after.

The Irish Peatland Conservation Council (IPCC) does not support the construction of wind farms on intact peatlands including upland blanket bog and heath habitats. There is a very significant overlap between sensitive upland blanket bog areas and areas of highest average wind speeds. According to the IPCC these areas have been targeted for wind farm development.

Constructing a wind farm on peat lands upsets the carbon accumulation process and leads to an increase of carbon into the atmosphere. What we also need to consider is the cumulative effect of a number of wind farms in this concentrated area, at present as well as this proposal for Maughanacneas, there are three others in this area with ACP awaiting a decisions.

At the Maughanacnea site close to wind turbines T11 to T 14 are Lough Naibree and Ardragh Bog. Lough Naibree is surrounded on three sides by bog and the wider area appears largely undisturbed. It doesn't seem to have been agriculturally improved in any significant way. Across the site there is a mix of wetter, lower ground around the lake and higher ground with rock outcrops and drier heath. Near by there are also water bodies including Lough Carrignanaeane. None of this landscape has been reported or assessed in MKOs EIAR. This has to be surveyed correctly by someone like the IPCC, to assess the risk of significant peat loss and serious environmental damage. IPCC report that wind farms have serious impacts on undesignated blanket bogs and this is considered an increasing threat in the wider countryside<sup>1</sup>.

### Peat land Biodiversity

In Ireland peat land biodiversity is protected under the EU Habitats Directive, EU Birds Directive and the Irish Wildlife (Amendment) Act, 2000.

Peat lands are home to a high proportion of Ireland's biodiversity. While only 10% of Ireland's biodiversity has been assessed we do know that 15% of the original flora of Ireland are peatland plants. 14% (59 species) bird species have been recorded on peatland. 49% of all endangered birds in Ireland occur on peatlands, most as breeding species. 26% of Ireland's animal species are dependent on peatlands in some phase of their life cycle. 23 of the 35 butterfly species found in Ireland are found on peatlands. There are two species that rely on bogs for breeding: the Large Heath (*Coenonympha tullia*) and Green Hairstreak (*Callophrys rubi*)<sup>2</sup>.

Ireland's bog land are home to a variety of plants and animals, many of which cannot be living in other Irish habitats. There is a wide variety of life on peat bogs, birds nest on these open sites

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<sup>1</sup> IPCC Website Article Wind Farms and Peatlands

<sup>2</sup> IPCC Website Article Wind Farms and Peatlands

relying on heather for shelter, other species, health butterfly, red grouse, cottongrasses and many species and plants can be found.

Peat Lands are an important part of Irelands biodiversity, and depending on how these are managed, they can contribute to Ireland Biodiversity emergency. The planned construction of of this wind farm is not just releasing mega amounts of stored carbon into the atmosphere, it is endangering the Peat Land biodiversity.

Clearly the significance of the Peat Land at the Maughanaclea site is of considerable importance and needs to be protected. The peat land is an extensive part of the site and adds to number of other concerns that considered altogether mean that this wind farm in an unsuitable and is an inappropriate development for this site.

The peat bog is an important element of the landscape and are a diminishing part of Ireland. They should be protected from any development , let alone a Wind Farm. This proposal is therefore not appropriate for this site and should be refused.





Mealagh Valley looking West.

Lough Carrignanaeane, in Ardah townland, which T14 will be less than 1KM away from this.



### The Wind Farm Effect on Water

My first reaction to MKOs Hydrology report is MKO continued use of the phrase 'no significant effects', however, their report tells us very little, if anything about the effect of the construction of the turbine bases and burrow pits or the possible long effects on the water table and subsequent well of each household.

I do not know much about Hydrology, However, I will try by best to raise my legitimate concerns. Luckily I am aware that a leading professional hydrologist will be submitting an independent report.

Lets' start with private domestic wells. If MKO had researched the area extensively they would know that all the houses surrounding this project have private wells of one sort or other. On the Mealagh Valley side, new properties will probably have deep bore wells, the older properties a mixture of shallow wells or are sourced from streams that flow from the Maughanaclea Hills. The Kealkill side would be similar except Kealkill itself which is sourced from a local waterworks using water from the Mauaghanaclea hills.

Obviously the major concerns are the contamination of the water and the change of water flows and possible damage to the water table. MKO have just ignored this fact and not made any effort to explore the situation. MKO water abstractions ignores the situation in the Mealagh Valley, and overall is very vague. Most of our domestic and drinking water is sourced from the Maughanacleas hills, water taken or streams for small bore holes in the hill. We, who get water from deep bore wells are concerned that digging and exploding deep foundations and even deeper borrow pits could effect our deeper sources of water. MMKO states:

The biggest risk to down-gradient wells will be from where deeper excavations are required such turbine bases and borrow pits... in order to be conservative and following a worse-case assumption, we have assumed that all dwellings have a private groundwater well.

MKO seems to think it good enough to assume that all dwelling have private ground water wells. Assuming is not good enough, it raises a serious question about their EIAR. Spending a lot of time reading their EIAR the general feeling I get is a lot of assumptions have made throughout.

[It ends by] significant effects on wells are unlikely. Pre-Mitigation Potential effect: Negative, imperceptible, indirect, short-term, unlikely effect on local wells. In the absence of mitigation measures there will be no significant effects on local groundwater well supplies.

Here we go again significant effects are unlikely this again is just an assumption, a simple statement. Where is the evidence to support these statements. This a very serious issue that MKO have failed to address. It highlights their dismissive attitude that is evident throughout this EAIR. I've underlined all the terms used to show that there are no problems.

We need some fundamental answers as well water could be a major problem for many people in the Mealagh Valley.

MKO believe they have covered private wells by saying 'the bedrock underlying the Site is classified as poorly productive in terms of well water yields', and there 'will be no impact on private wells'.

Which authority has suddenly classified this bedrock as poor? Certainly, at present, there are ample supplies of water seeping through the bedrock for the houses served by private wells. Second, not all our wells are deep-drilled to be fed from the water table, which is created by ground water. It seems to me that MKO are already justifying any future problems as not due to them.

Throughout this section MKO have dismissed the possibilities of endangering our water supplies. Again MKO uses its regular dismissive approach to any likely difficulties, '*there is a very low risk of impact*'.

### Ground Water

Groundwater is the water that soaks into the ground from rain and can be stored beneath the ground. Groundwater is used to supply drinking water and needs to be protected. It is mainly protected by layers of subsoils, sands or peats. The vulnerability map classifies how vulnerable groundwater is to pollution across Ireland, based on its level of protection. Knowing this helps people to plan and carry out activities on the land in a way that keeps our groundwater safe to drink.

The Groundwater Vulnerability map shows land areas across Ireland where groundwater can be easily polluted. It also shows areas where it is well protected by the subsoil layers. The vulnerability category given to a site or an area is based on how easy it is for water which may contain pollutants can reach the groundwater.

'On the GSI/EPA map, areas shown in dark pink indicate those which have the most extreme vulnerability to pollution as there is 'Rock at or near the Surface or Karst'. Many houses in our townlands are built directly on rock with a thin layer of peat covering, my house is a case in point. The lighter pink is Category One, ie. areas which have an extreme vulnerability to pollution. This raises question, what effects explosions and the shattering of the rock may have on our ground water, or the pouring of concrete saturated with chemical additives? This is without considering the the proposed borrow pits high on the hills which could be akin to sinkholes, and is readily acknowledged as being a feasible risk.

MKO have not given any assurances.

### Ground Water Effects

During the construction stage of the development there are a number of potential effects on the source catchment and infrastructure network.

Construction of turbines base and burrow pits raises considerable concern in terms of contamination of the ground water. The introduction of impermeable infrastructure and any

associated drainage during the construction phase of the development, may lead to the diversion of flow from upper catchment areas. The large turbines requires eight very large,

extremely large deep individual foundations. Turbine foundations will be impermeable, which effects the drainage of the site. Access tracks and material used for the temporary and permanent substation will be of crushed stone and will maintain a level of permeability. The diversion of flow could lead to deterioration in the quantity of water along its original pathway, causing a potential reduction in yield at any abstraction point; and could remain for the life of the impermeable barrier. In addition, excavation from borrow pit construction or dewatering can result in the lowering of the water table. The usual answer is given, no significant effects.

There will be contamination of the surface water and ground water caused by leakage and spills of chemicals from vehicle use, which has the potential to lead to a pollution event. Over the construction period there will be thousands of lorries extremely large and smaller entering and using the construction site, each being a possible hazard. We are told that mitigation measures will put in place such as lorries will be regularly cleaned, where, on site? The waste water will soak into the ground and eventually the water course and any mitigation measures are very ineffective.

Contamination could also be the result of concrete pouring for the turbine foundations within excavated areas, in close proximity to the groundwater. These events could occur during the construction phase and affect surface water, or, dependent on excavation depth, groundwater. The deterioration of the quality of either surface water or groundwater may cause a potential effect on the status of the receiving water bodies and any abstracting private water supplies.

Construction activities could alter the interaction between surface water bodies and local groundwater in systems where the two resources are hydrologically connected. In these circumstances, extracting water from one source eventually could affect the other source as well. Similarly, altering the water quality of one source could affect the water quality of other sources at down gradient locations.

Impacts also could occur if construction activities (e.g., excavation, blasting, trenching) create a conduit between a surface water body and a groundwater aquifer, or between two aquifers, by breaching the hydrologic barrier. This could result in unwanted dewatering or recharge of any of these water resources, depending on local hydrogeologic conditions. In addition, storm water control systems and any other activity that alters the ground surface could affect groundwater infiltration as well as the response time of a nearby surface water body.

The wind farm development could alter the direction of natural drainage paths to the source. This could result in a reduced volume of water along the natural drainage path. The potential for an activity to cause a reduction in flow is again based on a combination of the type of flow path, the nature, direction and extent of the activity and local topography.

We live directly below a number of wind turbines, the proposed construction compound both could be a cause of water course pollution, as well as the borrow pit, which will become a sink hole affecting the surface water, eventually effecting wells. All of the areas just above our home are serious potential for pollution of our deep bore well. None of the measures to stop pollution

are very effective, nor is there any attempt to monitor the quality of the ground water for possible deterioration or pollution.

This information must be set against CCDP 2022 Groundwater policy where it is noted that the 'quality of groundwater is threatened by worsening pollution levels, directly attributable to human activities' and would surely also be covered by EU Dir. 2024/1203. Following the precautionary principle, Cork CC / ACP has to ensure that an input of pollutants into groundwater is prevented, adding a severe caution that once contaminated, 'groundwater is difficult and expensive to clean'.

As I obtain my water from a deep bore well I am concerned with water contamination and disruption to supplies. Any disruption to flow or contamination will cause a considerable problems as there is no other alternative source of water. If it happens MKO/Enecro will deny that it has nothing to do with their Wind Farm.

MKO's EIAR failures to give me confidence that we not have water issues and problems do to their lack of concern or measures to stop water contamination.

### Rivers

In the Water Chapter of the EIAR for the proposed Maughanaclea WF the rivers are all High Status and not only that they are High Status Objective Rivers. These are very rare and really do need to be protected. The agent for the applicant states (opening para for page 63, Chapter 9) that "Our understanding of the objectives of the WFD is that surface waters, regardless of whether they have 'Poor' or 'High' status, should be treated the same in terms of the level of protection and mitigation measures employed, i.e. there should be no negative change in status at all.

There are strict mitigation measures in relation to maintaining a high quality of surface water from the wind farm to ensure that the status of surface waterbodies in the vicinity of the will be at least maintained regardless of their existing status. The rivers Mealagh and the Owengar have important salmonid status, there is also a population of Fresh Water Mussell. These could all be contaminated at some stage.

As I said at the start of this section my knowledge in this area is limited, however, MKO have failed to convince me that our well water is safe in their hands. The attitude through out this EIAR is simply, to say that is no significant issue/ risk/ effects. That's not good enough. ABP should question their assumptions and what data there is, rigorously, and if they cannot guarantee that there will be no negative effects on our water, then the proposal should be refused.

P75 V065

X Q

Show search results for P75 V065

Four empty search filter input boxes.



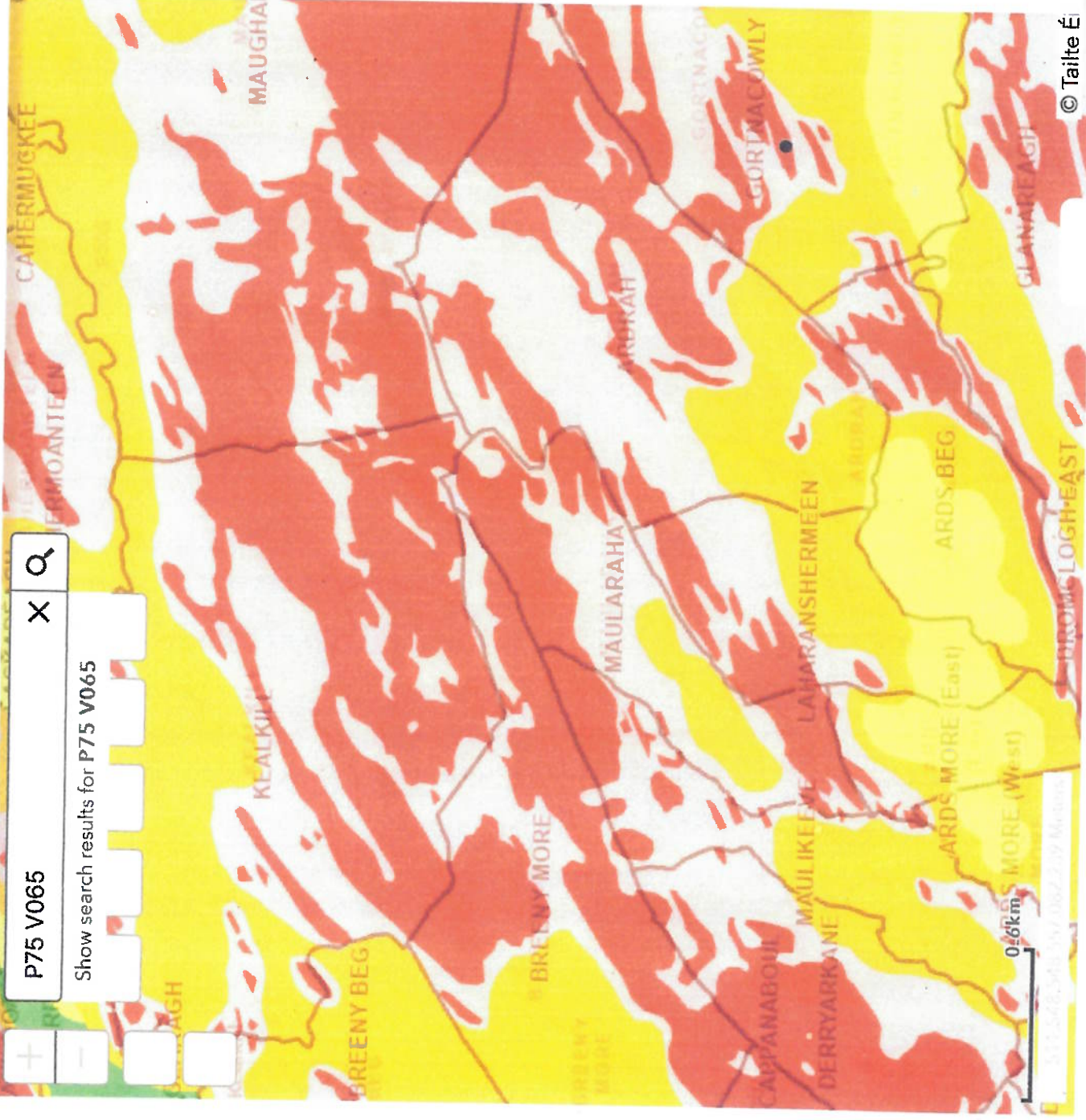
0.3 km

P75 V065, Bantry, Cork, IRL

[Zoom to](#)

P75 V065 X Q

Show search results for P75 V065



Legend

Groundwater Vulnerability

IE\_GSI\_Groundwater\_Vulnerability\_40K\_IE26\_ITM

- Rock at or near Surface or Karst
- Extreme
- High
- Moderate
- Low
- Water

Townlands

IE\_GSI\_Tailte\_Eireann\_Townlands\_IE26\_ITM



0.6km

Scale bar and coordinate information.



Carrigdangan Extension Wind Farm  
County Cork.

Currently being constructed by  
contractors for ENERCO,  
Consultants MKO.

On the day of visiting, this site seems  
to be unsupervised by Enerco's  
representatives.

The water may contain more than  
soil?



### My Conclusion and Thoughts about this EIAR.

Let's start at the beginning, MKO Scoping process was simply, as they say a desk top search. They openly admit that their prime objective was 'a wind farm project must be commercially viable/competitive'. County Cork has many sites in the areas of 'acceptable in principle' obviously these were not even considered. It comes back to commercial competitiveness.

I think it is important to be aware that there are a number of Wind Farm applications in this area, which all seem to be following the R585 route, and all are at present with An Commisum Pleanala. Just before the Cousane Gap is Gortloughra WF, 8 turbines, Curraglass WF 3 turbines, the the otherside of the Maughanacelas at Dereenacrinnig West WF 3 turbines. MKO admit themselves that within 25 Km there will eventually be sited, including current plans touching 300 wind turbines. Add to this, MKO makes the point numerous times in their EAIR that the area is ideal for further wind energy developments. MKO push the line that in this area there are already numerous wind turbines and people will accept them.

A very provocative statement, based on their own assumptions and that of the Wind Farm Industry as a whole. The strategy is simple it's a piece meal approach, a few wind farms at a time, however, the industry seems to be now speeding up their applications and swamping the area.

Let's get back to the Maughanacelas Wind Farm application and MKOs EIAR. Their EIAR is telling a very good fictional story to show us, that basically that 14x169.5m wind turbines will have no significant effect on the landscape, health due noise nuisance and whole array of issues effecting people, biodiversity and the environment in general.

How do they do it, lets briefly take landscape as example. MKO are aware this site is not appropriate for wind farms, however, MKO can change that situation. Simple, change the protections in place, change Cork Counties landscape characteristics within the CCDP, and just keep repeating their own evaluations, no significant effect. By continuing to say Medium Sensitivity instead of High, it will eventual be accepted. This strategy will remove a barrier to their application.

Additionally if they keep saying from different locations, Scenic Routes, Recreational Route that looking towards the turbines, significant visual effects are not likely to occur, better still tell receptors, if they don't to want to see the turbines do not look in that direction.

Reading MKOs EIAR story tells us that this is a prefect area for a wind farm, and using verbal gymnastics, and repeating simple phrases, as well as what George Orwell called double speak the fictional story becomes true. I do not think it has worked, well at least not for me.

At this point I will give a brief summary of why the Maughanacelas Hills are not an appropriate site for wind farm and never has been, as past planning history has shown.

The numerous CCDP objectives that MKO proposal fails, the question is this proposal situated in an appropriate location?

CCDP ET 13.2 objective, in the that County Cork will facilitate renewable energy developments.

*at suitable location within the county where such development has satisfactorily demonstrated that it will not have an adverse impacts on the surrounding environment (including water quality) landscape, biodiversity or amenities.*

### Summary

I have written in the submission numerous examples as to why MKO can not meet this objective, however, I will highlight some of the important areas.

a) Previous planning history, there have been a number of refusals for wind farms in the Mealagh valley over the last 25 years. The details of these can be seen in the appendices A&B. The reasons are all similar due to the negative visual impact on the surroundings. A precedent has been set by ABP for refusal.

The expansive cumulative of a number of proposed WF in this small area and their addition to high concentration within a 25Km radius.

b) Noise and Health, MKO dismiss that problem of AM and Infrasound and the resulting nuisance and health problems. even though there is now ample evidence that it is a problem. There is total denial of and mis-interpretation of the High Courts ruling regarding noise. Giving the same answer to noise, no significant impact or something similar.

c) Tourism a key employer in the area, the majority of tourists come here for the outdoor environment and the landscape. This Wind Farm will have dramatic effect on the landscape and consequently tourism. Tourists travelling the Scenic Route 29 want to look around, not as MKO suggest, not to turn their heads.

d) Dark Skies not a planning issue yet, but does effect the night visual amenity, a particular loss to the Mealagh Valley

e) Water, MKO has made assumptions about the water supply to homes. That is not good enough, however, it shows a negative attitude towards the residents of the area.

f) Peat Land, Very high extraction of peat from the site, 92,950 cubic metres.

g) Biodiversity, Negative impact on birds in particular the Coughs, Kestrels and the White Tailed Eagle. The destruction of Peat Land and the resulting loss in wild life, fauna and flora. MKO says the land lost totals 126,416 square metres, I doubt whether MKO's biodiversity areas comes anyway matching that loss.

h) Sparsely Populated For an Irish rural area we are not sparsely populated, there are between 650 -750 people living within 2Km of the proposed Wind Farm.

Due to time constraints and the need to carry out lots of research as well writing. I have not been able cover every area, and I have not as well as I would have liked.

The important point is that all the areas of the EIAR are dependent upon each other. In other words they effect each other, take away the peat and you effect biodiversity. Other examples are tourism is dependent on the landscape, like wise biodiversity is dependent on landscape and so on. What I am saying is we can not put each of these issues and concerns into neat boxes and not evaluate the overall effect. We have to consider the interconnections and how each area can effect each other. An Commisun Pleanala needs to be aware of the real situation. Many issues by themselves will not be a reason to refuse, however, connecting them all up gives a bigger picture that needs to be evaluated.

MKO's EIAR is their version of the story, with a careful use of language tells why the wind farm is acceptable. However, their statements and finding need to be robustly challenged as much of their assessments are based on very little substance, evidence as well as lots of unsubstantiated personal opinion. They use a small range of phrases to down play the effect of these massive wind turbine on the area, ie no significant effect, residual visual effect of slight, imperceptible, not significant, there is a long list of them.

Putting together all the various elements of this jigsaw it becomes very clear that this location is not appropriate for a wind farm as previous history has shown. Taking into account the multitude of weaknesses in this application this planning application must refused

An Commisun Pleanala must ignore the hyperbola of the language used, and use the EIA to robustly question much of the assessments, data and the many assumptions made in MKOs EAIR. An Commisun Pleanala should consider the previous refusals by ABP inspectors that have set a precedent that should be followed. On the evidence I have managed to gather the Maughanaclea Hills are not an appropriate site for a Wind Farm, particular as part of the site at Ardrah was refused. in the past.

Just one last issue, when the wind farm for Maughanacleas was announced a survey was carried out to find out peoples views. Please see Appendix

.Michael Colk BA, BSc (Hons) , MA.



21.05.2026

The Garthering, Gortnacowly, P75 V065, Bantry

AN COIMISIÚN PLEANÁLA

LDG- \_\_\_\_\_

ACP- \_\_\_\_\_

25 MAY 2026

Fee: € \_\_\_\_\_ Type: \_\_\_\_\_

Time: \_\_\_\_\_ By: \_\_\_\_\_

**Submission Ref: PAX04.324165**

**Maughanaclea Ltd Wind Farm**

**Submission from:**

**Michael Colk**

**Gortnacowly**

**Bantry**

**P75 V065**

**County Cork**

AN COIMISIÚN PLEANÁLA	
LDG-	_____
ACP-	_____
25 MAY 2026	
Fee: €	_____ Type: _____
Time: _____	By: _____

**THERE ARE 2 FILES**

**Main Submission**

**Appendices**

Appendices

Appendix A Past History Decisions by County Cork Planners for the Mealagh Valley

Appendix B Precis of An Bord Pleanala Inspectors Reports for the Mealagh Valley

Appendix C Cork Country Councils Development Plan Objectives

Appendix D Community Survey Results 2025, re: Mauglanacealas Wind Farm

Appendix E Pleistocene-Holocene Lakes Bantry

Proposed Development Turbine Layout -2Km Receptors

Research and Reference Documents

**Applications, Appeals and Decisions made by Cork County Council Planning and Board  
Members of An Bord Pleanala**

The first part of this Appendix is in regard to past applications for the North side of the Mealagh Valley.

**ARDRAH TOWNLAND:** Ardrah is the townland immediately on the West of the Maughanaclea Hills. It is important to note that these lands have now been gathered into the application for Enerco's Maughanaclea Wind Farm.

- 30/05/2011: an application for a wind farm at Ardrah was made for 5 wind turbines, with a hub height of 64 metres and a rotor diameter of 71 metres. (Tip height is 99.5metres). It included an Electrical tail station compound, a Sub Station and ancillaries.<sup>1</sup> Pre-planning meetings with CCC had been held on 02/08/2009 and 23/03/2011. After submitting the application, the developers were allowed six more months and re-submitted reports containing significant further information on the 18/01/2012. Forty (40) objection letters had been received against both applications. Planning permission was granted by Cork County Council on the 15/03/2012<sup>2</sup>, subject to 22 conditions.<sup>3</sup>
- 10/04/2012: Third Party Appeal was made to An Bord Pleanala, to rescind Cork County Council 's decision to grant permission for a wind farm at Ardrah. On 13/12/2012, Atkins Consultants were informed that they were required to submit the following to ABP by 15/10/2013:
  - 'A revised noise assessment for baseline monitoring to quantify background noise levels.
  - A revised Landscape and Visual Impact Assessment taking into consideration cumulative impacts of other permitted and proposed developments, particularly those within the Mealagh Valley.
  - Further surveys of habitats, flora and fauna.
  - Proposed sub-station should be relocated to achieve sufficient separation from tributary of Mealagh River.
  - Outline, for all stages of development, the purpose and scope of Ecological Site Management Plan, including particular actions to protect water quality.
  - Assessment of impact on known alignment of certain monuments, including the stone row (Co-106-008) with the summit of Seen, 29km to the northeast.

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<sup>1</sup> PA ref.11/318.

<sup>2</sup> These papers are no longer available one the Cork County Council planning web-site or An Bord Pleanala's.

<sup>3</sup> They included removing the foundations of the turbines if fully or partially decommissioned.

- In acc. with Article 111(2) of the Planning and Development Regulations 2001-2011, a description of the likely significant effects of the proposed development on air and climate factors.<sup>4</sup>
- 08/07/2014: An Bord Pleanala gave their decision to REFUSE permission for the above proposed development based on the reasons and considerations set out below.
  1. 'The Cork County Development Plan 2009 sets out policies and objectives in relation to wind energy development and identifies areas in broad strategic terms for the location and siting of such development, identifying "Strategic Search Areas" and "Strategically Unsuitable Areas". The overall strategic approach as set out in the said Development Plan is considered to be reasonable. The proposed development, which is not located within a "Strategic Search Area", is located immediately adjacent to areas designated as "Strategically Unsuitable Areas", would be unsuitable for wind energy projects and where such projects would normally be discouraged.
  2. The proposed development, which would by itself be visible over a wide area, would in conjunction with permitted and proposed development in the area, give rise to an undue concentration of wind energy development with significant negative impacts on the landscape character and visual amenities of the area, and in particular the Mealagh Valley, and its amenity, tourism and recreational potential. The proposed development would, therefore, seriously injure the visual amenities of the area and be contrary to the proper planning and sustainable development of the area.<sup>5</sup>

No appeal was given to / made by the First Party to the High Court regarding this refusal.

**COOMLEIGH EAST/WEST** townlands/hills, immediately on the East of the Maughanaclea Hills, and South East of the Ardrah, Maughanaclea site being proposed.

- 06/05/1999. Permission granted by Cork County Council, to E.F. Energy (Developments) Ltd. for a wind monitoring mast at Coomleagh: address given was Cousane.<sup>6</sup>
- 03/06/1999. Permission refused by Cork County Council to E.F. Energy (Developments) Ltd for a wind farm at Coomleagh East to include 20 no. turbines and ancillary works. The application included a meteorological mast.<sup>7</sup>
- 22/12/1999 Permission refused by CCC, to E.F. Energy (Developments) Ltd. for a wind farm to include 7 no. turbines, Hub Height 40m with Rotor Dia 48m + ancillary works etc on Maughanaclea.<sup>8</sup> The notification of decision to refuse permission reads as follows:

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<sup>4</sup> Letter from Executive Officer, dated 13/12/2012, held on An Bord Pleanala site. PL88.240461.

<sup>5</sup> Decision 08/07/2014, held on An Bord Pleanala web site. Ref PL 88.240461.

<sup>6</sup> PA ref. 99/1228 (Papers no longer available)

<sup>7</sup> PA ref. 99/1708 (Papers no longer available)

<sup>8</sup> Papers no longer available for PA ref. 99/5557. The decision is therefore taken from Inspector's report of 04.117606.

3. 'Having regard to the location of the site in a remote, elevated and unspoilt exposed upland area in a rural scenic landscape of amenity/tourism/ recreational potential and visible from a public road which is a designated Scenic Route in the current Cork County Development Plan, it is considered that the proposed large scale wind farm development would be visually obtrusive and out of character in the rural scenic landscape, and would seriously injure the visual amenities and natural beauty of the area. It is considered that the proposed development would be contrary to the objective of the Planning Authority as set out in the current Development Plan to preserve the views from such roads and would be visually obtrusive and conflict with this objective, which is considered to be reasonable. The proposed development would, therefore, be contrary to the proper planning and development of the area.
  4. Proposed development, in conjunction with existing and proposed wind farm development would constitute an unacceptable density of this type of large scale development in a sensitive and scenic area. Proposed development would, therefore, be contrary to the proper planning and development of the area.'<sup>9</sup>
- 23/06/2000. This application, for 7 turbines+ ancillary at Coomleagh East, was refused on appeal by An Bord Pleanala. The reasons for refusal were as follows:

'Having regard to the Guidelines for Wind Farm Development as issued by the Department of the Environment and Local Government in September 1996, and the location of the site in a remote, elevated and unspoilt exposed upland area in a rural scenic landscape of amenity, tourism and recreational potential, and visible from a public road which is a designated scenic route S30 in the current Cork County Development Plan, it is considered that the proposed wind farm development would be visually obtrusive and out of character in the rural scenic landscape and would seriously injure the amenities and natural beauty of the area. It is considered that the proposed development would be contrary to the objective of the planning authority, as set out in the current development plan for the area, to preserve the views from such roads and would be visually obtrusive and conflict with this objective, which objective is considered to be reasonable. The proposed development would, therefore, be contrary to the proper planning and development of the area'.<sup>10</sup>

- 06/03/2006. The application was from Pat & Catherine O'Leary for the erection of a 50m high wind monitoring pole at Coomleagh East . Permission refused by An Bord Pleanala, on appeal. Reasons given were:

1. 'The proposed site is located in an elevated, prominent and unspoilt upland area in close proximity to a designated scenic landscape and which is also readily visible from the designated scenic routes A80 and A81 as defined in the Cork County Development Plan, 2003. It is an objective of the said Development Plan as indicated in ENV 3-5 to preserve the character of those views and prospects obtainable from scenic routes identified in the Plan. The Development Plan also provides, in objective INF 4.4(b), to have regard in assessing wind energy projects to the visual impact of these projects on scenic routes and scenic landscapes.

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<sup>9</sup> p.7 of 23 PL04.117606

<sup>10</sup> p.1 of 1. 2000 An Bord Pleanala PL.04. 117606

These objectives are considered to be reasonable. It is considered that the proposed development would contravene the stated objectives of the Development Plan, would visually impact on the unspoilt nature of the area and landscape and would, therefore, be contrary to the proper planning and sustainable development of the area.

2. The Cork County Development Plan, 2003 sets out policies and objectives in relation to wind farm development including identifying areas in broad strategic terms for the location and siting of these developments and identifying "Strategic Search Areas" and "Strategically Unsuitable Areas". The overall strategic approach as set out in the said Development Plan is considered to be reasonable. The proposed development, which is not located within a "Strategic Search Area", is located in or proximate to "Strategically Unsuitable Areas", which are areas considered generally to be unsuitable for wind energy projects and where such projects would normally be discouraged. In the context of these provisions, it is considered that the erection of a meteorological mast in relation to the measurement of wind speed would be inappropriate in an area where it is likely that there would be a presumption against wind energy development. The proposed development would, therefore, be contrary to the proper planning and sustainable development of the area.<sup>11</sup>

**GOULACULLIN & BARRBOY:** townlands/hills next to Coomleagh West/East, again East of the Maughanaclea Hills. This site has a true history of try, and try again, by George O'Mahony, a farmer from Drimoleague.

- [97/1802] application by Innis Glas Energy for erection of a 40m wind monitoring mast and retention of a 10m wind monitoring mast. Permission granted with conditions.
- 01/10/1998 [97/4390] George O'Mahony applied for permission for a wind farm at Goulacullin (site1) comprising of 12 no. 660 Kw wind turbines with ancillary equipment for generation of electricity & control building. Permission refused by Cork County Council. Refused by An Bord Pleanála, on appeal [04.108973] on 25/05/1999. The Board Direction/ reason was given as follows:

Having regard to the Guidelines for the Wind Farm Development as issued by the DoE and the location of the site in a remote, elevated and unspoilt exposed upland area in a rural scenic landscape of amenity, tourism, and recreational potential and visible from a public road which is a designated Scenic Route in the current CCDP, it is considered that the proposed large scale wind farm development would be visually obtrusive and out of character in the rural scenic landscape and would seriously injure the visual amenities and natural beauty of the area.... The proposed development would, therefore, be contrary to the proper planning and development of the area.

- 14/12/1999. [99/5076. PL04.117428] Permission refused for erection of a wind farm at Goulacullin, comprising 12 no. wind turbines (height not stated) & ancillary development.<sup>12</sup>

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<sup>11</sup> p.5 of 35, Inspector's report PL 88.239767 18,19/01/2012, referencing out to 05/6090 PL 04.215033 06/03/2006.

<sup>12</sup> Information from CCC Planning website. PA ref. 995076, ABP ref. PL04.117428 decision date 13/04/2000. No papers can be found under this reference on the An Bord Pleanála site.

Appealed to ABP and refused 13/4/2000. A later An Bord Pleanála Inspector states the reason for refusal was the same as for Coomleigh West, above.

- 22/10/2003. Permission granted on the same site as above for five years, this time for a wind farm of 5 no. turbines, ( height of 76 metres not stated in Order) + ancillary: control buildings, substation & 40m wind monitoring mast .<sup>13</sup> There were two subsequent revisions to the plans. The decommissioning conditions included removal of all above ground structures and foundations.
- 20/10/2008. Application to extend permission submitted, then withdrawn. A wind monitoring mast had been erected but no construction work would be started until grid connection offer had been achieved. The permission above expired on 21/10/2008.
- 01/12/2008. New application submitted, with grid connection offer for 2009 (Gate 3).
- 12/03/2009. Permission granted for this new application on the same site at Goulacullin for the erection of wind farm comprising 5 wind turbines with towers up to 46m height and rotor diameter up to 62m (Tip height 76metres) and ancillary development.<sup>14</sup> No objection letters are recorded as being received. Twenty-eight conditions were imposed, including:
  - The identified mitigation measures, including measures to avoid slope instability and hydrogeological hazards, shall be implemented in full.
  - An assessment of vibration impacts from rock breaking on the borrow pit, spoil stockpile area, in-situ peat, to include comprehensive mitigation measures.
  - Archaeological monitoring of topsoil removal and of all clear felling of forestry and subsequent field walking of that area.
- 16/04/2014. An extension to this same permission was granted by Cork CC. No Observations were accepted from the public. No construction of the wind farm still took place. The extension was granted up to the 11/03/2019. <sup>15</sup>
- 11/04/2019. A further extension request by Mr O'Mohany's new consultants, Jennings O'Donovan, was submitted in the February, to extend the period for a further five years. This application for Goulacullin Wind Farm was refused by Cork County Council Planning as being against planning legislation.a

*The part of this Appendix is in regard to past applications for the Head of the Mealagh Valley. This begins in the Goulacullin townland, on the upper reaches of the Maughanaclea Hills, and then goes across to the Nowen Hills .*

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<sup>13</sup> PA ref. 02/5124. The permission as granted on the 21/11/2002, and then revised by details 18/02/2003 and 25/07/2003.

<sup>14</sup> PA. 08/2119.

<sup>15</sup> PA ref 14143.

**GOULACULLIN (Site2).** The majority of this new site is across the way from the old proposed Goulacullin wind-farm site and stretches towards Nowen Hill. The time line is as follows:

- 29/06/2023 A request for Pre- Application Consultation (for Goulacullin/Maughanaclea/Nowen) on behalf of Statkraft was made. The application, via their consultants, provided all initial paperwork and appendices. The project consists of 9 Wind turbines, 89.5 Hub Height, 155m Rotor, Tip Height 167metres, each with output of 6.6MW, plus a 38Kv sub-station and ancillaries. The total proposed site is 379.25 hectares. The consultants, Fehily Timoney, were proposing that the turbine blades and parts would be brought to site via the R585 and then the L4612-0 which is up and over the main ridge of the Hills, and is virtually a goat track towards the top. NB: whilst this was a formal pre-application submission, there had been no public consultation, and copies of the paperwork were only available because of a public access request made. ABP-317478-23 is the given reference by the Board. An entry for this pre-application can only be found on the ABP web-site if this reference is used: no entry can be found by location or description. The papers supplied gave the following timeline:
- 11/08/2023 Ashling Doherty provides a meeting date of 25 August.
- 14/08/2023 Consultant asks for deferment of the meeting whilst the Applicant is re-assessing the type of turbine used due to access issues. They stated that as a result, the development may not be deemed SID unless alternative lands are secured. They will be in contact once a decision is made on the overall development approach for the lands.
- 18/08/2023 Applicant given option to withdraw by ABP, and resubmit once they are ready to move forward.
- 07/03/2024 Applicant formally withdraws request for pre-consultation and fee is refunded.<sup>16</sup>

**NOWEN HILL** - *at the Head of the Mealagh Valley, across from Goulacullin.*

This hill is where Radio and Communications masts are situated- a necessity for the Mealagh Valley, Shehy Beg, and for the Drimoleague area. The four masts are of varying height, the tallest having a maximum height of 42 metres. The original permissions granted were not permanent ones: temporary permissions were granted for five and seven years until 2016 when retention of the masts were made permanent when applications submitted. Details are as follows:

(PA ref. 97/3467): Permission granted to East for a 24m antennae support structure. (PA ref. 99/4604): Permission granted to Irish Multi-Channel for retention of communications mast &

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<sup>16</sup> Following a Public Access request, this information is also verified by emails between An Bord Pleanala and Fehily Timoney.

ancillary buildings. (PA ref. 99/5804, ABP ref. 04.118746): Permission granted to East for retention of existing tower & equipment building. (PA ref. 01/1139): Permission granted to Skylink Communications to remove 2 no. 10 masts & erect 42m tower with 8 no. antennae dishes. (PA ref. 05/6831): Permission granted to O<sub>2</sub> for retention of a 300m section of track. (PA ref. 08/0053): Permission granted to O<sub>2</sub> for retention of permitted base station. (PA ref. 08/0535 PL 88.229423): Permission granted to Vodafone for retention of 15m support structure, associated development and access track. (PA ref. 08/1812): Permission granted 11/2008 to Skylink Communications for retention of 42m tower with associated antennae dishes and ancillary development. (PA ref.15/625): permanent retention granted 07/01/2026. (PA ref. 15/707): Permanent retention granted 02/02/2016.

*The next part of this Appendix is in regard to past applications and decisions for the South side of the Mealagh Valley.*

**DERREENACRINNIG WEST.** Coming round to the south side of the valley, Derreenacrinnig East is next to Nowen Hill, and then there is Derreenacrinnig West, next. In orientation, it is opposite Coomleagh East and West, and just short of being opposite the Maughanaclea Hills site where Enerco is proposing to place its turbines.

The planning permissions for Derreenacrinnig West are best considered in two parts, given there was an identified problem with project splitting. The tortuous planning route for the grid connection hasn't been detailed here: suffice to say that the development in its entirety has failed.<sup>17</sup> A judicial review was accepted and decisions regarding the grid connection were annulled or quashed on the 08 March 2021, confirming that the development had failed to correctly transpose the requirement of European Directive 2011/92 EU as amended. A Senior Executive Planner for CCC, notes that<sup>18</sup>.

'Given the quashing of these decisions clearly the developer, if the permitted wind farm is ever to be fully constructed and operational, must seek a further planning permission or Substitute Consent to obtain the cable route from the permitted wind farm to the Ballylickey substation. It is pertinent to note that the developer has indicated that they have "explored a number of options" but had concluded that':

*"The Section 34 process is the most prudent way to proceed ..... since ESP notes the issues raised in the Judicial Review in relation to splitting the two consenting processes into different applications and has decided to proceed on the basis of a singular Section 34 application."* (Paragraph 1.8 of the Submitted Planning Report dated October 2021).

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<sup>17</sup> See Cork CC planning: p.3 of 16: report from Phil O'Sullivan. 22/00153.

<sup>18</sup> p.3 of 16. Senior Planners Report 28/04/2022.

An Bord Pleanala formalised this annulment regarding the grid connection in September 2024.<sup>19</sup>

A first wind farm application at Derreenacrinnig West was approved by CCC planners on 03/10/2011 with 28 conditions.<sup>20</sup> There had only been one known objection, consisting of a single line of correspondence, from someone living in Co.Kerry. The Derreenacrinnig West wind farm, for seven(7) turbines, was permitted by An Bord Pleanala who turned down the co.Kerry appeal on 05/12/2012. The turbines were to have a hub height of 55 metres and a rotor diameter of 52 metres + ancillary including a sub-station.<sup>21</sup> This permission was subject to 16 conditions. The Board, as formed at the time, decided not to accept their own Inspector's recommendation to refuse permission. They considered the scale of the development proposed would be acceptable at this location, whilst noting it would impinge to some extent on views from scenic route s30 and might form a backdrop to certain views of the castle at Castledonovan: 'it was not felt that these impacts were so negative as to warrant a refusal of permission'. It is important to note there is nothing in the Board's statement to show that they considered the Mealagh Valley and how the scale of turbines, at height of 81metres, could negatively impact the visual amenity of the valley's landscape. The technical specification for the turbines was later amended, and agreed as the hub height or tip height remained the same.

An extension to this permission was granted by CCC on the 03/05/2022, with an end date of 29/04/2024.<sup>22</sup> This permission has now lapsed. An open information evening was held by Jennings O'Donovan in Drimoleague in November 2024 to reintroduce the 'wind farm project' to local people living on that side. It was said at that time the intention was to double the height of the turbines whilst reducing the number to three. This entails breaking up the old hardstandings that had been poured for the smaller turbines, though at the open evening there was nothing to show they had yet considered the ecological and environmental damage caused by these actions. The overhead wires and poles, to make a grid connection to Ballylickey, were not part of this 'public consultation', although they have now been included in the subsequent application.

A new application was submitted to Cork County Council on the 08/09/2025<sup>23</sup> but then invalidated as the development descriptions in the press notice and application form did not match. The application was for a wind energy complex with three (3) turbines having an overall ground to blade tip height of 119.3m, with a rotor diameter of 82m and a hub height of 78.3m. The same application was resubmitted by Jennings O'Donovan on 29/09/2025, and CCC has since received fifty five (55) objections and one observation. The current status of the application is one of deferment awaiting 'further information' which must be submitted within six months of 21/11/2025. The further information required includes a complete appraisal of the

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<sup>19</sup>ABP-315059-22.

<sup>20</sup> The decision papers, with the set out conditions are no longer on CCC planning's website, nor are the planning reports.

<sup>21</sup> PA ref. 10857, PL88.239767.

<sup>22</sup> PA ref. 22/153.

<sup>23</sup> 25/5826

collision risk for birds at the proposed site, and scaled plans showing the precise location of both new proposed poles and those of existing poles which are to be removed.

Planning permission was given by Cork County planners 06.05.2006. Appeals have now been submitted the ACP, ref: PL-5012243-WC-26.

**MULLAGAMESHA.** *These are the highest and longest hills of the Mealagh valley, on its the South side, and directly opposite the Maughanaclea Hills.*

Permission refused by CCC Planning on 01/10/1998, so appealed.<sup>24</sup> Refusal by ABP on 25/05/1999, to grant permission to Green Power Ltd of Macroom<sup>25</sup> for a wind farm comprising 20 no. turbines, generating 12mw, ancillary works etc at Coomanore South, Mullaghmesha and Glanaclougha. The County's decision was upheld by An Bord Pleanala, following an appeal from developer, for the following reasons:

'Having regard to the Guidelines for Wind Farm Development as issued by the Department of the Environment and the location of the site in an elevated and unspoilt exposed upland location in a rural scenic landscape of amenity, tourism and recreational potential and visible from a public road which is a designated Scenic Route in the current Cork County Development Plan, it is considered that the proposed large scale wind farm development would be visually obtrusive and out of character in the rural scenic landscape, and would seriously injure the visual amenities and natural beauty of the area. It is considered that the proposed development would be contrary to the objective of the planning authority as set out in the current Development Plan for the area to preserve the views from such roads and would be visually obtrusive and conflict with this objective, which objective is considered to be reasonable. The proposed development would, therefore, be contrary to the proper planning and development of the area.'<sup>26</sup>

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<sup>24</sup> CCC 98/1166. PL 04.108995.

<sup>25</sup> might this be a forerunner of the Craydel / Enerco Empire?

<sup>26</sup>CCC 98/1166. PI 04 108995 ABP.

### **Précis of Inspectors' and Planners' reports.**

Please note that not all Planners' and Inspectors' reports are available on the websites, especially those pre-2016 - but there are sufficient to show a true consistency that runs through all the reports, especially in regards to the visual impact that industrialised wind-energy complexes would have on the Mealagh Valley, and far beyond. No turbines considered in these reports have a hub height higher than 64 metres or a tip height higher than 109 metres, so the very tallest one proposed is some 60metres **check** shorter than the ones Enerco wishes to install on the ridges of the Maughanaclea Hills.

**ARDRAH TOWNLAND:** starting with past applications for the North side of the Valley, Ardrah is the townland immediately on the West side of the Maughanaclea Hills. These lands have now been gathered into the application for Enerco's Maughanaclea Wind farm.

23/03/2011. Pre Planning Meeting with Cork CC Planners. Kevin Irwin, CCCPlanner, requested

- photomontages (looking towards Ardrah site) for any scenic roads within a 15km radius, and suggested views along Castle Donovan Road, and the Castle. He noted that the Drinagh, Drimoleague, Dunmanway triangle as being a very sensitive impact area.
- Residential Properties Assessment was necessary of visual, noise, and shadow flicker for all houses in close proximity, in particular the Mealagh Valley which was sensitive in terms of visual amenity for visitors, water courses, and existing residential properties.
- Environmental issues around ecology, archaeology, access and surface water around turbines bases...likely to be issues.
- 30/05/2011. [CCC11/318] An application was submitted for a wind farm at Ardrah, consisting of 5 Wind turbines, with a hub height of 64 metres and a rotor diameter of 71 metres,<sup>1</sup> plus Electrical Tail Station compound, Sub Station and ancillaries. Planning permission was granted by Cork County Council (CCC) on the 15/03/2012 and was subject to 22 conditions.<sup>2</sup> The CCC planning reports are no longer available. However, the ABP Inspector has summarised some of the points in that further information was sought by CCC planners prior to granting permission. It appears the reason for CCC granting permission was 'having regard to the fact there were no scenic or other designations relating to the site and the enclosing

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<sup>1</sup> The Tip height is 99.5metres: p.8 2922DG04 Appeal document Atkins.

<sup>2</sup> PA ref.11/318. These papers are no longer available one the Cork County Council planning web-site or An Bord Pleanala's.

topography, the development would not have significant adverse visual impacts'.<sup>3</sup> The ABP Inspector has purposefully quoted the CCC Planner's note that the proposed mitigation measures, including screening around residential boundaries, would not be effective, are questionable and difficult to implement by condition. CCC's Senior Planner seems to have simply concurred with CCC's Area Planner, whilst adding she/he was aware of the sensitivity of the landscape and that the extent of wind farm is modest and the height is not excessive. The ABP Inspector also noted that no response to the third party appeals (discussed next) had been received from the planning authority.

- 10/04/2012. The application/ permission, for a wind farm at Ardrah, was the subject of a third party appeal to An Bord Pleanála. The first report, dated 13/07/2012, is by Mr Conor McGrath, from its Inspectorate. His assessment and conclusions included the following extracts:
  - 'The appeal site occupies an elevated position (approx. 190-220m OD) at Ardrah at the western end of the Mealagh Valley, approx. 10.5km northeast of Bantry and approx. 2.5km southeast of the village of Kealkill. The site lies on the lower, western end of the Maughanaclea Hills on the northern side of the Mealagh Valley. The ridge of Mullaghmesha / Nowen Hill lies on the southern side of the valley. The site is irregularly shaped and comprises a stated area of 42.27ha. The main area of the site slopes to the south. A ridge or series of hummocks trends NE / SW across the northern section, while the topography of the central and southern sections of the site are more even.
  - '....I note that walking trails have been developed through this area in recent times, which connect the Sheep's Head Way with the Bearagh Way. There are a number of existing wind energy developments within the surrounding area. There is an existing wind monitoring mast on the site, which does not comprise part of the development the subject of this appeal. I cannot identify any planning permission granted in respect of this mast and the exemptions under Class 20A may apply. An existing overhead powerline also crosses the northern section of the site.' <sup>4</sup>
  - 'The proposed development comprises the erection of five wind turbines on these lands. The turbine type is identified as Enercon E-70's, having a hub height of 64m and a rotor diameter of 71m, giving a tip height of 99.5m. The turbines have a rating of 2.3MW each such that the overall development would have a total potential output of approx. 11.5MW. Turbine base heights vary from 190m to 228m elevation. A borrow pit is to be created within the site, adjacent to the most northerly turbine, T1, measuring approx. 30m x 26m x 5m deep. The application indicates that in a worst case scenario, the development will require the excavation of 3,870metres/sq. of rock from the pit.'<sup>5</sup>
  - 'The site is understood to be in the developer's ownership and the EIS does not identify any alternatives examined with regard to site location. The selection of this site appears therefore to

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<sup>3</sup> p.8 of 46. PI 04.240461.

<sup>4</sup> p.2 of 46 Inspector's report 13/07/2012.

<sup>5</sup> pp.2/3 of 46.

have been based on its availability rather than its suitability for development over other locations. The Development Plan identifies Strategic Search Area for wind energy development and areas that are determined to be Strategically Unsuitable for such development. While the appeal site is not located within either category of lands, lands immediately adjoining the site to the north, west and southwest are identified as Strategically Unsuitable for wind energy development. The plan indicates that areas not identified as either search areas nor strategically unsuitable will be considered on their merits having regard to normal planning criteria including landscape sensitivity, visual and environmental impacts.<sup>6</sup>

- 11.2.2 Scenic routes: 'The R584 and R585 to the north are identified as Scenic Routes in the development plan. The hub height of the proposed turbines is 64m and the rotor diameter is 71m. Turbine base heights vary from 190m to 228m elevation. Lands to the north of the site rise to between approx. 220m and 260-272m, while the Maughanaclea Hills to the east rise eventually to approx. 450m. The sub-station compound is located at the southern end of the site such as to be generally screened from external views. Separation from the site and intervening topography reduce the visibility of the development from Scenic Route S28 (R584) to the north. Topography also provides significant screening from the R585 (S29) and there will be only limited views from the R585 to the development. While the development will be visible from locations along these routes, it is not considered that the development would have significant negative impacts on the character of, or views from, these designated scenic routes. The development will be visible from a number of locations on the N71, scenic route. Views from this route are, however, primarily directed toward the coast and Bantry Bay, and having regard to the separation distance involved it is not considered therefore that the development would detract from the character of this scenic route in a significant adverse manner. **[Note; tip height of proposed turbines was 99.5 metres, only.]**
- 11.2.2. Scenic Routes cont/ 'In addition to the designated scenic routes in the development plan, other tourist / amenity routes in the area include the Beara Gougane Barra Cycle Route to the north and walking routes through the Mealagh Valley. The development would feature prominently features in views from these routes. The orientation of the site is such that the development would also feature widely in views from the surrounding road network to the south and west. While such roads are not designated scenic routes, they are generally within the area identified as unsuitable for wind energy development. Other wind energy developments also feature in such views.'<sup>7</sup>
- 11.2.3 Mealagh Valley. 'The appeal site is located at the western end of the Mealagh Valley, on an east-west trending ridge. The valley comprises a distinct landscape unit, enclosed by hills on three sides. In recent times, a number of marked walking routes have been developed locally, within the valley and linking the Sheeps Head Way and the Beara Way. Within the Mealagh Valley, there are two permitted and/or proposed windfarm developments at Barrboy and Derreenacrinnig West.
- 11.2.3 cont/ In contrast to other existing and proposed wind energy developments in the area, the subject development, notwithstanding its lower elevation, would be visible over a wider area,

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<sup>6</sup> p.23 of 46.

<sup>7</sup> p.24 of 46.

while also having local visual dominance. This is reflective of the zoning of immediately adjacent lands as unsuitable for wind energy development. The primary visual impacts arise on views from the west and south. In particular, views from the public roads along the southern side of the Mealagh Valley would be dominated by the development. As one travels east from Drumbrow Lough along this road toward Barnagowlane, turbines would assume greater skyline prominence. Views from this road are located largely within the area identified in the development plan as Unsuitable for Wind Energy Development. I note also that the existing wind monitoring mast is visible along sections of roads on the northern side of the valley. I consider that the development of a third wind energy development within this enclosed landscape unit would significantly erode the remote rural character of the valley and negatively impact on views therein. As one travels through the valley, there would no point at which wind energy developments were not visible, thereby undermining the tourism and recreational potential of the valley. The cumulative effect of the development in this regard has not been considered in detail in the application or by the planning authority. I consider, however, that the overall impact of the development would be significant adverse and would lead to an excessive concentration of such development within a distinct landscape element.

- 11.2.4 Residential amenity: There are a considerable number of houses within the Mealagh Valley, particularly at its western end. The visual and landscape assessment contained in the EIS acknowledges that a number of residential properties will experience moderate or significant visual impacts from the proposed development. There are approx. 20 no. houses on the southern side of the valley which face toward the appeal site, which number is not reflected in the visual impact assessment of the EIS. Having regard to the elevation of the proposed development and the aspect of such houses, it is considered that the development would comprise an unduly dominant feature in the landscape and would negatively impact on their residential amenities. There are also properties to the southwest of the site, which would be significantly impacted on by the proposed development. I consider that the assessment of impacts on the amenities of properties to the southwest of the site and on the southern side of the valley, are underestimated in the assessment. Mitigation measures identified in the EIS include the erection of fencing and screen planting around dwellings, however, such measures are regarded as inappropriate and unenforceable.
- 11.2.5 Wider Cumulative Impacts. Cumulative landscape and visual impacts arise in respect of inter-visibility of such developments, but also arise where one views or experiences a number of such developments as one moves through a landscape area. I have already made reference to two proposed wind energy developments within the Mealagh Valley, while there are other existing and proposed wind energy developments within the wider area.
- 11.2.5 WCI cont/ 'I have previously raised concerns regarding the overall concentration of such development in this wider area and its encroachment into more upland areas (under appeal ref. PL04.239767), with consequent impacts on the perception of landscape character and quality. There is an issue of conflict between national renewable energy targets and the further erosion of the rural and upland character of this area. In this regard, I note that the map of indicative Strategic Search Areas and Unsuitable Areas was produced originally in the 2003 Cork County Development Plan and remains unchanged in the current (2009) plan. Since its original publication, there has been a considerable level of wind energy development in areas identified as neither Strategic Search Areas or as Strategically Unsuitable. Similarly, as noted by the third parties, technology and turbine height has increased in recent years. The 2007 Draft Landscape

Strategy noted the potential cumulative impact further wind energy development could have on the character of this landscape type. It is not apparent that an assessment of the overall impact of constructed and permitted wind energy projects, or an assessment of the capacity of this landscape to accommodate further development, has been carried out.

- 11.2.5 WCI cont/ As identified earlier, the National Renewable Energy Action Plan Progress Report identifies that sufficient quantities of wind generation are already scheduled to meet national targets for 2020. In this regard, the imperative giving rise to proposals for the further development of wind energy projects in areas of high landscape sensitivity would appear to be reduced.<sup>8</sup>
  
- 11.3 Soils and Geology: 'The potential for the failure and movement of peat soils has been highlighted by a number of events in recent years, however, such events are also known to have occurred historically. Recorded bog failures have occurred on slopes ranging upwards of 2 degrees and such failures are usually associated with human interference. In general, it has been suggested that natural failure in peat bogs is unlikely in slopes below 3 degrees. Failures generally occur during or immediately after periods of heavy rainfall. Best Practice guidance produced by the Scottish Executive in 2006 identifies two broad types of peat landslide, "peat slide" generally occurring in peat up to 2m depth on steeper slopes (5 -10 ) and "bog bursts" generally occurring in deeper peat (>1.5m) and on shallower slopes (2 -10 ). The EIS notes that data collected on the site includes peat depths, un-drained peat shear strength and visual observations of bedrock, soil, topography, land use, drainage and ground conditions. The site comprises a mixture of soil types with peat arising in basins generally bounded by shallow NE - SW trending bedrock ridges. The terrain is generally undulating with slopes of 2 to 6 degrees, with higher elevation slopes of 6-8 degrees generally, locally steeper. While peat depths are generally shallow, between 0.1m and 0.4m depth at turbine locations, two areas of deep peat are identified. The first area, to the south of Lough Nabirree, is to be crossed by the temporary northern access road, by means of a floating road. The prevailing slope in this area is such that the risk of failure in this area is identified in the EIS as not significant. The second area occurs within the extent of excavation at T4, wherein peat depth of 1.7m is identified. The EIS indicates that this area cannot be avoided, however, slope is not a significant factor in this area. Shear strength is noted to vary across the site. ....It is indicated that total peat excavation across the site will be 9,919 metres square bulking up to approx. 11,900m . Three peat storage areas are identified, while peat from the northern access track will be side cast. The storage areas comprise an area of disturbed ground currently used for stockpiling rock at the south-western end of the site, an area of cut- over bog adjacent to T4 confined by peat banks and the proposed borrow pit, such that no loading of peat soils from such storage will arise.
  
- 11.4 Water: 'Upland areas of this type usually experience rapid run-off following sustained rainfall events and a high rate of overland flow. A site water management plan was submitted at further information stage, which classifies site soils as having very low winter rainfall acceptance potential with minimal soakage potential. The main site development area and southern section of the site drain to the Mealagh River to the south via two watercourses, which combine to form the Ardsbeg waterbody. This tributary is noted to have potential for salmonid species and has an objective to protect its High Status. The Mealagh River, itself an important salmonid river flowing toward

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<sup>8</sup> p.25 of 46.

Bantry Bay, is identified in the RBMP as being of High Status, with an overall objective to Protect Water Quality. The river is identified as being Not At Risk, while the tributaries are rated as Probably Not At Risk. The northern sections of the site, accommodating the northern access road, drains via two tributaries to the Owengar River to the north, another important salmonid river. The Owengar flows to Bantry Bay via the Owvane River. This is also of High Status, with an overall objective to Protect Water Quality. Both the Owengar and the Mealagh Rivers have been identified as accommodating populations of Freshwater Pearl Mussel, downstream of the appeal site. Site works have the potential to increase the volume of run-off due to excavation and removal of ground cover. The most significant hydrological risk arising from the development, however, is considered to be the risk to surface water quality due to increased silt / suspended solid loading to receiving waters. There are also risks to surface water quality from hydrocarbon leakage, wastewater leakage or other pollutants...<sup>9</sup>

- 11.5 Noise ...'The adequacy of the noise impact assessment, and in particular the measurement of background noise levels, has been the subject of detailed third party submissions. Based on the submitted results and notwithstanding the separation of houses from the development, the queries raised would appear to be valid and first party correspondence on the file has not adequately addressed those issues. The Board may wish to request the first party to address these issues by way of a request for further information in order to ensure that satisfactory baseline data is used in the assessment of noise emissions from the proposed development.'<sup>10</sup>
- Conclusions on the Ardrah application, from Conor McGrath's first report, 13/07/2012, on behalf of An Bord Pleanála's Inspectorate: 'I have identified a number of deficiencies in the submitted EIS. I have also identified other areas where further information would be required in order to adequately assess the impacts of the development. Notwithstanding these matters, and the provisions of Article 108 as amended, I consider that there are fundamental issues in the consideration of this proposal, relating particularly to the landscape and visual impacts of the development. The Mealagh Valley comprises a distinct landscape element, recognised in the county landscape character assessment as being of high sensitivity... The site is exposed to views from a relatively wide area to the south and west, notwithstanding its relatively low elevation. Notwithstanding its relative scale, I consider that the proposed development, by reason of its overall exposure and cumulative impact on the character and amenities of the Mealagh Valley, would have significant negative impacts on the landscape and visual amenities of the area and its potential as a tourism and recreational resource'.<sup>11</sup>
- Recommendation: 'Having regard to the foregoing, I recommend that the decision of the Planning Authority be overturned in this instance and that permission be refused for the proposed development...<sup>12</sup> In the event of the above recommendation not being accepted by the Board, the following items of further information would be required. [Mr McGrath listed seven points, the last point being]:

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<sup>9</sup> p.27 of 46.

<sup>10</sup> p.33 of 46.

<sup>11</sup> p.43 of 46.

<sup>12</sup> p.44 of 46. mlght need to expand on this - there is more.

- 7. 'The EIS, and supplementary further information submitted to the planning authority and to the Board, is considered to be deficient and fails to comply with the requirements of Articles 94 and 111 of the Planning and Development Regulations, 2001-2011 and in particular the requirements of paragraph 1 and 2 of Schedule 6 of the Regulations. In this regard, in accordance with Article 111(2) of the regulations as amended, you are requested to submit the following:
  - a) A description of the air and climatic factors likely to be significantly affected by the proposed development and a description of the likely significant effects (including direct, indirect, secondary, cumulative, short, medium and long-term, permanent and temporary, positive and negative) of the proposed development on air and climatic factors resulting from: the existence of the proposed development, the use of natural resources, the emission of pollutants, the creation of nuisances and the elimination of waste.
  - b) An indication of any difficulties (technical deficiencies or lack of know-how) encountered by the developer in compiling the EIS.
  - c) The developer should identify and outline the main alternatives studied by the developer and an indication of the main reasons for his or her choice, taking into account the effects on the environment. <sup>13</sup>

The ABP Board decided at that time to request further information from the consultants, to be sure of their final decision. Atkins engaged MosArt Ltd, which provided additional information to ABP in Oct 2013, stating the following:

*'Cumulative impacts of windfarms tend to be adverse rather than positive as they relate to the addition of moving made made structures in a landscape and viewing context that already contains such development... A new wind farm might also contribute to a sense of being surrounded by turbines with little relief from the view of them. The term 'skylining' is used in SNH [Scottish National Heritage] Guidelines to describe the effect "where an existing windfram is already prominent on a skyline the introduction of additional structures along the horizon may result in development that is proportionally dominant. The proportion of developed to the non-developed is therefore an important landscape consideration."*

MosArt continues: *In terms of visual amenity, there is a range of ways an additional wind farm might generate visual conflict and disharmony in relation to other wind energy developments. Some of the most common include visual tension caused by disparate extent, scale or layout of neighbouring developments. A sense of of visual ambivalence might also be caused by adjacent development traversing different landscape types. Turbines that seen stacked in perspective against the turbines of nearer or further developments tend to cause visual clutter and confusion. <sup>14</sup>*

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<sup>13</sup> p44 of 46

<sup>14</sup> NB this report is in the Ardrah file. I think MKO and Jennings uses the same criteria and tables: Magnitude of cumulative impact, but do not Draw the same conclusions as MosArtLtd. Mozart says its rigorous methodology draws DoEHLG Wind Energy Guidelines (2006) but principally based on SNH Guidance relating to the Cumulative Effects of Wind Farms (2005). This was absorbed into guidelines for Landscape and Visual Impact Assessment (2013) produced by the Landscape Institute and the Institute of Environmental Management and Assessment.

[this is relevant to both the proposed Northern Maughanaclea site, and the Southern Site. Turbines 4,5,6,2,3,1 will be seen in the same viewpoint as proposed Shehy Beg site and the operational site of Shehy More. Likewise, though Maughanaclea is being courted as one proposal there are three different sites: The cumulative effects of these mean that turbines 14, 13, 12 will be seen on the same skyline as turbines 4, 5, 6, 2, 3 and 1, but at different heights.]

- 15/10/2013 Conor McGrath provided a thirteen-page supplementary report on Ardrah which related to the further information received back from the first party, and their consultants, subsequent to the request by the Board under section 132 of the Act. His conclusion is as follows:

- 'It is stated that the "steep and meandering nature of the Mealagh River Valley aids the visual absorption of the modest scale wind farms that are located on the ridges above the valley." ...It is clear from documentation submitted with the planning application and at further information stages, that the development will be visible in conjunction with other existing and permitted wind energy developments along almost the entire southern side of the Mealagh Valley. While I note the analysis submitted, I consider that the cumulative impact with other permitted development within the area would be significant adverse rather than medium as suggested. I do not consider that the succession or sequential nature of such views, as opposed to a combined view, significantly mitigates the landscape character impacts of the development. The concentration of three wind energy developments around this valley, notwithstanding their modest scale, would significantly alter and erode its character. In this regard, I remain of the opinion that the permission for the development should be refused for the reason previously recommended.'<sup>15</sup>

- The ABP Inspector's recommendation is as follows:

- I consider, based on the information submitted with the planning application and associated further information responses, and the information subsequently submitted to the Board in October 2013, that there is sufficient information before the Board on which to make a determination in this instance. I have previously raised concerns with regard to the overall landscape and visual impacts of the proposed development, particularly on the character of the Mealagh Valley, when taken in conjunction with other permitted developments in the area. I do not consider that the submissions received have addressed these concerns and remain of the opinion that permission should be refused on these grounds:

1. The Cork County Development Plan 2009 sets out policies and objectives in relation to wind energy development and identifies areas in broad strategic terms for the location and siting of such development, identifying "Strategic Search Areas" and "Strategically Unsuitable Areas". The overall strategic approach as set out in the said Development Plan is considered to be reasonable. The proposed development, which is not located within a "Strategic Search Area", is located immediately adjacent to areas designated as "Strategically Unsuitable Areas", considered generally to be unsuitable for wind energy projects and where such projects would normally be discouraged. The proposed development, which would itself be visible over a wide area, would in conjunction with permitted and proposed development in the area, give rise to an undue concentration of

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<sup>15</sup> p.11 of 13. PL88.240461 Supplementary report.

wind energy development with significant negative impacts on the landscape character and visual amenities of the area, and in particular the Mealagh Valley, and its amenity, tourism and recreational potential. The proposed development would therefore be contrary to the proper planning and sustainable development of the area.<sup>16</sup>

This conclusion formed the reasons given in the final order made by the Board, on the 08/07/2014. There was no appeal/ application for a Judicial Review.

**COOMLEAGH EAST/WEST:** the townlands/hills, immediately East and South East of the Maughanaclea Hills site being proposed.

- 23/06/2000. Permission refused by CCC for a wind farm, and again on appeal by ABP. Application was from E.F. Energy (Developments) Ltd. for the industrialised complex to include 7 no. turbines, Hub Height 40m with Rotor Dia 48m + ancillary works etc.<sup>17</sup> Mr Dermot Kelly, from the Inspectorate of An Bord Pleanála, included maps and 27 photographs<sup>18</sup> in his 23 page report and the following extracts give an indication of his extensive and forthright assessment on placing a wind farm on ridges and hills surrounding the Mealagh Valley:

○ [Under "Visual Impact", Mr Kelly first considers the suitable placement of wind farms:] I note the comments in the Guidelines (para 2.3) in regard to "areas of the midland bogs" with "substantial energy infrastructure" and "flat landscape", which areas would be less critical from the viewpoint of visual impact of proposed wind farm development than the present appeal site which is an "exposed upland" site in my opinion - in this regard, see photographs attached in Appendix B of this report. There is also reference in Para 2.3 of the Guidelines for Wind Farm Development to "coastal" sites as "Areas of high wind energy". In this regard I note recent proposals for offshore wind farms, notably a proposed 200 megawatt wind farm on the Kish bank in Dublin Bay about 10 kilometres off Dublin, and again I consider that the visual impact of such offshore wind farm developments - with very significant generating capacity - in appropriate and sufficiently offshore locations would be less critical than in "exposed upland" locations such as the present proposed wind farm development above the Mealagh Valley to the west, noting the number (7) and the blade tip heights of the proposed turbines (at circa 64 metres, or over 200 feet) - which, for comparison purposes I note exceeds the height of the landmark building, Liberty Hall (59 metres) in Dublin City, and also exceeds the approximately similar height of the landmark building Cork County Hall in Cork City.<sup>19</sup>

○ [In referring to the Coomleagh East application, he adds]: as such, consideration of the visual impact of wind farms on "exposed upland sites" such as the appeal site is particularly critical (which visual impact for all potential wind farm sites is stated to be "among the more important

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<sup>16</sup> p.13 of 13.

<sup>17</sup> Papers no longer available for PA ref. 99/555. ABP ref. PL04/117606.

<sup>18</sup> Maps and Photos no longer attached to this report on the ABP web-site.

<sup>19</sup> p.14 of 23.

considerations to be taken into account in arriving at a decision on a particular application" - para 4.8 of the Guidelines<sup>20</sup>). In regard to visual impact considerations re such exposed uplands sites, I note that proposed radio communication towers on upland sites to service mobile telephone networks have been refused permission on many occasions by reason of visual obtrusiveness in the landscape, e.g. Ref PL 04.100370 re a proposed mast in the Kealkill area to the northwest of the appeal site, and that such proposed single structures - generally of lattice work construction - rarely exceed 30-35 metres in height, which heights are much lower than the 64 metre heights of the proposed seven turbines...<sup>21</sup>

- [He further notes]: that the Irish Planning Institute's Guidelines for Wind Energy considered in regard to wind farm developments that "the Irish landscape is generally small and compact and has limited capacity to absorb large wind farms... except in exceptionally suitable landscapes which are already blighted by development and have low amenity value". I concur with such an assessment and I consider that the proposed wind farm on a scenic exposed upland site within an attractive rural scenic landscape should be refused permission, by reason of visual impact.<sup>22</sup>
- [In referencing to his site inspection and photographs]: I consider that the proposed wind farm development [at Coomleagh East] by reason of its scale and location on this exposed upland site above the Meelagh Valley to the west would dominate landscape features in the area and be "prominent when seen against an elevated skyline background from public roads" in the area... and, as such, would be contrary to the above Guidelines for Planning Authorities (Para 4.9) issued by the Department of the Environment in regard to Wind Farm Development - which Guidelines are considered reasonable - and as such be contrary to the proper planning and development of the area. In this regard, I concur with the planning authority's appeal response that the appeal site is located within a surrounding landscape that is "of an attractive scenic character", and in particular I consider that the scenic Meelagh Valley to the west (see Photos in Appendix B) qualifies as "an adjacent area of high landscape quality" which should be considered in the "assessment of visual impact" (Ref. Para 4.9 in Wind Farm Development - Guidelines for Planning Authorities).
- [He then states]: in my opinion the proposed wind farm development on this exposed site on the upland slopes of Coomleagh Mountain overlooking the Meelagh Valley to the west would result in a significant adverse visual impact on the receiving landscape both in the immediate Coomleagh and Meelagh Valley area and in views from a distance...and as such would contravene Section 4.9 of the above Guidelines that "turbines should not dominate landscape features..."<sup>23</sup>
- [In turning to the Cork County Development Plan that was current in 2000, Mr Kelly from the ABP Inspectorate states:] I concur with the planning authority that the visual character of "the surrounding landscape, while not designated as such, is of an attractive scenic character", and as such would be incapable of assimilating the proposed wind farm without significant adverse

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<sup>20</sup> Visual Impact in the Wind Farm Development Guidelines for Planning Authorities

<sup>21</sup> p.14 of 23.

<sup>22</sup> p.15 of 23.

<sup>23</sup> p.15 of 23.

visual impact by reason of the exposed and elevated location of the proposed wind farm and the scenic quality of the area – see Photos in Appendix B of this report...

- The proposed wind farm comprises 7 three-bladed turbines (with hub- heights of 40 metres and blade-tip heights of circa 64 metres as per submitted drawings), which would include rotating blades in a 'static landscape' of high scenic quality, including the adjoining Mealagh Valley area to the west and also the adjacent semi-wilderness areas to the south of Barragowlane and to the northeast of Barrboy – see Photos 3 and 19 in Appendix B. I consider that the proposed development close to the summit of Coomleagh (see contour lines and base levels of proposed turbines as per submitted Site Layout Map, Scale 1:2500) – on a scenic exposed elevated mountainous site – would be widely visible in the surrounding attractive scenic landscape, and would be visible from designated Scenic Routes in the area, including from Scenic Route A80 and the Scenic Area B20 to the south of the Pass of Keimeinagh and, as such, should be refused permission on grounds of visual obtrusiveness.<sup>24</sup>
- West Cork Volume, Para 2.38 re Inland Areas: 'many inland areas in West Cork have attractive scenery and good access to mountain and coastal areas, and may represent suitable bases for touring holidays. Small scale development of tourism accommodation on working farms could be attractive to tourists as well as helping to support the agricultural sector. The quality of such development, and in particular its ability to fit into the landscape, and make use of existing or traditional type buildings, is likely to be critical for its acceptability and success...I consider that the appeal site above the Mealagh Valley similarly lies within such an Inland Area with "attractive scenery" and tourism potential, as stated. In this regard, I note that long term employment in the proposed wind farm development would involve few persons. While I accept the first party appellants' E.I.S. submission (Para 2.4) that wind farms may have some tourism interest, on balance I consider that the proposed wind farm development in this scenic exposed upland area would result in a significant adverse visual impact which would detract from such tourism development potential as identified in Section 2.38 of the Development Plan, which "small scale development of tourism accommodation on working farms" I consider could "fit into the landscape" unlike the present proposed wind farm development adjoining the Mealagh Valley area, which area is promoted in tourism literature as the 'Valley of the Rushing Streams' or the 'Valley of the Standing Stones'.<sup>25</sup>
- Other interesting aspects also come into play in the ABP Inspector's assessment regarding this industrial wind-energy complex being built on the Coomleagh Mountain overlooking the Mealagh Valley :
  - I do not consider this appeal site is a 'secluded area' site which, as such, would warrant consideration for a 'large scale wind farm'... as I do not consider that its visual impact could be minimised'...achieved on this elevated site at Coomleagh.
  - I concur with the planning authority that the proposed development should be refused permission by reason of visual obtrusiveness on this exposed upland site of high scenic amenity,

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<sup>24</sup> pp.16/17 of 23.

<sup>25</sup> pp.18/19 of 23.

and that the surrounding landscape is incapable of assimilating the proposed development without 'severe' adverse visual impact.

- I do not consider that the Noise Impact of the proposed wind farm development would be significant noting the distance from the nearest house, though I would consider that noise can travel extensively within such areas as the Meelagh Valley.
- I consider that the proposed wind farm would involve significant disturbance of the upland area including areas of blanket bog (and areas of potential archaeological interest, noting in particular the comments re same in Para 9.5 of the Environmental Statement), particularly in the construction of the proposed access roads within the site, and there would also be an impact on the fauna of the area (and it is noted that the Birds Survey indicated the presence of Ravens in the area) and also that disturbance of birds may occur at "upland wind farm sites" (Para 8.5.5 in the Environmental Statement).
- I also consider that the visual impact of the proposed wind farm turbines would be significantly much greater than afforestation of the appeal site (which afforestation would form natural growth in a static landscape) whereas the proposed wind farm turbines - with moving parts - would represent "man-made" industrial type structures with vertical elements of significantly increased height (64 metres or 200 feet) in a static landscape with blade tip height ranging up to 470 m AOD above the summits of Barrboy (453m) and Coomleagh (450m).
- Noting the provisions in the Development Plan (Para 2.38) re further tourism potential in areas such as the Meelagh Valley area beneath the site, I consider that the proposed wind farm development by reason of visual obtrusiveness would seriously detract from such tourism potential in the Meelagh Valley area...and particularly noting that the proposed wind farm would be widely visible from houses and public roads in the Meelagh Valley area, and particularly visible across the Meelagh Valley from the far side of the valley in the Barnagowlane area (see Photos in Appendix B); and in this regard I note that movements at great distances in the natural static landscape can be detected; and that wind farms form highly visible elements in the landscape. I note that the case is often made that such levels of visibility of wind turbines within the landscape may be regarded as "positive", though I would not accept this argument by reason of the scale and elevated location of the proposed seven turbines with moving parts within the static landscape, and the subsequent extent of visual impact. Nor would I accept that such a "negative" assessment of the visual impact of the proposed wind farm is "subjective" but rather a matter of objective fact by reason of the scale and elevated location of the proposed wind farm development within the natural landscape, and the subsequent extent of visual impact of such large scale wind farm development in the landscape.
- Any required fitting of aircraft navigation safety lights on the proposed tall turbines (which if fitted as close to the top as possible would be on the moving blade tips) would result in a visual impact from the proposed wind farm even at night-time within the Meelagh Valley area below. In this regard it is noted that Para 8.5.8 in the Environmental Statement noted that "the site will not be illuminated at night (apart from a low-intensity flashing light)".
- [Mr Kelly begins the conclusion of his report by saying:] 'though noting the Guidelines promotion of wind farms as an alternative energy source, on balance, I consider that the proposed large scale wind farm development at Coomleagh should be refused permission by reason of visual

obtrusiveness in a scenic landscape area, noting that blade tip heights of the proposed wind turbines range up to 470 m AOD and that "the sites are located at the eastern end of the Meelagh Valley and are part of the Maughanaclea Hills, which separate the Meelagh Valley from the Cousane Gap to the north. This is largely unspoilt mountain range. The ridge levels vary between 440 and 453 MOD" as stated in the Area Planner's Report dated 09/11/1999; and noting the provisions of the Cork County Development Plan re "Renewable Energy" (in particular re stated reluctance to sanction large scale commercial wind farms) and re "Amenity and Preservation" (in particular re Scenic Route A80 and Scenic Area B20); and noting also the provisions of the Guidelines for Planning Authorities re "Visual Impact", which include stating that "the visual impact is among the more important considerations to be taken into account in arriving at a decision on a particular application" (Para 4.8).<sup>26</sup>

- 'In conclusion, further to the above assessment of matters pertaining to this appeal, including consideration of the submissions of each party to the appeal, and including the site inspection, I consider that the proposed development would be contrary to the proper planning and development of the area, having regard to the relevant provisions of the Cork County Development Plan, and to the Guidelines for Planning Authorities re Wind Farm Development, which are considered reasonable.'<sup>27</sup>
  
- 06/03/2006. Coomleagh East: Permission refused, on appeal, to Pat & Catherine O'Leary for erection of a 50m high wind monitoring pole.<sup>28</sup> Derek Daly, from the Inspectorate of An Bord Pleanála, produced the report following a site visit, and having taken many photographs (which are not now on ABP's site). He noted the following:
  - Site location and description: the proposed development is located in the townland of Coomleagh East in an upland / mountainous area... The site located on the upper reaches of the Maughanaclea Hills, which are a visually very prominent area and visible from a wide area. The Maughanaclea Hills are between the Meelagh Valley to the south and the Owvane and Owngar River Valleys to the north. The site is also in close proximity to the Cousane Gap two kilometres to the northeast on the R585 regional route between Kealkill and Dunmanway / Macroom and also overlooks lands running northwards to the Pass of Keimaneigh on the R584 regional route between Kealkill and Gougane Barra / Inchigeela.
  
  - The site is located near the ridge of the mountain at an altitude of approximately 450 metres in an open and exposed area. The upland area is characterised by open areas interspersed with relatively new plantations of conifer afforestation...The proposed development as submitted to the planning authority is for the construction of a temporary 50 metre high wind monitoring pole for the collection of wind data. Four cable guy wires support the pole.

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<sup>26</sup> pp.21/22 of 23.

<sup>27</sup> p.22 of 23. (Dermot Kelly, Inspectorate ABP April 2000)

<sup>28</sup> PA ref. 05/6090 ABP ref. PL04.215033 06/03/2006.

- Assessment: The proposal as submitted to the planning authority is for a temporary 50 metre high wind monitoring pole for the collection of wind data. The applicants' agent in the response to the grounds of appeal has indicated that it is necessary to locate such a development in the area to investigate potential wind resource and that it is unreasonable to suggest a wind monitoring programme would be followed by a large scale wind farm application and also that such a proposal would be the subject of a separate planning application. The applicant is correct that it is necessary to build up data in relation to investigating the potential wind resource of the area and in this regard taken in isolation the erection of a single monitoring mast in itself is unlikely to have a major visual impact on the area.<sup>29</sup>
- In considering the proposal, however, broader strategic issues also require to be considered. The site although not a designated scenic landscape is located in a very open, prominent and vulnerable area. The site is in close proximity to a designated scenic landscape around the Cousane Gap and is readily visible not only from the nearest designated scenic routes A80 and A81 but from a much wider area.
- The appeal site and / or the area immediate to it have also been the subject of two applications for wind farm developments, which were refused. The reason for refusal in both planning applications refers to the natural beauty of the area, the visual obtrusiveness of the development and to the preservation of views along designated scenic routes. In the period since these developments were refused a new county development plan was adopted, which retains the scenic routes and an area of scenic landscape in the locality of the Cousane Gap and in this context the issue of visual impact for which the applications were refused remains.
- ...The site it can be stated is not within a strategic search area, which are areas favoured for windfarm developments but a large area of this part of the county in which the appeal site is located are within the designation of strategically unsuitable areas and it is possible that the appeal site itself is within this designation or proximate to this designation.
- In this context it is therefore questionable whether it is appropriate to permit a mast for the collection of wind data particularly in the context of paragraph 4.2 of the Draft Guidelines where it is indicated that it would be inadvisable to grant permission in an area where there would be a presumption against wind energy development either in the wind energy strategy or the development plan. It is also questionable whether there is a need to gather data specific to this site as there a number of windfarm developments in operation in the Drimoleague / Dunmanway / Drinagh area of West Cork. The site and immediate area were also the subject of previous planning applications for twenty wind turbines and seven wind turbines, which were refused and it would be reasonable to presume that these applications were made on the basis that the area and site has a wind resource.
- Recommendation: I would therefore recommend that permission be refused.

**GOULACULLIN (SITE 1) AND BARRBOY:** the Townlands of hills next to Coomleagh West /East, so again East of the Maughanaclea Hills. No planning reports are available for Site 1 on the

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<sup>29</sup> p.6 of Inspectors report.

Cork CC Planning site or An Bord Pleanala. However, someone in the valley has kept a history of previous objections and has been able to provide the following:

- 11/04/2000: [CCC99/ 5076 PL04.117428] Dermot Kelly, ABP Inspector's Report<sup>30</sup> for Goulacullin, for 12 Turbines:

I recommend that permission is refused for the following reasons:

1. Having regard to the Guidelines relating to Wind Farm Development which were issued by the DoE to planning authorities in 09/1996, it is considered that the proposed development by reason of its scale and prominent elevated location and visual impact on the scenic exposed upland slopes of Barrboy Mountain above the Mealagh Valley, would constitute a visually dominant and prominent obtrusive feature within a sensitive scenic rural landscape of amenity, tourism and recreational potential and would seriously injure the amenities and natural beauty of the area, particularly when seen against the elevated skyline background from the public roads in the area, and as such would be contrary to the Guidelines and contrary to the proper planning and development of the area.
2. The proposed wind farm does not conform to the small local based project (of less than 1MW) which the CCDP(Para6.24) considers may be acceptable on carefully selected sites, but is rather a large scale commercial wind farm on an exposed uplands site which is not considered to be secluded or capable of minimising the visual impact of the proposed wind farm development (and in this context noting also the designated Scenic Routes and Scenic Areas to the north and east from which scenic routes are designated in the CCDP as views to be preserved) and would be contrary to the stated Renewable Energy Policy (Para.6.26) in the CCDP re wind farm developments in the County, which policy is considered reasonable, and as such would be contrary to the proper planning and development of the area.

**GOULACULLIN (Site2) 29/06/2023.** The majority of this new site is across the way from the old proposed Goulacullin wind-farm site and stretches towards Nowen Hill. A request for Pre-Application Consultation (for Goulacullin/Maughanaclea/Nowen) on behalf of Statkraft was made at this time, and then withdrawn (temporarily?) on 07 /03/2024. No CCC planning reports or ABP Inspectors reports have been produced so far, as the Applicant is re-assessing the type of turbine used due to access issues.

**NOWEN HILL -** at the Head of the Mealagh Valley, across from Goulacullin. The eight planning permissions granted between 1998 and 208 have been for a limited period of either five or seven years and the actual location of each mast was strictly controlled. In February 2008, with 4 existing masts in place. Olivia McGeough, CCC assistant planner, notes that

- 'the purpose of the 5 year lifespan was to allow for a review of the technology to see if more environmentally friendly systems had emerged during the interval'. 'the {Nowen Hill}

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<sup>30</sup> p.22 of 22.

site contains up 4 existing telecommunications stations which are not clearly visible in the wider rural landscape'. The development being considered for retention was the tallest mast and 'it is considered that the site would benefit from additional natural landscaping'.<sup>31</sup>

By 2016, however, it was recognised that there were gaps and the temporary permissions had lapsed. Using Circular PL07 12 dated 19<sup>th</sup> October 2012, planners were able to sign off the four masts with permanent permissions:

'Such masts have now become a feature of the landscape given that they have been in situ for a number of years (8-15 years) the removal of such structures is not a realistic proposition. Furthermore it is considered that such an approach would also have required to have been underpinned by a policy objective contained within the County Development Plan 2014 that had require the closure and the removal of existing mast site(s) and for other alternative sites to be examined. However there is no such policy objective in force but rather continued support for digital broadband and telecommunications services'.

**DERREENACRINNIG WEST.** Looking at the south side of the Mealagh Valley, Derreenacrinnig East is next to Nowen Hill, then Derreenacrinnig West, which is opposite Coomleagh East and West, and just short of being opposite the Maughanaclea hills.

In considering the wind farm application alone, Conor McGrath's report, following his site visit for the Inspectorate in January 2012, makes many useful observations regarding the height of the turbines and the Mealagh Valley.

- Referring to Cork County Council's senior planner's observations of 16/02/2011, the ABP Inspector copies the following from the Planner's report:

The development is not located within a Natura 2000 site or a designated amenity area and would be significantly lower than more contemporary turbine models. The recommended minimum separation from dwellings is exceeded. The site is partly screened by adjoining hills and would be visible (long distance) from the Dunmanway - Drimoleague Road. The EIS considered the use of alternative turbines and a less obtrusive model was selected. The Mealagh Valley has significant visual qualities. On balance the height and location of the turbines would not have an adverse visual impact on the qualities of the area. The development would be a significant distance from the majority of existing wind farms, which are largely concentrated close to Dunmanway / Drimoleague. The development will result in the loss of peat habitat and details of compensatory habitat creation measures are required. Mitigation measures should also be incorporated into the construction plan. Proximity to Nowen Hill is a concern; however, contacts indicate that no impact on transmissions networks are anticipated. Recommend [from CCC senior planner] grant of permission.<sup>32</sup>

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<sup>31</sup> 15/707 Planners Report 7/01/2016.

<sup>32</sup> p.9/10 of 35

- The ABP Inspector noted responses from the developers's consultants, to the grounds of the third party's appeal, include: Elevated positions are necessary to capture high winds; proposed turbine dimensions are quite small; layout of turbines was chosen to limit impacts on views and landscape character; having regard to the location etc there will be no major adverse landscape impacts.
- After quoting various current policies, the ABP Inspector begins his own extensive assessment of the Derreenacrinnig Wind Farm proposal, parts of which are usefully given here:
  - The development plan landscape character map indicates that the site straddles the boundary between Landscape Area no. 72: Mealagh Valley (Serrated Ridge and Upper Mooreland Valley) located within Landscape Type 15: Ridged and Peaked Upland to the north, and Landscape Area no. 52 Drimoleague- Skibbereen (Basin of Moorland Ridge and Semi-Marginal and Mosaic Farmland) located within Landscape Type 9 (Broad Marginal Middleground and Lowland Basin), to the south. The boundary between these areas runs along the ridge of Derreenacrinnig West (note: looking at the site plan, the seven turbines were all to be placed in landscape area no 72) . The Draft Cork Landscape Strategy identifies Landscape Type 15 as being of High Landscape Value and High Landscape Sensitivity and notes that an accumulation of more windfarms could have a more intolerable visual impact in the future. Walking routes have been developed through these hills in recent times<sup>33</sup>.
  - Permission has been refused for a number of wind energy developments on the surrounding hills in the past. Permission was refused on the western slopes of Mullaghmesha, under ref. PL04.108995 on grounds of visual and landscape impacts. That site is now located within a Strategically Unsuitable Area. Permission was refused at Coomleagh East and Goulacullin to the north under ref. PL04.117606 (and subsequently under 99/1708) and PL04.117428, on grounds of landscape impacts and impacts on views from a scenic route. There was a subsequent refusal in 2006 for a wind monitoring mast under ref. PL04.215033 at Coomleagh East. Notwithstanding these decisions, permission was granted under PA ref. 08/2119 for a wind farm at Goulacullin at the eastern end of the Mealagh Valley. <sup>34</sup>
  - It is not considered that the mitigation measures identified in the EIS would be sufficient to overcome the impacts of the development on the landscape character and visual amenities of the area.<sup>35</sup>

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<sup>33</sup> p16 of 35

<sup>34</sup> p16 of 35.

<sup>35</sup> p.18 of 35.

○ The Recommendation from the An Bord Pleanála's Inspector in 01/2012 was to refuse permission for the proposed development at Derreenacrinnig West. The reasons and considerations were set out as follows:<sup>36</sup>

- The site is located in a remote, rugged and exposed upland area in a rural scenic landscape of amenity, tourism and recreational potential, and visible from a public road which is designated as scenic route (S30) in the current Development Plan for the area. It is an objective of the development plan to preserve the character of all important views and prospects, including views of unspoilt mountains, upland landscapes, views of historical or cultural significance (including buildings and townscapes). Furthermore, it is an objective to preserve the character of those views and prospects obtainable from scenic routes and protect the character and quality of those particular stretches of scenic routes that have very special views and prospects. These objectives are considered to be reasonable.
- The proposed windfarm development and its associated infrastructure and site works would comprise an obtrusive feature in the landscape, and would have a negative impact on the landscape character and visual amenities of the area. The proposed development would be detrimental to the preservation of views obtainable from the scenic route, including views toward the castle at Castledonovan. The proposed development, which is not located within a Strategic Search Area for wind energy development, as designated in the County Development Plan, would be contrary to the above objectives of the development plan, and would, therefore, be contrary to the proper planning and sustainable development of the area.

As stated in Appendix A, the An Bord Pleanála's members at that time decided not to accept Conor McGrath's recommendation for refusal. It is interesting to note, however, there is nothing in the Board's statement to show that they considered the Mealagh Valley separately, and how the scale of the seven turbines, at heights of 107metres, would visually impact its landscape.<sup>37</sup>

The disconnect between the inspector's recommendation and the decision of CC Planning and the Board resonates through subsequent paperwork. Even ten years later, the CCC Executive Planner notes in his report of 28/04/2022, for Derreenacrinnig:

- 'It is observed that whilst Cork County Council had resolved to grant permission the appointed inspector Conor McGrath, following a site visit on 18/19 January 2012 had recommended refusal on the grounds of the adverse impact upon the S30 Scenic Route and views towards the castle at Castledonovan. At the time of the decision in December 2012 the proposed wind farm was not located within a Strategic Search Area for wind energy development....[but it is now in an area 'open to consideration']. '<sup>38</sup>

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<sup>36</sup> p.35 of 35. An Bord Pleanála, Inspector's report. Conor McGrath Report dated January 2012

<sup>37</sup> PL88.239767 - ref 10/857,

<sup>38</sup> Planners Primary Report 22/00153

**MULLAGHAMESHA;** The highest and longest hills, on the South side of the Mealagh valley, and opposite the Maughanaclea hills.

There are no planning reports available for this application on Cork CCC planning website or An Bord Planning website. Refusal from ABP is dated 25/05/1999. However, someone in the valley who has kept a history of previous objections has been able to provide the following:

- Dermot Kelly, ABP Inspector's Report for Mullaghamesha, 13/05/1999<sup>39</sup>: to consider a wind -energy complex consisting of 20 Turbines:
  - I do not consider that locating the proposed development on the skyline would 'reduce visual impact', as suggested in the appeal grounds [*this was a suggestion by the first party appellant - the developer*].
  - I would not concur with the first part appellant that Mullaghamesha is 'not unspoilt', as on site inspection I considered Mullaghamesha to be of a particularly attractive scenic character. I fully concur with the planning authority that the proposed development should be refused by reason of visual obtrusiveness in this open unspoilt mountainous area of high scenic amenity, and that the area landscape is incapable of assimilating the proposed development without 'severe' adverse visual impact.
  - In conclusion, though noting the Guidelines promotion of wind farm as an alternative energy source, on balance, I consider that the proposed large scale Wind Farm development at Mullaghamesha should be refused permission by reason of visual obtrusiveness in a scenic landscape area, noting the provisions in the CCDP re: 'Renewable Energy' and 'Amenity and Preservation' (in particular Scenic Route A86) and also the provisions of the Guidelines for Planning Authorities re: 'Visual Impact'.
  - ....Accordingly I recommend that permission be refused for the following reason: Having regard to the location of the site in a very elevated and unspoilt exposed upland location in a rural scenic landscape of amenity/tourism/recreational potential and highly visible from a public road which is a designated Scenic Route in the current CCDP. It is considered that the proposed large wind farm development would be visually obtrusive and out of character in the rural scenic landscape, and would seriously injure the visual amenities and natural beauty of the area. It is considered that the proposed development would be contrary to the objective of the planning authority as set out in the current development plan to preserve the views from such road and would be visually obtrusive and conflict with this objective, which is considered to be reasonable. The proposed development would, therefore, be contrary to the proper planning and development of the area.

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<sup>39</sup> pp.19/20 of 20. 13/05/1999: [CCC98/ 1166 PL04.108995]. (Acknowledgment: Appendix provided as a courtesy by T Colk Lynch - thank you)

*This Appendix is an extract of Relevant policies and objectives from County Cork Development Plan 2022-28.*

As well as setting out some of the objectives of the CCDP 2022-28, accompanying sub-sections are included, which are designed to enrich and expand on the objectives, providing clarity and further direction as to the meaning of statements and actions intended. These fourteen pages show how objectives for Energy/ Renewable Energy - both for existing and proposed developments, sits within a whole raft of others. There is no indication that at county level development of renewable energy complexes have a precedent to override other policies and objectives to be met in the lifetime of the plan. In fact, mention of renewable energy development tends to be followed by: as appropriate' or 'at suitable locations' or 'where such development will not have adverse environmental impacts', similar to objectives within EU, National, and Southern Assembly policies.

**DEVELOPMENT PLAN AIMS:** *Our aim in this Plan is to deliver sustainable urban and rural communities across the county to ensure a better quality of life for all making Cork County the most attractive place to live, work and invest in.*

**AIMS: CHAPTER 1: 1.9.1 p.23+** The Development Plan presents an opportunity to shape the future growth of County Cork to plan for and support the sustainable long term development of the County. The Plan aims to build on our previous successes and to strengthen our strategic advantage as a County, to ensure that we utilise the **strengths of our citizens, communities, built and natural heritage, infrastructure, economy and tourism to their full potential.**

**BE: BIODIVERSITY AND ENVIRONMENT. CHAPTER 15: p.335+.** Ensure that the natural environment, biodiversity and ecosystems are **protected**, delivering benefits essential for all sectors of society and that Cork County contributes to efforts to reverse the loss of biodiversity and the degradation of ecosystems and the environment.

**(BE) 15.1. Introduction.** 15.1.3 Biodiversity is threatened globally and locally by the ever increasing demands of people for space, fuel, food and other resources. Loss or damage to sites and places of biodiversity value caused by changes in landuse practices and pressure for development, disturbance of places inhabited by wild plants and animals, pollution of watercourses and the spread of invasive alien species all affect the extent and quality of our natural environment.

(BE)15.1.4 The link between biodiversity loss and climate change is becoming better understood. Changing climate increases pressure on habitats and species, while the protection of biodiversity helps to mitigate some of the impacts of climate change. The extent of damage to our biodiversity has been acknowledged by the Dáil, which declared a Climate and Biodiversity Emergency in 2019.

(BE) 15.1.5 As land use policy makers, development managers... Cork County Council has an important role to play in ensuring the protection of biodiversity. This chapter sets out Cork County Councils key objectives

for protection and enhancement of biodiversity resources in the areas of Policy, Land Use Planning, Consenting development and other activities, supporting community led biodiversity initiatives.

**BE15.1 COUNTY DEVELOPMENT PLAN OBJECTIVE: SUPPORT AND COMPLY WITH NATIONAL BIODIVERSITY PROTECTION POLICES.** a) Support and comply with the objectives of the National Biodiversity Plan 2017-2021 (and any future National Biodiversity Plan which may be adopted during the period of this Plan) as appropriate, b) Implement the current County Biodiversity Action Plan and any future updated Plan...

**(BE) 15.2 Policy Context:** 15.2.2 At European level, the 2030 EU Biodiversity Strategy sets out a long term plan to protect nature and reverse the degradation of ecosystems...

(BE) 15.2.3 At national level, biodiversity policy is set out in the National Biodiversity Action Plan 2017-2021 (NBAP) which identifies habitat degradation, climate change...as significant factors negatively impacting on biodiversity in Ireland today.

**BE15.1 COUNTY DEVELOPMENT PLAN OBJECTIVE: PROTECT SITES, HABITATS AND SPECIES.**

a)...b) Provide protection to species listed in the Flora Protection Order 2015, to Annexes of the Habitats and Birds Directives, and to animal species protected under the Wildlife Acts in accordance with relevant legal requirements. c) Protect and where possible enhance areas of local biodiversity value, ecological corridors and habitats that are features of the County's ecological network. This includes rivers, lakes, streams and ponds, peatland and other wetland habitats, woodlands, hedgerows, tree lines, veteran trees, natural and semi-natural grasslands as well as coastal and marine habitats. It particularly includes habitats of special conservation significance in Cork (Volume 2 of the Plan).

**(BE)15.3 Protecting Sites, Habitats and Species – Legislative Context.**

(BE) 15.3.2 The Birds Directive provides for the protection of sites used (for breeding or feeding) by species of birds that are rare, or vulnerable or in danger of extinction.

(BE) 15.3.8 Nature Conservation legislation provides for the protection of sites and species of national and international importance. However, sites and species benefiting from statutory protection do not alone represent the full extent of our natural heritage. In fact, most of our biological diversity occurs in the wider landscapes. Rare and protected sites and species cannot survive independently of their surroundings. Features of our landscape can be of high natural value and often provide the vital links and corridors to allow the movement of plants and animals between protected sites.

**BE15.10 COUNTY DEVELOPMENT PLAN OBJECTIVE: SOILS.**a)...b) Identify areas of poorer soil in the County **acknowledge their potential value for wildlife, and respect their limitations, particularly in terms of their assimilative properties to prevent pollution.**

**(BE)15-11 Noise and Light Emissions:** 15.11.3 While artificial lighting is essential for a safe and secure night-time environment, the Council recognises the impacts light pollution (glare, skyglow, light trespass, clutter and spillage) can have on the visual, wildlife and residential amenities of surrounding areas. **Dark**

**skies and unpolluted night skies are an asset to the County.** The Planning Authority will explore how best to identify and manage areas of dark sky/unpolluted sky in the County during the lifetime of the Plan....

#### **BE15.11 (13) COUNTY DEVELOPMENT PLAN OBJECTIVES: NOISE AND LIGHT EMISSIONS**

Seek the minimisation and control of noise pollution associated with activities or development, having regard to relevant standards, published guidance **and the receiving environment.**

- a) Ensure noise-sensitive developments are adequately protected from potential source of noise (e.g. national roads). New developments should take account of, and mitigate against, any existing noise sources.
- b) Support the implementation of Noise Action Plans prepared for the Cork County Area
- c) Seek the minimisation and control of light pollution associated with activities of development, having regard to the relevant standards, published guidance and the receiving environment and **Dark Sky principles.**
- d) Review and update Cork County Council Policy Guidelines for Public Lighting to take account of impacts of public lighting on **wildlife and night skies.**

**CS: CORE STRATEGY. CHAPTER 2: p.27+.**

**(CS) 2.14 STRATEGIC PLANNING AREAS IN CORK/ WEST CORK STRATEGIC PLANNING AREA/ CS2.6 COUNTY DEVELOPMENT PLAN OBJECTIVES: p.52+.**

CS2-6: West Cork Strategic Planning Area, can be defined from the Map on p.48, the area goes from Clonakilty to Skibbereen, to Bantry, Dunmanway, and the island peninsulas).

There are twelve objectives set out in this planning strategy for West Cork. They include:

(d) Recognise the international importance and the importance to the region's **tourism economy**, of the **scenic and landscape qualities of the coastal and upland areas**, particularly along the peninsulas in the southwest and **to protect these landscapes from inappropriate development.**

(f) Support a vibrant and well populated countryside, recognising the need to strength and protect rural communities of the area by encouraging sustainable and balanced growth in both urban and rural populations, maintain traditional rural settlement patterns in rural areas and the islands, protecting agricultural and fishery infrastructure and productivity and **focusing other employment development** in the main towns and key villages;

(g) Recognise the need to encourage **diversification of the rural economy by promoting a stronger tourism and leisure economy through the protection of the area's natural and**

**built heritage.** This will also be achieved by recognising opportunities arising from wildlife tourism in the area...<sup>1</sup>

(h) Prioritise the adequate provision of water services and transport infrastructure to meet current needs and future population targets **while protecting the areas environment;**

**(j) Protect and enhance the natural and built heritage assets of the towns and villages (Kealkill) from inappropriate development.**

(l) Facilitate the development of renewable energy projects in support of national climate change objectives. [NB This is broad brush statement that appears for all four strategic areas of County Cork: Metropolitan Cork, Greater Cork Ring, West Cork and North Cork. It is a simple confirmation for supporting projects at suitable sites. Also, Renewables in the CCDP 2022-2028 include solar panels for houses, car parks etc. as well as industrial solar complexes, and development of hydro-electric. **This objective must not conflict directly with the other stated strategic objectives of this plan.** For wind-energy, potential suitable sites are those already assessed as being 'acceptable in principle' areas in West Cork].

**ET13: ENERGY AND TELECOMMUNICATIONS CHAPTER 13: p.292+.** Facilitate and support investment in sustainable energy production and infrastructure in Cork to meet the future local, regional and national needs, while transitioning to a low carbon economy, addressing the climate change challenge with greenhouse gas emissions and **protection** of the environmental, cultural and heritage assets of the county...

**ET13.1 COUNTY DEVELOPMENT PLAN OBJECTIVE FOR ENERGY: p.294.** a) Ensure that County Cork fulfils its potential in contributing to the sustainable delivery of a **diverse** and secure energy supply and to harness the potential of the county to assist in setting renewable energy targets and managing overall energy demand.

(ET)13.2.7....It is acknowledged that the development of new infrastructure to support the energy transition can give rise to community concerns, and the active engagement of communities in the development of such infrastructure is critical. Community led projects will also have an important role to play in the transition process. <sup>2</sup>

**(ET)13-2 COUNTY DEVELOPMENT PLAN OBJECTIVE FOR RENEWABLE ENERGY:**

a) Support Ireland's renewable energy commitments as outlined in Government Energy and Climate Change policies by facilitating the development of renewable energy sources such as wind, solar, geothermal, hydro and bio-energy and energy storage **at suitable locations** within the county **where such development has satisfactorily demonstrated that it will not have adverse impacts on the surrounding environment (including water quality), landscape, biodiversity or amenities.**

d) To promote the potential of micro renewables where it can be demonstrated that that it will not have adverse impacts on the surrounding environment (including water quality), landscape, biodiversity or

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<sup>1</sup> p.52. Core Strategy. CCDP 2022-2028 Volume 1 Main Policy Material.

<sup>2</sup>p.292. Energy and Telecommunications. CCDP 2022-2028 Volume 1 Main Policy Material.

amenities.

**ET13.3: COUNTY DEVELOPMENT PLAN OBJECTIVE FOR HYBRID ENERGY SYSTEMS: p.296.**

Support and facilitate proposals for hybrid energy systems and /or co-location of renewable energy where applicable where **such development has satisfactorily demonstrated that it will not have adverse impacts on the surrounding environment (including water quality), landscape, biodiversity or amenities.**

(ET)13.4.2 In terms of renewable energy County Cork currently has 38 commissioned wind farms with capacity to produce 603 MW of electricity and 43 permitted solar farms with capacity to produce 358MW of electricity. [How many of these are in this local area of West Cork?]

(ET)13.4.4 Energy generation in [County] Cork is likely to evolve significantly over the next number of years as the move towards a low carbon economy increases and the need to produce more energy from renewable sources. Cork is well positioned to become self-sufficient in renewable energy and contribute to the achievement of national energy targets outlined above.

(ET)13.4.5 Other aspects of energy use are also likely to change over the life of this plan .... The need to reduce overall energy demand is also acknowledged.

**ET13.4: COUNTY DEVELOPMENT PLAN OBJECTIVE FOR WIND ENERGY: p.296.** In order to facilitate increased levels of renewable energy production consistent with national targets on renewable energy and climate change mitigation as set out in the National Energy and Climate Plan 2021-2030, the Climate Action Plan 2021, and any updates to these targets, and in accordance with Ministerial Guidelines on Wind Energy Development, the Council will support further development of on-shore wind energy projects including the upgrading, repowering or expansion of existing infrastructure, at appropriate locations within the county in line with the Wind Energy Strategy and objectives detailed in this chapter and other objectives of this plan in relation to climate change, biodiversity, landscape, heritage, water management and environment etc. [It is stressed here that support for on-shore wind energy projects must be in line with objectives set out in other chapters of the Development Plan]

**ET13.5 COUNTY DEVELOPMENT PLAN OBJECTIVES FOR WIND ENERGY PROJECTS: p.297.**

- a) Support a plan led approach to wind energy development in County Cork through the identification of areas for wind energy development. The aim in identifying these areas is to ensure that there are **minimal environmental constraints**, which could be foreseen to arise in advance of the planning process.
- b) Onshore wind energy projects should focus on areas considered 'Acceptable in Principle' and 'Areas Open to Consideration' and generally avoid "Normally Discouraged" areas **as well as sites and locations of ecological sensitivity.**

(ET)13.6.4 The Strategy identifies three categories of 'Wind Deployment Area' for large scale commercial wind energy developments - Acceptable in Principle, Open to Consideration and Normally Discouraged.

(ET)13.6.6. 'Acceptable in Principle': These areas (River Ilen basin north of Skibbereen and an area south of Macroom) are an optimal location for wind farm development with minimal environmental impacts. They

have **viable wind speeds (>7.5m/s) and good proximity and access to the grid**. These areas exclude urban areas and town green belts, avoid Natura 2000 Sites (SPAs and SACs), high value landscapes and Natural Heritage Areas (NHAs).

(ET)13.6.7 Open to Consideration': This area comprises almost 50% of the County area. Within these areas there are locations that **may** have potential for wind farm developments but there are also some **environmental issues** to be considered. **This area has variable wind speeds and some access to the grid**. Urban areas, metropolitan/town green belts, and Natural Heritage Areas (NHA's) within this area are not generally considered suitable for wind farm developments. Any proposals within Freshwater Pearl Mussel Sub Basin Catchments or in other sensitive catchments must be able to demonstrate that they have been designed in a manner which prevents any risk of peat slippage or erosion; and ensures the ongoing protection of water quality and the maintenance of natural hydrological processes. The **cumulative effect** of wind energy developments with regard to landscape and visual impacts and also impacts on Natura 2000 sites will also **be a consideration**. High design standards in terms of environmental protection measures are likely to be required to be included in projects located in sensitive catchments.

(ET)13.6.8. Normally Discouraged: These areas (coastal areas, some areas in North Cork, Cork Harbour, and the Lee Valley) are normally **not suitable** for commercial wind farm developments due to their overall **sensitivity arising from ecological, landscape, amenity, recreational and settlement, considerations**.

(ET)13.6.10 The Councils Wind Strategy has been reviewed in light of the requirements of the Draft Revised Wind Energy Development Guidelines 2019, particularly the sieve mapping exercise outlined in the Draft Guidelines. It is considered that the strategy remains applicable and appropriate. The strategy facilitates commercial wind energy development in approximately 55% of Cork County with the remaining 45% unlikely to be suitable.

**ET 13.6 COUNTY DEVELOPMENT PLAN OBJECTIVE: ACCEPTABLE IN PRINCIPLE.** Commercial wind energy development is normally encouraged in these areas subject to protection of residential amenity particularly in respect of noise, shadow flicker, visual impact and the requirements of the Habitats, Birds, Water Framework, Floods and EIA Directives and taking account of protected species of conservation concern.

p.298. **ET 13.7 COUNTY DEVELOPMENT PLAN OBJECTIVE: OPEN TO CONSIDERATION.** Commercial wind energy development is open to consideration on these areas where **proposals can avoid adverse impacts** on:

- **Residential amenity particular in respect to noise, shadow flicker and visual impact;**
- **Nature 2000 Sites, Natural Heritage Sites, proposed Natural Heritage Areas and other sites and locations of significant ecological value.**
- **Architectural and archaeological heritage;**
- **Visual quality of the landscape and the degree to which impacts are highly visible over wider areas.**

In planning such development, consideration should also be given to the **cumulative impacts** of such proposals.

p.299. **ET 13.8 COUNTY DEVELOPMENT PLAN OBJECTIVE:NORMALLY DISCOURAGED.** Commercial wind energy developments will be discouraged in these areas which are considered to be sensitive to adverse impacts associated with this form of development (either individually or in combination with other developments). **Only in exceptional circumstances where it is clear that adverse impacts do not arise will proposals be considered.**

**ET 13.16 Transmission Network/ Electricity Network:** 13.16.1. The provision of a secure and reliable electricity transmission infrastructure and transmission grid is essential to meet the growth in demand and ensure that a reliable electricity supply is available. Cork has a very strong electrical grid and substation network and this network will be instrumental in supporting the development of the renewable energy industry in the county.

**ET 13.21/22 COUNTY DEVELOPMENT PLAN OBJECTIVE: ELECTRICITY NETWORK.** p.308. a)-c) d) Proposals for development which would be likely to have a significant effect on nature conservation-sites and/or habitats or species of high conservation value will only be approved if it can be ascertained, by means of an Appropriate Assessment or other ecological assessment, that the integrity of these sites will not be adversely affected.

**Gi14.8.5** Encourage a more integrated and coherent approach to managing the Green Infrastructure assets of the County which will **protect** and enhance biodiversity, provide for recreational and amenity facilities, maintain and **enhance landscape character**, **protect** architectural and archaeological heritage, improve ecological connectivity, provide for sustainable water management and facilitate climate change adaptation and mitigation by requiring the retention and strengthening of substantial networks of green space in urban, urban fringe and into the wider countryside leading to improved quality of life and better economic opportunities for communities across the County now and in the future.

**(GI) 14.7: LANDSCAPE.** 14.7.1: The coastal and countryside landscapes of County Cork are a key green infrastructure asset not only for their intrinsic value as places of natural beauty but also because of their importance in terms of recreation, tourism and other uses. They are also a source of pride and inspiration for many residents and visitors alike. All aspects of our natural, built and cultural heritage come together in the landscapes we experience every day. Landscapes are an important part of people's lives, giving individuals a sense of identity and belonging, contributing to our wellbeing.

**(GI) 14.8 LANDSCAPE CHARACTER ASSESSMENT OF COUNTY CORK. P.329.**

(GI) 14.8.2: Based on the Guidelines, Cork County Council prepared a Draft Landscape Strategy in 2007 (precis) 76 landscape character areas reflecting the complexity and diversity of the county, amalgamated into a set of 16 landscape character types.

(GI) 14.8.3: The Value of each landscape character type is defined as the environmental or cultural benefits...which are derived from various landscape attributes.

(GI) 14.8.4: The Sensitivity of each character type is defined as the ability to accommodate change or intervention without suffering unacceptable effects to its character and values. Sensitivity is evaluated using criteria ranging from Very High to Low. A highly sensitive landscape is likely to be vulnerable to change whereas a landscape with a low sensitivity is likely to be less at risk to change.

(GI) 14.8.5: In order to indicate the correlation between the sensitivity of a landscape and the degree to which it can be changed by development:

**Low sensitivity landscapes** are robust landscapes, which are tolerant to change, and which have the ability to accommodate development pressure.

**Medium sensitivity landscapes** can accommodate development pressure but with limitations in the scale and magnitude. In this rank of sensitivity, landscape elements can accept some changes while others are more vulnerable to change.

**High sensitivity landscapes** are vulnerable landscapes with the ability to accommodate limited development pressure. **In this rank landscape quality is at a high level, landscape elements are highly sensitive to certain types of change. If pressure for development exceeds the landscape's limitations the character of the landscape may change.**

**Very high sensitivity landscapes are extra vulnerable landscapes** (e.g. seascape area with national importance) **which are likely to be fragile and susceptible to change.**

(GI) 14.8.6 The Importance of a landscape character type is rated as Local, County, or National. The LCA will inform decision making in relation to the protection of the environment, natural resources and heritage and will be used to guide development. (NB. Up to 2014, LCA15a was designated as County Importance up to 2014; the creation of 'High Value Landscapes' as a new simpler term, separated some LCTs as being County and others being Local Importance)

(GI) 14.8.8 Landscape Character Types which have a very high or high landscape value and high or very high landscape sensitivity and are of county or national importance are considered to be our most valuable landscapes and therefore are designated as High Value Landscapes (HVL), highlighted in green in the Table in Appendix F Landscape Character Assessment attached and shown in Figure 14.2.

(GI) 14.8.9 Within these High Value Landscapes considerable care will be needed to successfully locate large scale developments without them becoming unduly obtrusive. Therefore, the location, siting and design of large-scale developments within these areas will need careful consideration and any such developments should generally be supported by an assessment including a visual impact assessment which would involve an evaluation of visibility and prominence of the proposed development in its immediate environs and in the wider landscape. **(NB. The Maughanaclea 'Southern Site' is within 240Metres<sup>3</sup> of areas designated as High Value Landscapes!)**

(GI) 14.8.10. The key role of the Draft Landscape Strategy of Cork County is to assist in the achievement of sustainable development, by promoting an approach to landscape planning and management, which links objectives and recommendations for landscape character to existing planning policies. To recognise that

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<sup>3</sup> ref and check

the landscapes are dynamic and continuously evolving, the objectives do not attempt to prevent new uses or changes but **to manage the change ensuring that the past remains visible for future generations.**

(GI) 14.8.11. The capacity of each landscape character type to absorb new development will largely depend on the sensitivity of the landscape type. Developments which are likely to create a significant environmental and particularly visual impact will best be absorbed in areas where the landscape is robust, i.e. has the capacity to absorb development without significantly changing its character. All developments should be assessed on a site-by-site basis to avoid, minimise or mitigate any potential environmental or visual impact.

(GI) 14.8. 12. Seascape Assessment is an extension of landscape character assessment and with 1,100km of coastline; seascape is a crucial element of the County's history, identity and culture...

#### **(GI) 14.9: LANDSCAPE VIEWS AND PROSPECTS.**

(GI) 14.9.1 The County contains many vantage points from which views and prospects of great natural beauty may be obtained over both seascape and rural landscape. This scenery and landscape are of enormous amenity value to residents and tourists and constitutes a valuable economic asset. **The protection of this asset is therefore of primary importance** in developing the potential of the County. Therefore, the Plan identifies specific Scenic Routes consisting of important and valued views and prospects within the County.

(GI) 14.9.2 Each of the Scenic Routes was examined individually and their location related to the landscape character type (15a and 4a) and some of the features lending themselves to the attractive nature of these particular routes identified. Scenic routes highlight the quality of the overall environment and landscape experienced within Cork County. It is important **to protect the character and quality** of those particular stretches of scenic routes that have special views and prospects, particularly those associated with High Value Landscapes.

(GI) 14.9.3 All proposals should be assessed on their merits taking into account the **overall** character of the scenic route including...the Landscape Character Type through which the route passes.

#### **p.331 GI 14.9. COUNTY DEVELOPMENT PLAN OBJECTIVE: LANDSCAPE.**

- a) **Protect** the visual and scenic amenities of County Cork's built and natural environment.
- b) Landscape issues will be an important factor in all land-use proposals, ensuring that a proactive view of development is undertaken while **protecting** the environment and heritage generally in line with the principle of sustainability.
- c) Ensure that new development meets high standards of siting and design.
- d) **Protect skylines and ridge lines from development.**
- e) Discourage proposals necessitating the removal of extensive amounts of trees, hedgerows and historic walls or other distinctive boundary treatments.

**GI 14.10 COUNTY DEVELOPMENT PLAN OBJECTIVE: DRAFT LANDSCAPE STRATEGY.** Ensure that the management of development throughout the County will have regard for the value of the landscape, its

character, distinctiveness and sensitivity as recognised in the Cork County Draft Landscape Strategy and its recommendations, in order to minimise the visual and environmental impact of development, particularly in areas designated as High Value Landscapes where higher development standards (layout, design, landscaping, materials used) will be required. ( and those landscapes within close proximity where wind turbines will negatively impact High Value Landscapes, whether it is Visibility, Noise/sound, Shadow Flicker, Heritage, Ecology, or Biodiversity)

**GI 14.12. COUNTY DEVELOPMENT PLAN OBJECTIVE: GENERAL VIEWS AND PROSPECTS.** Preserve the character of all important view and prospects, particularly sea views, river or lake views, unspoilt mountains, upland or coastal landscapes, views of historical or cultural significance... and views of natural beauty as recognised in the Draft Landscape Strategy.

**GI 14.13. COUNTY DEVELOPMENT PLAN OBJECTIVE: SCENIC ROUTES.** Protect the character of those views and prospects obtainable from scenic routes and in particular stretches of scenic routes that have very special views and prospects identified in this Plan.

**GI 14.14. COUNTY DEVELOPMENT PLAN OBJECTIVE: DEVELOPMENT ON SCENIC ROUTES.**  
a) Require those seeking to carry out development in the environs of a scenic route and/or an area with important views and prospects, to demonstrate that there will be no **adverse obstruction or degradation of the views towards and from vulnerable landscape features**. In such areas, the appropriateness of the design, site layout, and landscaping of the proposed development must be demonstrated along with mitigation measures to **prevent** significant alterations to the appearance or character of the area.

**GI 14.15. COUNTY DEVELOPMENT PLAN OBJECTIVE: DEVELOPMENT ON THE APPROACHES TO TOWNS AND VILLAGES:** Ensure that the approach roads to towns and villages [Kealkill] are protected from inappropriate development, which would detract from the setting and historic character of these settlements.<sup>4</sup>

**HE16: BUILT AND CULTURAL HERITAGE CHAPTER 16: p.353+.** The Plan recognises the importance of identifying, valuing and safeguarding our archaeological, architectural and cultural heritage for future generations through appropriate protection, management and enhancement measures or via the sensitive development of this resource.

(HE) 16.1 Introduction. (HE)16.1.2: The National Planning Framework is the Government's high-level strategic plan for shaping the future growth and development of the country up to 2040. It includes a strong focus on enhanced amenities and heritage by highlighting how our built, cultural and natural heritage has intrinsic value in defining the character of urban and rural areas and adding to their liveability, attractiveness and sense of place. It also emphasises how Ireland's built heritage assets are a non renewable resource that merit being nurtured in a manner appropriate to their significance as an aid to understanding the past, contributing to community well-being and quality of life as well as regional economic development.

(HE) 16.2.1 Archaeological heritage consists of the material remains left behind by past societies from earliest times up to the post- medieval period and includes all structures, places, caves, sites, features and portable objects, whether located on land, underwater or in the inter-tidal zone. In general, those parts of the archaeological heritage that are part of or attached to the landscape are referred to as monuments. Cork has a rich archaeological heritage, which has left its traces across its urban and rural landscape. The

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<sup>4</sup> p.332 CCDP 2022-2028 Volume 1 Main Policy Material

Council fully recognises its role in protecting this resource for future generations to enjoy.

(HE) 16.2.29: ARCHAEOLOGICAL LANDSCAPES Where a concentration of archaeological sites of a similar period but not necessarily so, occur they should be seen as a collective group. Within County Cork there are varied archaeological landscapes such as Allihies Copper mining landscape, fortifications at Cork Harbour, upland prehistoric settlement in Shehy Beg. Where these collections of monuments occur, their protection will be based not only as an individual site but as part of a wider archaeological landscape.

(HE)16.2.33 UNDISCOVERED ARCHAEOLOGICAL SITES. The Planning Authority is aware of the potential to identify previously unrecorded archaeological sites as part of development proposals across the County. To date these have particularly been identified in upland areas or as a result of Archaeological investigation on large scale development but not exclusively so. Development management need to factor this potential when assessing planning applications. There should always be a presumption in favour of avoiding developmental impacts on the archaeological heritage and preservation in situ is the recommended approach. Preservation by record will only be considered in exceptional circumstances.

(HE) 16.3.27 HISTORIC LANDSCAPE The landscape of County Cork contains various layers of historic fabric which are a valuable contribution to the appearance of the countryside, are an intrinsic element of place, are tangible tourism assets and are significant as archaeological, architectural, historical, cultural and ecological resources. The Council recognises the value of the various and diverse historic landscapes of the County and seeks to protect them from destruction or inappropriate development.

**HE16.11. COUNTY DEVELOPMENT PLAN OBJECTIVE: ARCHAEOLOGICAL LANDSCAPES.** To protect archaeological landscapes and their setting where the number and extent of archaeological monuments are significant and as a collective are considered an important archaeological landscape of heritage value.

**HE16.13. COUNTY DEVELOPMENT PLAN OBJECTIVE: UNDISCOVERED ARCHAEOLOGICAL LANDSCAPES.** To protect and preserve previously unrecorded archaeological sites within County Cork as part of any development proposals. The Council will require preservation in situ to protect archaeological monuments discovered. Preservation by record will only be considered in exceptional circumstances.

**HE16.20. COUNTY DEVELOPMENT PLAN OBJECTIVE: HISTORIC LANDSCAPES.** a) Recognise the contribution and importance of historic landscapes and their contribution to the appearance of the countryside, their significance as archaeological, architectural, historical and ecological resources. b) Protect the archaeological, architectural, historic and cultural element of the historic/heritage landscapes of the County of Cork.

**RP: RURAL: CHAPTER 5 P.105 +.** Ensure that the housing needs of all rural communities including island communities, which have many distinctive needs from those in urban areas are identified, and that policies are put in place to ensure that the type and scale of development in rural areas, at appropriate locations, necessary to sustain rural communities is accommodated.

**RP 5.4 IDENTIFYING RURAL AREA TYPES:** (RP) 5-4-5 TOURISM AND RURAL DIVERSIFICATION AREA. These parts of rural and coastal County Cork exhibit characteristics such as evidence of considerable pressure for rural housing, in particular higher demand for holiday and second home development. These rural areas are more distant from the major urban areas and the associated pressure from urban generated

housing. These areas also have higher housing vacancy rates and evidence of a relatively stable population compared to weaker parts of the County. **These areas have higher levels of environmental and landscape sensitivity and a weaker economic structure with significant opportunities for tourism and rural diversification.**

**RP 5-5 COUNTY DEVELOPMENT PLAN OBJECTIVE: TOURISM AND RURAL DIVERSIFICATION AREA.**

'This rural area has experienced high housing construction rates and above average housing vacancy rates which has led to concerns that a higher demand for holiday and second homes is depriving genuine rural communities the opportunity to meet their own generated housing needs, Therefore, in order to make provision for the genuine rural generated housing needs of persons from the local community based on their social and/or economic links to a particular local rural area and to recognise the significant opportunities for tourism and rural diversification that exist in this rural area, it is an objective that applicants must demonstrate that their proposal complies with one of the following categories of housing need'.<sup>5</sup>

*NB: Seven categories are then listed- essentially, the applicant is one who is returning to reside near other immediate family members or have spent a substantial period of their lives (i.e. over seven years), living in the local rural area in which they propose to build a first home and/or linked to working full time in farming, forestry, inland waterways...or rural based sustainable tourism.*

Further, **COUNTY DEVELOPMENT PLAN OBJECTIVE:RURAL RP5-25** covers Occupancy Conditions which are imposed in the form of an indenture, usually for seven years, under Section 47 of the Planning & Development Act 2000. (Ireland's government is at last talking of relaxing this stricture because of some of the real problems that occur with such a long period, from mortgage scarcity to a change in people's circumstances)

**TO: TOURISM. CHAPTER 10: p.209+.** Promote a sustainable and well managed tourism industry which protects the environmental and heritage assets of the County while delivering economic benefits throughout the County. Identify and **develop** new and diverse tourism products - particularly those associated with **heritage and environment, arts and culture** and acknowledge the need to spread appropriate tourism growth and tourist related enterprises beyond established resorts and larger towns to rural areas.

(TO) 10.4 FAILTE IRELAND REGIONAL BRANDS: 10.4.1 the Wild Atlantic Way and Irelands Ancient East are evident in Cork County and are making a significant impact to our tourism industry. The Council intends to continue to support the growth of these regional brands. 10.4.2 The development of the 'Wild Atlantic Way' along the west coast from Donegal to West Cork has been a major contribution to the tourism industry. There are 188 Discovery Points along the route with 27 of these in County Cork alone. They are offering the best views of the Irish Landscape.

**TO10-1 COUNTY DEVELOPMENT PLAN OBJECTIVE, PROMOTION OF SUSTAINABLE TOURISM IN COUNTY CORK:** a) Ensuring the protection of the natural, built and cultural heritage assets of the county, including Natura sites, which are in themselves part of what attracts visitors to the county.

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<sup>5</sup> p.114. CCDP 2022-2028 Volume 1 Main Policy Material This same policy appears in the CCDP for 2014 under RC14-3.

**TO 10.2 COUNTY DEVELOPMENT PLAN OBJECTIVE: WILD ATLANTIC WAY:** Continue to actively engage, invest, encourage and promote the development of the Wild Atlantic Way and Irelands Ancient East regional brands through sustainable tourism, which will enable visitors to have enjoyable experiences while having regard for the **cultural, built and natural heritage, and environmental impacts**, including the protection of Natura 2000 sites.

(TO) 10.5.2 Tourism in County Cork is based on its rich natural and built heritage. The principle features of the area's tourism product include mountains and upland habitats; rivers and lakes, over 1100 km's of scenic rugged coastline and peninsulas with long stretches of sandy beaches, fertile agricultural land and many upland peatlands and forest/woodland areas. These natural assets combined with a rich heritage of archaeological and historical sites, built environment including manor homes and gardens, attractive towns and villages offer a unique tourism product.

**(TO) 10.6 PROTECTION OF TOURIST ASSETS:** 10.6.1 County Cork has a wide range of nationally significant tourism assets (including): Mountain ranges including: - the Slieve Miskish and Caha Mountains, the Galtee Mountains, the Shehy Mountains, and the Ballyhoura Area –important centres for , cycling, and adventure related activities. - The Gaeltacht areas which are of significant cultural heritage value and frequently visited by tourists. - The West Cork Peninsulas (Beara, Mizen, Sheep's Head) – with their unique visual amenity and landscape character offer potential for and cycling and other outdoor activities. - Cork has rich fertile agricultural land and many bogs and peatlands with a higher than national average land mass of forest and woodland area; - A wide range of archaeological monuments that occur across the County;. -Opportunities to observe wildlife particularly in terms of bird and marine life.

(TO)10.6.2...It is important to ensure that other development generally and tourism development in these areas does not have a negative impact on the overall character of such areas and does not cause harm to the environment, designated sites or protected species.

(TO) 10.6.3. Many areas that are important to the tourist industry of County Cork owe their attraction to the **exceptional quality of the landscape** or particular features of the built environment. It is important to recognise the valuable role of natural assets such as lakes, rivers and forests as economic resources for tourism, particularly **in rural areas, and to protect and enhance the qualities of such areas** so that they can continue to contribute to the growth in tourism visitors into the County as a whole. It is also important to recognise the **night sky as a tourism asset** for the county and it should be **protected** from light pollution in sensitive areas.

**TO 10.10 COUNTY DEVELOPMENT PLAN OBJECTIVE: TOURISM FACILITIES** b) Carefully consider tourism-related developments outside settlements at an appropriate scale and balance having regard to the pertaining environmental conditions and sensitivities, scenic amenity, availability of services and the cumulative impact of such developments on the environment. c) Support sustainable environmentally sensitive **small-scale tourism enterprises** including Agri-tourism enterprises and other initiatives **that are developed in conjunction with established rural activities such as, fishing, , cycling, mountain biking, surfing, equestrian sports and other activities where these are compatible with environmental legislation.**

**WM: WATER MANAGEMENT. CHAPTER 11: p.226+.** Introduction: Water is a fundamental building block of life and therefore the quality of the water we use in our daily lives is of huge significance to, not only our physical wellbeing but is also critical to our economic wellbeing...The Planning and Development Act 2000, as amended, seeks to integrate the development plan process and water management...to support the protection and enhancement of water quality, and compliance with environmental standards and objectives regarding water quality.

**11.2. The Water Framework Directive (WFD)** is a key initiative aimed at protecting and improving water quality throughout the EU. The WFD was adopted in 2000 and requires governments to implement management measures in their waters (rivers, canals, lakes, reservoirs, groundwater, protected areas (including wetlands and other water dependent ecosystems), estuaries (transitional) and coastal waters up to 1 nautical mile) so as to achieve good ecological status or restore high status.

**WM11-3-18. Groundwater Protection:** Groundwater is a natural resource with both an ecological and economic value. It is of vital importance for sustaining life, health, agriculture and the integrity of ecosystems. This is particularly true...where 90% of the water supply comes from groundwater sources. Groundwater also contributes to our rivers, lakes and sea and therefore influences their amenity and recreational value. The quality of groundwater is threatened by worsening pollution levels, directly attributable to human activities...Once contaminated, groundwater is difficult and expensive to clean. (b) Prevent or limit, as appropriate, the input of pollutants into groundwater and prevent the deterioration of the status of all bodies of groundwater.

**WM11-3-26** In all cases where groundwater is being used as a water supply source or where effluent is being discharged to ground, or both, a report on the impact of the proposed development on existing infrastructure will have to be provided....It should be borne in mind that the development must respect the existing land uses and developments on adjoining sites. While karst regions generally yield hard water in abundant quantities, their vulnerability is generally extreme and this needs to be properly considered in abstracting and treating groundwater for consumption.

**(WM)11-5 Sensitive Water Catchments, 11-5.9:** The issue of discharges from the Dunmanway Wastewater Treatment Plant...is directly into the Bandon River within the SAC and within an area known to support a population of Freshwater Pearl Mussel. Cork County Council is working with other stakeholders in particular Irish Water and the National Parks and Wildlife Service to address this issue. Pending resolution of the issue, and in compliance with the requirements of Various European Directives and the River Basin Management Plan any new development in Dunmanway which discharges into the Bandon SAC will have to be put on hold.

**WM11-3 COUNTY DEVELOPMENT PLAN OBJECTIVE: GROUNDWATER PROTECTION AND ZONES a)** Preserve and protect groundwater and surface water quality throughout the County. b) Prevent or limit, as appropriate, the input of pollutants into groundwater and prevent the deterioration of the status of all bodies of groundwater. c) Protect, enhance and restore all bodies of groundwater...

**ZU: ZONING AND LAND USE: CHAPTER 18: p.391+. 18.2.2. Transitional Lands:** While the zoning objectives indicate the different uses permitted in each zone, it is important to **avoid abrupt/ disconnected transitions in scale and use** in the boundary areas of adjoining land use zones. In dealing with development proposals in these contiguous transitional zonal areas, it is necessary to avoid developments that would be detrimental to the amenities of these zones and in particular the more environmentally sensitive zones. For example, regard should be had to the use, scale and density of development proposals in zones abutting residential or rural areas in order to protect residential or rural amenity, as appropriate. (This statement is regarding Land Zoning in the broadest sense so equally applies to wind energy developments?)

**CA: CLIMATE ACTION. CHAPTER 17: p.226+. (CA) 17.2.2 MITIGATION AND ADAPTION:** Measures in this plan include the following:

- Promoting energy efficiency;
- Promoting new renewable energy technologies and enterprise;
- Enhancing and protecting biodiversity; note how the three are hand in hand

(CA) 17.2.3 Climate adaptation refers to actions taken to reduce the negative effects of climate change or to take advantage of emerging opportunities. Adaptation measures in this plan include the following:

- Flood risk management;
- Promotion of nature-based systems for water management services;
- Enhancement and protection of green infrastructure and biodiversity;

(CA) 17.7 CLIMATE ACTION STRATEGY: 17.7.9 ENERGY: [The vision from Chapter 13] is to facilitate and support investment in sustainable energy production and infrastructure in Cork to meet the future local and national needs, while transitioning to a low carbon economy, addressing the climate change challenge with greenhouse gas emissions and **protection of the environmental, cultural and heritage assets** of the county.

(CA) 17.7.10 In relation to renewable energy an objective is outlined to facilitate the development of renewable energy sources **at suitable locations where such development will not have adverse environmental impacts**, and to support and facilitate renewable energy proposals that bring about a direct socio-economic benefit to the local community. It also outlines an objective that will promote building energy efficiency and conservation.

(CA) 17.7.17 [The vision from Chapter 15] of this plan contains a range of objectives that aim to **protect the natural environment, biodiversity and ecosystems**, delivering benefits essential for all sectors of society, and contribute to efforts to halt the loss of biodiversity and the degradation of ecosystems and the environment.

(CA) 17.7.18 [The vision from Chapter 14] is an important element of an overall aim **to enhance biodiversity**. Green Infrastructure is commonly defined as an interconnected network of multi-functional green space, urban and rural, that is capable of delivering a wide range of environmental and quality of life benefits for local communities and wildlife. Green infrastructure is based on the principle that **protecting**

**and enhancing nature** and natural processes, and the many benefits human society gets from nature, are consciously integrated into spatial planning and territorial development...

Implementation and Delivery The Planning Authority will improve on reporting by establishing a strong, frequent and ongoing monitoring system for the Plan as a permanent function in line with the Draft Development Plan Guidelines for Planning Authorities issued by the Department of Housing, Local Government and Heritage August 2021. The Planning Authority will place particular focus on biodiversity monitoring during the lifetime of the Plan which will be predominately delivered through the Strategic Environmental Assessment (SEA) monitoring process (see Paragraph 19.3.1). In light of this, the biodiversity monitoring targets and indicators in Volume 6 of the Draft Plan have been reviewed and revised with a focus on more tangible measurements and accounting methodologies (see addendum to SEA).

### A Case in Point.

p.35 of MKO Planning Report typically plucks out part of a statement to prove its own point. Just one of example of this, it states: In relation to renewable energy and climate action, the relationship between increased renewable energy production and a reduction in GHG emissions is recognised. Objective 17-2 states:

*“ In order to achieve a reduction in greenhouse gas emissions, an increase in renewable energy production, an increase in energy efficiency and enhanced biodiversity, support the transition to a low carbon, competitive, climate resilient and environmentally sustainable economy by 2050 through implementation of the polices of this plan...”*

They have purposefully foreshortened the quote. Objective 17-2 should have been state in full for the reader, as actually states how the reduction in greenhouse gas emissions will be achieved, with renewable energy **only being part of the mix**:

- **CA 17-2:** In order to achieve a reduction in greenhouse gas emissions, an increase in renewable energy production, an increase in energy efficiency and enhanced biodiversity, support the transition to a low carbon, competitive, climate resilient and environmentally sustainable economy by 2050 through implementation of the polices of this plan that seek to deliver the following:
  - compact growth,
  - integrated land use and transport,
  - sustainable transport choices,
  - liveable settlements,
  - renewable energy production and reduced energy consumption,
  - enhanced ecological biodiversity and

# Appendix D

## MAUGHANACLEA WIND TURBINE DEVELOPMENT COMMUNITY SURVEY RESULTS

Of the 277 distributed door-to-door by volunteers, we received back 118 completed surveys - a respectable response rate of 42.6%. The survey was printed, distributed, and counted within a 10 day period May 6th-16th.

Within the first day of distributing surveys, volunteers noticed that a few families support the wind turbine development and some wish to remain silent or neutral and not respond for social reasons.

### SUPPORT

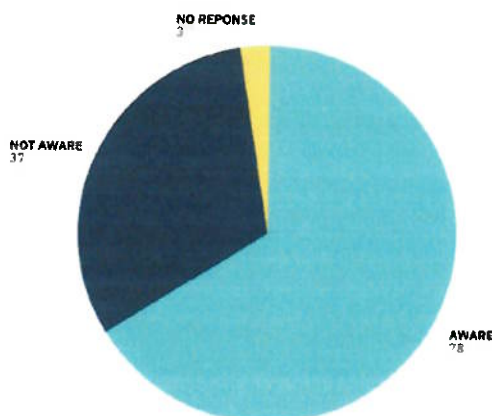
DO YOU SUPPORT THE PROPOSED WIND TURBINE DEVELOPMENT?



Over 95.8% of respondents (113) **do not** support the Maughanaclea Wind Turbine Development. 4 Support it and 1 resident answered "neither".

### AWARENESS

WERE YOU PREVIOUSLY AWARE OF THE WIND TURBINE DEVELOPMENT?



Nearly a third of respondents were unaware of the turbines. Most of these respondents were outside the 2km zone, although 13 respondents were less than 2km and unaware of the development until receiving the survey.

## PROXIMITY

How far do you live from the proposed wind farm?

50 Less than 1km

37 Less than 2km

28 More than 2km

3 No Response

## A CONCERNED COMMUNITY

The results show that the community is highly concerned. On a scale of 1-5, every single category scored an average above 4 with visual impact, night skies, and environmental issues topping the list.

The top community concerns are consistent with the top reasons planning applications have been turned down in the past.

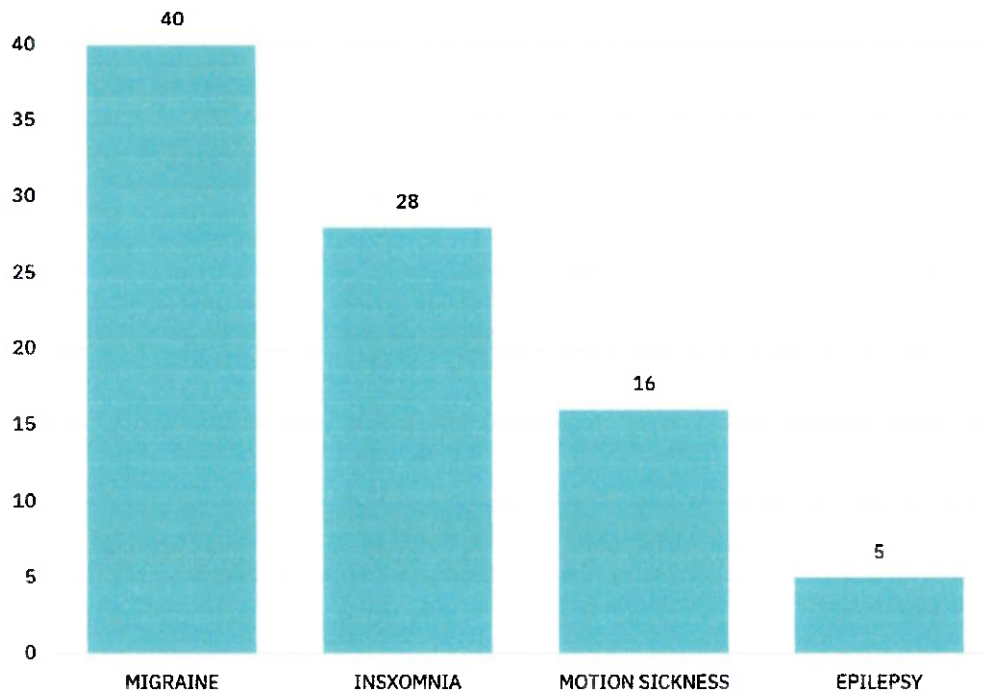
Issues where respondents were most divided were EMF, decrease in property values ( a suspected renters vs homeowners divide), fire & safety issues, tourism, and shadow flicker from blades.

Rank	Concern	Avg. Concern
1	Visual impact on landscape	4.71
2	Harm to protected species (bats, birds, etc.)	4.70
3	No dark skies, stars, northern lights	4.62
4	Noise & disruptions during construction	4.58
5	Damage to archaeological sites	4.56
6	Rural community cost for urban energy demand	4.50
7	Lack of community benefit	4.41
8	Greenwashing (lack of true sustainability)	4.38
9	Pollution from blades & blade disposal	4.36
10	Low-frequency vibration health risks	4.36
11	Noise pollution from turbines	4.31
12	Risk to well water quality	4.24
13	Shadow flicker from blades	4.23
14	Impact on local tourism	4.21
15	Decrease in property values	4.21
16	Toxic smoke / fire evacuation risk	4.16
17	Effect on farm animals	4.16
18	Fire risk of substations / battery storage	4.15
19	EMF (electromagnetic fields) health risks	4.11

## HEALTH ISSUES

The survey showed that 54 respondents (45.7%) had one or more health issue that they worried might be exacerbated by the wind turbine development.

A number of respondents wrote in answers as well including autism, ADHD, tinnitus, vertigo, and misophonia. Migraines and insomnia topped the list of common health concerns.



## COMMUNITY COMMENTS

- "No focus on energy descent. - Damage to water cycles - "Renewable" energy projects implemented at huge scale under the same political / economic framework as fossil fuels PTO"

"170m turbine = 350 cubic metre concrete base x 14 turbines = 4900 cubic meter concrete that will never be removed again. All the while i have to count the flowers in the grass on the same hill to improve biodiversity. It's insane. All for the benefit of one man. China has already developed a solution which is sustainable. It will come. We have to wait, meanwhile protect our hills from irreversible damage."

"As an island nation, we should make use of wave power and install wind turbines at sea rather than on land"

"Putting sign up along the Cousane Gap to create greater awareness of what is happening there...the bulk of people would not know about these proposed Windmill parks..."

"We learnt recently that businesses (ie call centres, server farms) use more electricity than all of the homes in the country, yet electricity prices continue to rise. It seems clear that there is no benefit to the people of the country and it all feels like a continued exploitation of our natural resources. concerns."

## **Pleistocene-Holocene Lakes in the Bantry Valley, County Cork.**

by

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### **Introduction**

The Pleistocene Epoch has been considered to have commenced about 2.4 million ago and to have ended about 10,000 years ago at the beginning of the present warm epoch, known as the Holocene. It was a time, which witnessed the introduction of repeated glacial and interglacial conditions across much of the northern hemisphere. The alternation of these contrasting conditions has had a major environmental impact on the landscape of Ireland, which has included episodes of extensive erosion and deposition of glacial sediments. Typically, such deposits have a very low preservation potential as they are susceptible to erosion and reworking during subsequent glacial and interglacial periods. Consequently, the bulk of the glacial deposits in southern Ireland are probably the result of the most recent glacial events.

The last major glacial phase which affected southwest Ireland, commenced about 70,000 years BP in the Late Pleistocene and ended about 10,000 years BP (Mitchell, 1976; 1987; Warren, 1985). This resulted in a local ice cap known as the Kerry-Cork Ice Sheet centred in the Kenmare area. Farrington (1936) suggested that ice moved southwards from the Kenmare Valley across the Caha Mountains into the Bantry Valley where it was partially dedirected towards the southwest and northeast resulting in the deposition of a drumlin field within the valley. Part of the ice mass continued to move southeastwards across the hills on the south side of the Bantry Valley towards Skibbereen (Farrington, 1936). The landscape of the Bantry Bay and Valley area of southwest Ireland contains extensive deposits associated with this glaciation (Farrington, 1936; Lewis, 1977). Analysis of these deposits and the topography in the Bantry Valley provides a means of reconstructing the evolving environmental conditions associated with the final stages of this last glacial phase here. This paper presents a brief description of the glacial features and deposits of the Bantry Valley and attempts to use these to reconstruct the changing environmental conditions during and immediately following the decline of the last major episode of glaciation in this region.

### **Topography and Glacial Features**

Bantry Bay occupies a northeast-southwest trending ria which opens in a southwesterly direction to the sea. It's northeastern end is rimmed by a range of mountains with summits ranging from about 400m to about 700m altitude. A series of prominent v-shaped valleys separate these mountains (Fig. 1). These include the Pass of Keimaneagh, 'Doughil Pass', 'Gortloughra Pass', Cousane Gap, 'Barrboy Pass' and 'Derreenacrinig Pass'. A further four passes are located on the southeastern side of the valley (Fig. 1). Two are located each at Gortacloona and Trawlebawn. A distinctive glacial spillway is located at Cummertlibawn (Fig. 1) and adjacent to this is another v-shaped valley and associated 'fossil' waterfall, which is now almost completely dry, here termed 'Cappaboy Waterfall'. This was first observed by Jukes (1864). Farrington (1936) and Jukes (1864) recognised the development of glacial spillways on the northeastern end of the Bantry Valley and suggested that the valley was partially occupied by a glacial lake.

The mountains in the area are generally of a rounded form testifying to extensive erosion probably during successive glaciations. The northern side of the Bantry Valley contains smaller tributary valleys known as the Borlin, Coomhola, Owenbeg and Cooleenlemane Valleys. These are essentially u-shaped valleys and combine and discharge into the sea at Snave. The head of the Borlin and Cooleenlemane Valleys exhibit the form of corries which suggests that these valleys may have been occupied by localised mountains glaciers (Figs. 2 & 3).

## **Glacial Deposits**

### *Drumlins*

Farrington (1936) presented the most detailed description of the deposits and features of this area to date. He mapped the distribution of over one hundred drumlins, which are superbly preserved in the Bantry Valley (Fig. 1). The drumlins are best seen along the shoreline at Reelane Point, Beach, Bantry beach, Reendonagan, Ardnamanagh and Ballylickey where they have been extensively eroded by recent marine processes. They are composed of diamict, which comprises cobbles and boulders set within a matrix of stiff bluish grey clay. Typically, this is gradationally overlain by a roughly 1-2m thick intensely weathered surface zone, which exhibits a distinctive brownish colour. The drumlins, which are exposed along the southern shore of the bay, contain a conspicuous array of large limestone boulders. The general absence of this type of limestone within the exposed bedrock of the Bantry region prompted Sevastopulo and Naylor (1981) to carry out an analysis of the erratics in order to determine their age and source. They concluded that the boulders may have been derived from the Kenmare Valley where the nearest known limestone bedrock is exposed, though they could not explain the absence of limestone boulder erratics on the north side of the Bantry Bay which otherwise contains extensive non-carbonate erratics. Farrington (1936) suggested that the boulders were derived from limestone outcrops within Bantry Bay. The recent discovery of substantial limestone bedrock in the subsurface south of Whiddy Island (Sevastopulo *et al.*, 2000; see MacCarthy, 2002 for location) now provides a more likely source for the limestone boulder erratics.

### *Fluvioglacial Outwash and Lacustrine Deposits*

Farrington (1936) also described the distribution of fluvioglacial outwash deposits in the area (Fig. 1). These are best seen on the northern side of the Maughanaclea Hills and at Maulavannig and consist of waterlain gravels, sands and silts. At Maulavannig sand pits, the deposits consist of cm to mm thick alternations of silt/clay with sand, comparable to those seen in lacustrine varves. Other evidence for lacustrine conditions is suggested by thick accumulations of dark grey to black clays which are preserved between drumlins at Cappanaloha (located about half way between Knocknaveagh and Knockboolteenagh) and immediately to the north of Knockboolteenagh. These deposits, however, await detailed analysis which may well provide important information on the environmental history of the area.

Stillman (1968) described the results of an analysis of deposits partially overlying the 'boulder clay', which are located beneath the seabed in the area of the jetty on the northwestern side of Whiddy Island. These deposits are 27m thick and comprise interbedded clay, sandy silt and fine sand. A finegrained black lacustrine deposit occurs at the base of these deposits, the base of which lies at a depth of -57m OD. This contained fresh water diatoms and herbaceous pollen, which suggest an age of 11,000-12,000 years BP (Stillman, 1968).

### **Palaeoenvironmental Reconstruction of the Glacial Lakes**

It must be remembered that at the time of the maximum of the last glaciation, sea level was about 130m lower than it is today so that the coastal zone was located well to the west of Sheep's Head. Temperatures during this last major glacial phase (70,000-10,000 years BP) varied considerably with the result that there were two warm periods known as interstadials, which alternated with three colder periods known as stadials.

Analysis of the geographical distribution and altitude of the various spillways/outlets, the distribution and type of glacial deposits and the topographical form of the landscape in the Bantry Valley and its surrounding uplands indicates that a number of proglacial lakes became established in the valley towards the end of the last glaciation. The contained lake waters must have been impounded by a decaying ice mass in the Bantry Valley to the west and by the mountains lying to the south, east and north of the valley (Figs. 2 & 3). The present interpretation indicates that three distinct lakes became established in the area and they developed and amalgamated at different times. These lakes are here termed Glacial Lakes Bantry, Owenbeg and Maolagh. The interpretation of the history of these lakes is difficult because the present topography is clearly not the same as that which prevailed when the lakes existed. The landscape must have endured extensive erosion and modification during the Holocene so that the contours would have been quite different compared to those of today. The models for the glacial lakes, which are presented here are largely based on the present day contour

patterns. The history of the development and evolution of these lakes during the glacial phase is interpreted as having taken place in the following stages;

1. The extensive evidence from glacial erratics, glacial striae and the orientations of the drumlins indicates that initially ice moved from the Kenmare Valley into Bantry Bay through Glengarriff Harbour. Part of this was diverted southwestwards and part towards the northeast where it crossed the eastern margin to the valley. Glacial striae provide clear evidence for ice movement through the Cousane Gap and across the hills to the east of the Maolagh Valley (Fig. 1). Ice also moved across the southern side of the Bantry Valley towards Skibbereen.
2. The subsequent decay of the eastern margin of the ice mass resulted in southwesterly retreat of the ice front. This led to the development of a lake in the Maolagh Valley, Glacial Lake Maolagh. The level of this lake was 340m+. It drained through Barrboy Pass cutting it down to 340m, at which point the pass was abandoned.
3. A separate lake, Glacial Lake Bantry, developed to the north of the Maolagh Valley. The level of this lake must have been higher than 275m which is the altitude of Doughil Pass, the highest pass in this part of the valley. At this stage, the lake may have been discharging through Keimaneagh, Doughil, Gortloughra and Cousane Passes, though at higher levels than today. It is difficult to interpret the altitude of these outlets in the past or indeed if and when they may have been active. Subsequent to this, the level of Lake Bantry fell gradually and its eastern outlets were successively abandoned.
4. Doughil Pass was abandoned at 275m. The level of Lake Bantry fell from 275 to 260m and then discharged through Gortloughra Pass at 260m+.
5. Gortloughra Pass was then abandoned. As the level of Lake Bantry fell below 240m, Glacial Lake Owenbeg developed as a separate lake from the larger Lake Bantry. This led to the development of two spillways, Cummerlibawn and Cappaboy Spillway and Waterfall, which drained out of Lake Owenbeg.
6. Lake Bantry level fell to 230m as it discharged through the Cousane Gap.
7. The Cousane Gap was abandoned at 230m. The lake waters fell to 200m and discharged through Keimaneagh Pass. This stage is shown in Figure 2. At this stage, Lake Bantry was the source of the ancestral River Lee.
8. Ice retreated to the west of Whiddy Island (Fig. 3). Lake Owenbeg finally drained into Lake Bantry through Derryfadda Pass.
9. The retaining ice front to the west retreated further resulting in the amalgamation of Lakes Bantry and Maolagh. This led to the successive abandonment of Keimaneagh, Barrboy and Derreenacrinnig Passes.
10. As the level of Lake Bantry fell further, drainage out of the lake switched to Trawlebawn Pass at 160m.
11. Drainage through Trawlebawn Pass was abandoned and the lake level fell to 90m and drained through Gortacloona Passes. At this time, the lake depth may have been at its deepest.
12. The surface of the drumlins must have been reworked as the lake level continued to fall. Infiltration of water into the drumlins must have taken place when they were exposed to the elements. This has resulted in extensive alteration of the upper part of the drumlins resulting in a widespread brownish weathered rim which is seen today.

#### **The Age of the Glacial Lakes**

There is no known evidence for the date of the inception of the glacial lakes described above. However, the last thick ice mass which occupied the Bantry Valley probably melted during the last interstadial warm phase known as the Woodgrange Interstadial (13,000-11,000 years BP) which

effectively marks the end of the glacial history of the region. It is, therefore, likely that the initial development of the glacial lakes took place during the early part of this interstadial. The age of the Whiddy Island lacustrine muds (12,000-11,000 years BP) indicates that they accumulated during the latter part of this interstadial when the climate of southern Ireland may have been almost as warm as it is today. Little or no ice would have remained in the Bantry Valley at this time and Glacial Lake Bantry contracted to a small area located to the north of Whiddy Island. This marked the ending of its history as a purely 'pro-glacial' lake (Fig. 4).

#### **The Post-Glacial History of the Bantry Valley**

The melting of ice in the valley resulted in unrestricted access from Lake Bantry to the open sea during the Woodgrange Interstadial. As the base of the lake deposits lies at -57m, sea level at the time must have been much lower than this taking account of the gradient of the valley floor. The Bantry Valley was occupied by a southwesterly flowing river system possibly draining out of the remnant of Lake Bantry towards the southwest (Fig. 4). The ancestral rivers to those in the region today probably developed at this time and minor lateral tributaries drained the margins of the valley. The river system reworked earlier glacial deposits in the valley. As the gradient within the valley was low, the river was probably of a high sinuosity type and it discharging into the sea beyond the present mouth of the bay where the sea bed lies beneath -60m. The tidal regime would have been comparable to that of today. Hence, it is likely that the rivers would have discharged through sinuous macrotidal estuaries (Fig. 4).

There was a final brief cold spell known as the Nahanagan Stadial, which lasted from 11,000 to 10,000 years BP. It is likely that no ice occupied the valley during this last cold period. Localised remnants of mountain glaciers may have occupied some of the corries in the region. The melting of the last of the ice about 10,000 years BP was followed by a gradual rise in sea level from below -57m to its present level (Mitchell, 1987) known as the Holocene rise in sea level. This resulted in an erosive transgression of the sea, which sheared off the upper layers of earlier glacially and fluviially deposited sediments within the valley. It also brought about the termination of the remnants of Lake Bantry, which by now had shrunk considerably in size. However, the timing of the ending of the lake is not known. It may have persisted well into the Holocene before the marine transgression finally flooded the lake.

The erosive Holocene marine transgression continues today and is manifested in the contemporary marine erosion of the coastal drumlins in the bay. This process has removed the finer matrix from the drumlins and transported it offshore where it has been accumulating on the sea floor as a finegrained marine shelf deposit. The coarser cobbles and boulders from the drumlins have remained close to where they fell following the removal of the supporting matrix. This must have resulted in a layer of concentrated boulders and cobbles, which now extends offshore from the eastern shoreline of Bantry Bay.

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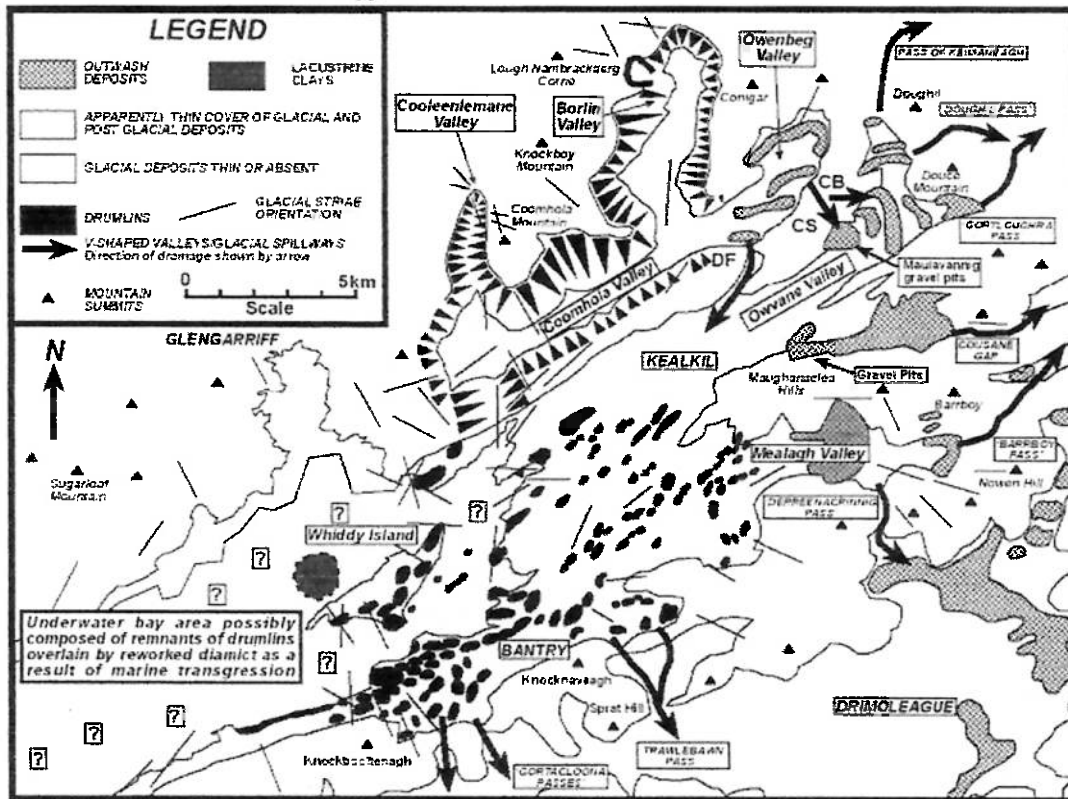


FIGURE 1. Schematic distribution of glacial deposits and features in the Bantry Valley and surrounds (modified after Farrington 1936). CB-Cappaboy dried valley and waterfall, CS-Cummertibawn Spillway, DF-Derrifadda outlet.

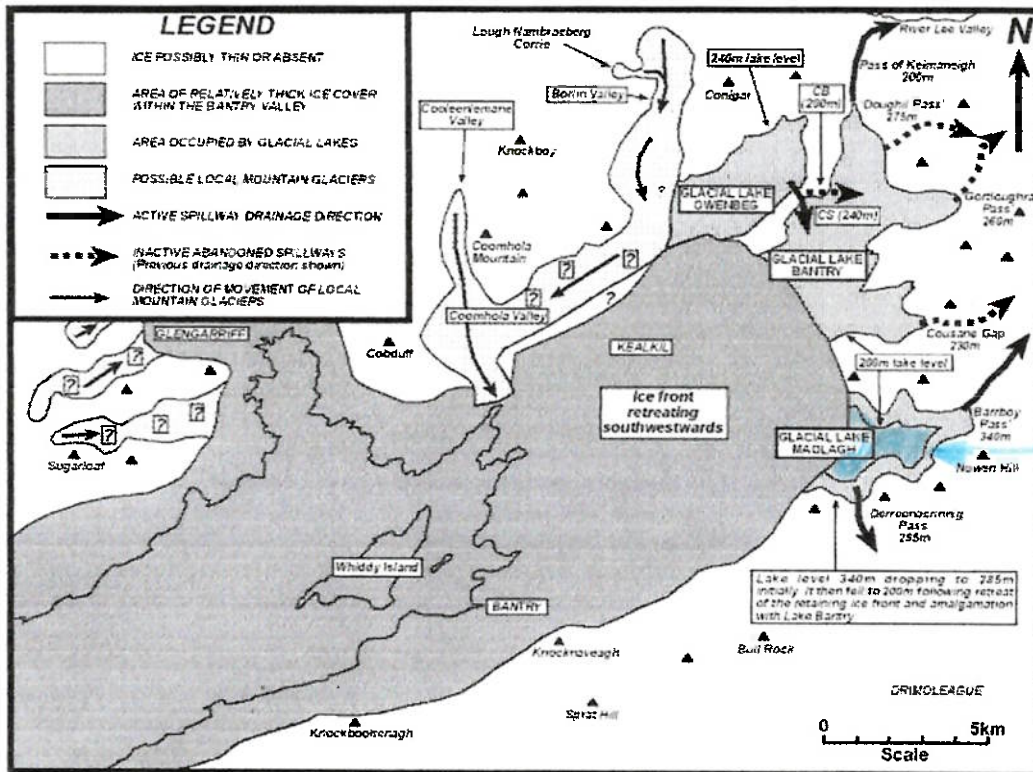


FIGURE 2. Reconstruction of glacial lakes in the Bantry Valley towards the end of the last glaciation. The level of the lakes at this time were; Lake Bantry-200m, Lake Owenbeg-240m, Lake Maolagh-340m. The lake waters were contained to the west by the southwesterly retreating ice mass. The lake was the source of the River Lee at this time. CB-Cappaboy Spillway and Waterfall, CS-Cummerlibawn Spillway.

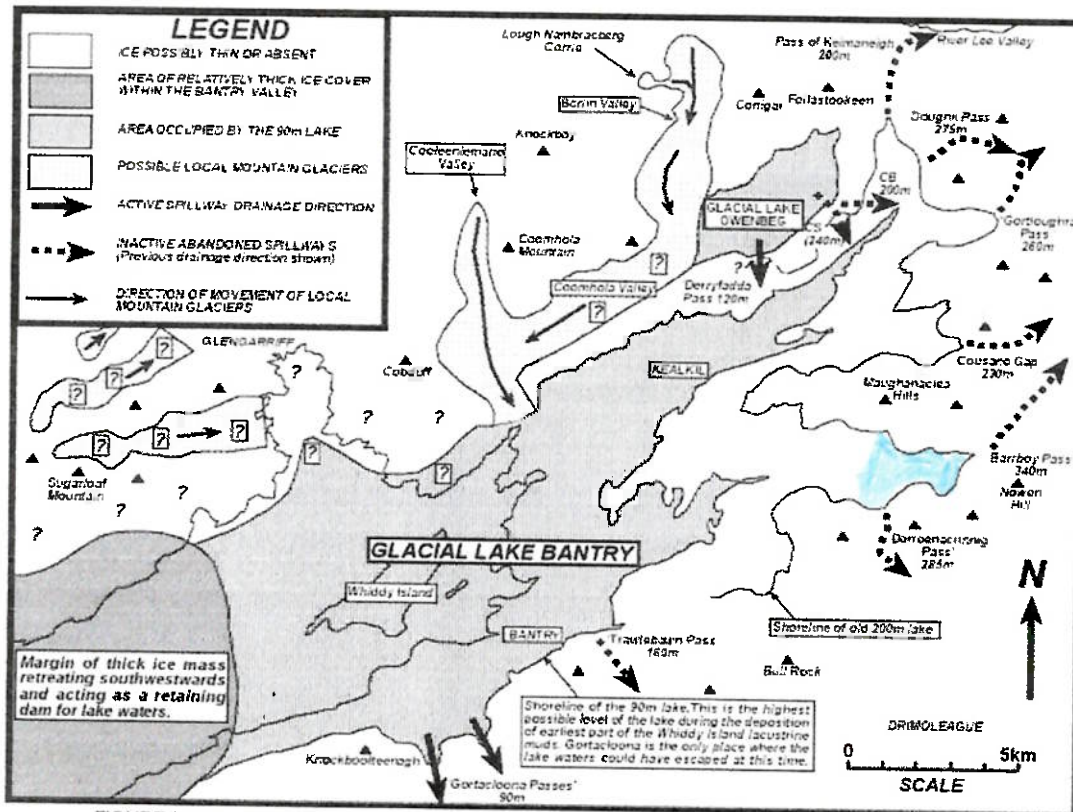


FIGURE 3. Reconstruction of Glacial Lake Bantry towards the end of the last glaciation when the lake waters had fallen to 90m OD. At this time, the southwesterly retreating ice sheet was located somewhere to the west of Whiddy Island and the dammed lake waters were only able to escape through the Gortacloona Passes. CB-Cappaboy Waterfall, CS-Cummerlibawn Spillway.

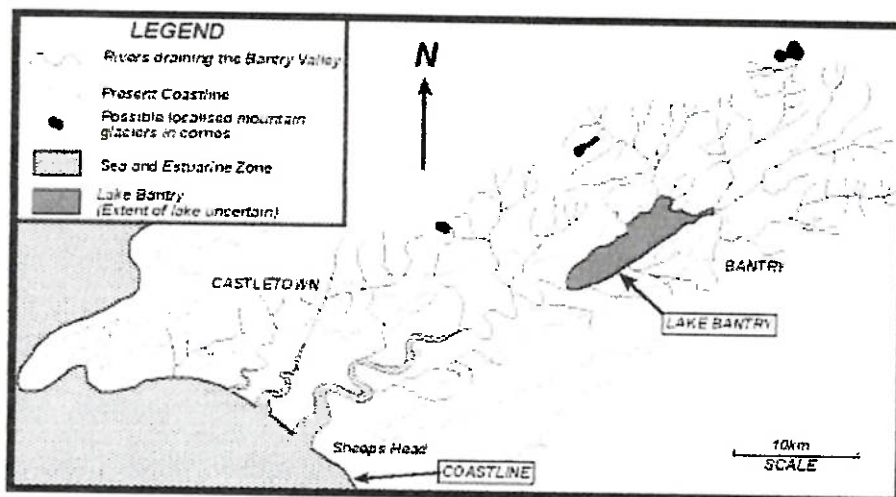



FIGURE 4. Schematic reconstruction of environments in the Bantry Valley towards the end of the last glaciation, during the deposition of the Whiddy Island muds (12,000-11,000 years BP). This corresponded to the latter part of the Woodgrange Interstadial. The position of the coast is highly speculative. The position shown is probably the closest it could have been to the mouth of the Bantry Valley at this time.







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## How Does Wind Turbine Noise Affect People?

*The many ways by which unheard infrasound and low-frequency sound from wind turbines could distress people living nearby are described.*

### Introduction

Recent articles in *Acoustics Today* have reviewed a number of difficult issues concerning wind turbine noise and how it can affect people living nearby (Leventhall 2013, Schomer 2013; Timmerman 2013). Here we present potential mechanisms by which effects could occur.

The essence of the current debate is that on one hand you have the well-funded wind industry 1, advocating that infrasound be ignored because the measured levels are below the threshold of human hearing, allowing noise levels to be adequately documented through A-weighted sound measurements, 2, dismissing the possibility that any variants of wind turbine syndrome exist (Pierpont 2009) even when physicians (e.g., Steven D. Rauch, M.D. at Harvard Medical School) cannot otherwise explain some patients' symptoms, and 3, arguing that it is unnecessary to separate wind turbines and homes based on prevailing sound levels.

On the other hand you have many people who claim to be so distressed by the effects of wind-turbine noise that they cannot tolerate living in their homes. Some move away, either at financial loss or bought-out by the turbine operators. Others live with the discomfort, often requiring medical therapies to deal with their symptoms. Some, even members of the same family, may be unaffected. Below is a description of the disturbance experienced by a woman in Europe we received a few weeks ago as part of an unsolicited e-mail.

*"From the moment that the turbines began working I experienced vertigo-like symptoms on an ongoing basis. In many respects, what I am experiencing now is actually worse than the 'dizziness' I have previously experienced, as the associated nausea is much more intense. For me the pulsating, humming, noise that the turbines emit is the predominant sound that I hear and that really seems to affect me.*

*While the Chief Scientist [the person who came to take sound measurements in her house] undertaking the measurement informed me that he was aware of the low frequency hum the turbines produced (he lives close to a wind farm himself and had recorded the humming noise levels indoors in his own home) he advised that I could tune this noise out and that any adverse symptoms I was experiencing were simply psychosomatic."*

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**“Almost all measurements of wind turbine noise are A-weighted, making the unjustified assumption that hearing is the only way by which infrasound generates physiologic effects.”**

We asked how she felt when she was away from the wind turbines, to which she replied:

*“I did manage to take a vacation towards the end of August and for the two weeks we were away I was perfectly fine.”*

The goal of our work in this field is to understand whether the physiology of the ear can, or cannot, explain the symptoms people attribute to wind turbine noise. As it is generally the case when debate influences a specific industry’s financial interests and legal well-being, the scientific objectivity of those associated with the industry can be questioned. Liability, damage claims, and large amounts of money can hang in the balance of results from empirical studies. Whether it is a chemical industry blamed for contaminating groundwater with cancer-causing dioxin, the tobacco industry accused of contributing to lung cancer, or athletes of the National Football League (NFL) putatively being susceptible to brain damage, it can be extremely difficult to establish the truth when some have an agenda to protect the status quo. It is only when sufficient scientific evidence is compiled by those not working for the industry that the issue is considered seriously.

### **Origins of Our Involvement in Infrasound from Wind Turbines**

What is the evidence leading us to conclude that unheard infrasounds are part of the wind turbine problem, and how did we become involved in this debate? We are a small group of basic and applied scientists, which means that our work addresses fundamental questions on how the ear works in normal and diseased states. While developing paradigms for our studies, we had been using a classic technique called “low-frequency biasing” – measurement of auditory responses to a test sound within the range of audibility, while simultaneously presenting a low-frequency tone (e.g., 4.8 to 50 Hz) to displace the sensory organ of the inner ear. Some auditory responses saturate when displaced by the bias tone, which can be used to establish whether the sensory organ is vibrating symmetrically or whether a fluid disturbance has displaced it to one side. A condition called “endolymphatic hydrops,”

which is found in humans with Ménière’s disease, can displace the sensory organ as the space containing the fluid called endolymph swells. In our animal experiments we initially used 20 to 50 Hz bias tones, but for many reasons, and in large part based on a study in which we found that the ear responded down to 1 Hz (Salt and DeMott, 1999), we started using the lowest frequency our hardware could generate, 4.8 Hz, a frequency considered to be infrasound. Over the course of hundreds of experiments, we have found numerous biasing effects with 4.8 Hz tones at levels of 80 to 90 dB SPL (i.e., -13 to -3 dBA). We also found that the ear became about 20 dB more sensitive to infrasonic bias tones when the fluid spaces in the cochlear apex were partially occluded, as occurs with endolymphatic hydrops.

In late 2009, the first author received a report of a woman with Ménière’s disease whose symptoms – primarily dizziness and nausea – were severely exacerbated when she was in the vicinity of wind turbines. From our animal data, we knew this woman was likely hypersensitive to very low-frequency sounds. Our subsequent review of the literature on wind-turbine noise revealed two aspects that were absolutely astounding:

1. Almost all measurements of wind turbine noise are A-weighted, making the unjustified assumption that hearing is the only way by which infrasound generates physiologic effects. The few studies that reported un-weighted measurements of wind-turbine noise, or recalculated spectra by removing the A-weighting from published A-weighted spectra, clearly demonstrated increasing energy towards low frequencies with highest energy levels in the infrasound region. We were surprised that objective full-frequency measurements showed that wind turbines generate infrasound at levels capable of stimulating the ear in various ways. Under such circumstances, A-weighting measurements of turbine noise would be highly misleading.

2. Literature and websites from the wind turbine industry often contained strong statements that wind turbine infrasound was of no significance. This view was largely based on publications by Leventhall (2006; 2007). Wind turbine noise was described as comparable to rustling leaves, flowing streams, air-conditioned offices or refrigerators heard from the next room. If wind turbine noise really was comparable to such sources then complaints would not be expected. But the turbines sounds are only comparable to these sources if the ultra-low frequencies emitted by the turbines are ignored through A-weighting. Stations that monitor infrasound or low frequency seismic (vibrational) noise for other purposes (for the detection of explosions, meteors, volcanic activity, atmospheric activity, etc.) are well-aware that low frequency sounds emanating from distant wind farms, or coupling to the ground as vibrations, can influence their measurements. The UK, Ministry of Defense has opposed wind turbines cited within 50 km of the Eskdalemuir Seismic Array. We have seen no reports of the Ministry opposing the presence of refrigerators in the region, suggesting they appreciate that sounds emitted from wind turbines and refrigerators are quite different. It was thus quite astounding to see the vast majority of wind turbine noise measurements excluding the low frequency noise content. Given the knowledge that the ear responds to low frequency sounds and infrasound, we knew that comparisons with benign sources were invalid and the logic to A-weight sound measurements was deeply flawed scientifically.

### The Ear's Response to Infrasound

Experimental measurements show robust electrical responses from the cochlea in response to infrasound (Salt and DeMott, 1999; Salt and Lichtenhan 2013). This finding was initially difficult to reconcile with measures showing that hearing was notably insensitive to such sounds but the explanation became clear from now-classic physiological studies of the ear showing that the two types of sensory cell in the cochlea had very different mechanical properties (Cheatham and Dallos 2001).

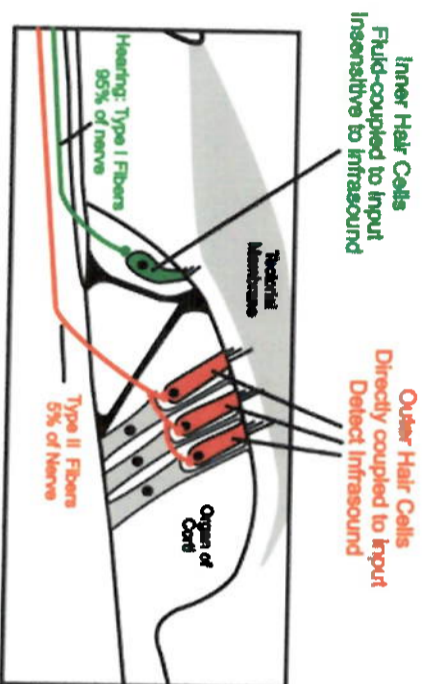
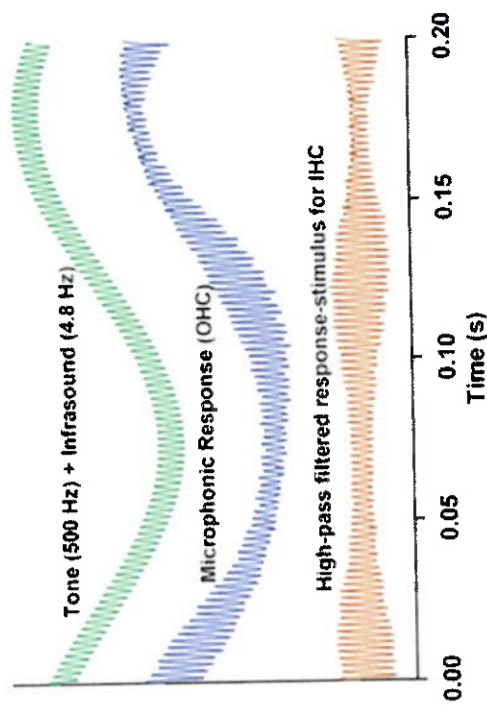


Figure 1 : The sensory organ of the cochlea, showing inner and outer hair cell and neural anatomy.

The auditory portion of the inner ear, the cochlea, has two types of sensory cell. The inner hair cells (IHC; shown green in Figure 1) are innervated by type I afferent nerve fibers that mediate hearing. The stereocilia (sensory hairs) of the IHCs are free-floating and do not contact the overlying gelatinous tectorial membrane (shown gray). They are mechanically displaced by fluid movements in the space below the membrane. As their input is fluid-coupled to the vibrations of the sensory organ they exhibit “velocity sensitive” responses. As the velocity of motions decreases for lower-frequency sounds, their fluid-coupled input renders the IHC insensitive to very low-frequency sounds. The other type of sensory cell, the outer hair cells (OHC; shown red in Figure 1) are innervated by type II afferent nerve fibers that are not as well understood as type I fibers and probably do not mediate conscious hearing per se. In contrast to the IHC, the stereocilia of the OHCs are inserted into the tectorial membrane. This direct mechanical coupling gives them “displacement sensitive” properties, meaning they respond well to low-frequency sounds and infrasound. The electrical responses of the ear we had been recording and studying originate from the sensitive OHCs. From this understanding we conclude that very low frequency sounds and infrasound, at levels well below those that are heard, readily stimulate the cochlea. Low frequency sounds and infrasound from wind turbines can therefore stimulate the ear at levels well below those that are heard.

The million-dollar question is whether the effects of wind turbine infrasound stimulation stay confined to the ear and have no other influence on the person or animal. At present, the stance of wind industry and its acoustician advisors is that there are no consequences to long-term low-frequency and infrasonic stimulation. This is not based on studies showing that long-term stimulation to low-level infrasound has no influ-



**Figure 2 :** Demonstration of biologically-generated amplitude modulation to a non-modulated stimulus consisting of an audible tone at 500 Hz tone summed with an infrasonic tone at 4.8 Hz. The cochlear microphonic response, which is generated by the OHC, includes low and high frequency components. The IHC detect only the high frequency component, which is amplitude modulated at twice the infrasonic frequency for the stimuli in this example.

ence on humans or animals. No such studies have ever been performed. Their narrow perspective shows a remarkable lack of understanding of the sophistication of biological systems and is almost certainly incorrect. As we consider below, there are many physiologic mechanisms by which long-term infrasound stimulation of the cochlea could have effects.

One important aspect of wind turbine noise that is relevant to its physiological consequences is that the duration of exposure can be extremely long, 24 hours a day and lasting for days or longer, depending on prevailing wind conditions. This is considerably different from most industrial noise where 8 hour exposures are typically considered, interspersed by prolonged periods of quiet (i.e., quiet for 16 hours per day plus all weekends). There are numerous studies of exposures to higher level infrasound for periods of a few hours, but to date there have been no systematic studies of exposure to infrasound for a prolonged period. The degree of low-frequency cochlear stimulation generated by wind turbine noise is remarkably difficult to assess, due to the almost exclusive reporting of A-weighted sound level measurements. It certainly cannot be assumed that cochlear stimulation is negligible because A-weighted level measurements are low. For example, with 5 Hz stimulation cochlear responses are generated at -30 dBA and stimulation is sufficient to cause responses to saturate (indicating the transducer is being driven to its limit) at approximately 20 dBA (Salt and Lichtenhan, 2012; Salt et al., 2013). We have also shown that 125 Hz low-pass filtered noise at just 45 dBA produces larger responses than wide band noise with the same low-frequency content presented at 90 dBA (Salt and Lichtenhan 2012). We conclude that low frequency regions of the ear will be moderately to strongly stimulated for prolonged periods by wind turbine noise. There are a number of plausible mechanisms by which the stimulation could have effects:

### 1. Amplitude Modulation: Low-Frequency Biasing of Audible Sounds

Modulation of the biological mechano-electric transducer of the inner ear by infrasound is completely different from the amplitude modulation of audible sounds that can be measured with a sound level meter near wind turbines under some conditions. This can be demonstrated in low-frequency biasing paradigms in which a low-frequency tone and higher-frequency audible tone are presented simultaneously to a subject.

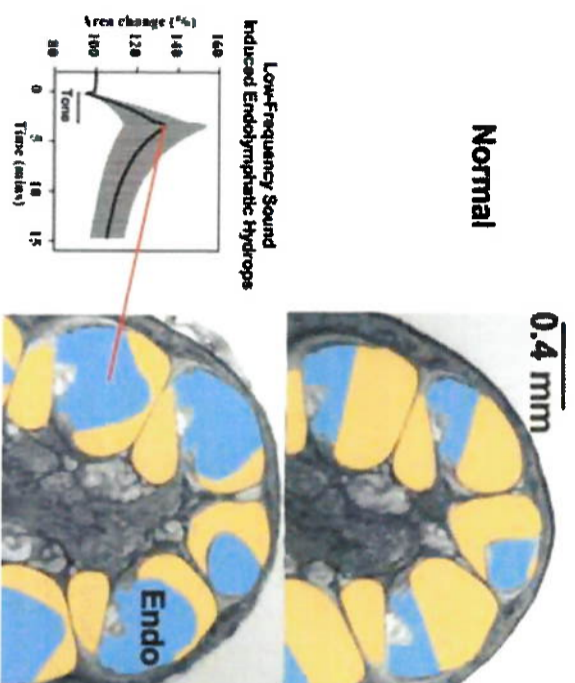
OHCs respond to both low- and high-frequency components and modulate the high-frequency components by either saturation of the mechano-electric transducer or by cyclically changing the mechanical amplification of high frequencies. IHCs, being insensitive to the low-frequency tone, see a high pass-filtered representation of the OHC response – an amplitude modulated version of the audible probe tone, as shown in *Figure 2*. As hearing is mediated through the IHCs that receive approximately 90-95% of afferent innervation of the auditory nerve, the subject hears the higher-frequency probe tone varying in amplitude, or loudness. A similar biasing influence on cochlear responses evoked by low-level tone pips was explained by the low-frequency bias tone changing OHC-based cochlear amplifier gain (Lichtenhan 2012). This same study also showed that the low frequency, apical regions of the ear were most sensitive to low-frequency biasing. Studies like this raise the possibility that the amplitude modulation of sounds, which people living near wind turbines report

as being so highly annoying, may not be easily explained by measurements with an A-weighted sound level meter. Rather, the low-frequency and infrasound levels need to be considered as contributing to the perceived phenomenon. Subjectively, the perceived fluctuation from an amplitude modulated sound and from a low-frequency biased sound are identical even though their mechanisms of generation are completely different. For the subject, the summed effects of both types of amplitude modulation will contribute to their perception of modulation. Acousticians therefore need to be aware that the degree of modulation perceived by humans and animals living near wind turbines may exceed that detected by a sound level meter.

## 2. Endolymphatic Hydrops Induced by Low-Frequency Tones

As mentioned above, endolymphatic hydrops is a swelling of the innermost, membrane bound fluid compartment of the inner ear. Low-frequency tones presented at moderate to moderately-intense levels for just 1.5 to 3 minutes can induce hydrops (Figure 3), tinnitus (ringing in the ears) and changes in auditory potentials and acoustic emissions that are physiological hallmarks of endolymphatic hydrops (Salt, 2004, Drexel et al. 2013).

Unlike the hearing loss caused by loud sounds, the symptoms resulting from endolymphatic hydrops are not permanent and can disappear, or at least fluctuate, as the degree of hydrops changes. Return to quiet (as in Figure 3) or relocation away from the low-frequency noise environment allow the hydrops, and the symptoms of hydrops, to resolve. This which would be consistent with the woman's description of her symptoms given earlier. As hydrops is a mechanical swelling of the membrane-bound endolymphatic space, it affects the most distensible regions first – known to be the cochlear apex and vestibular sacculus. Patients with sacular disturbances typically experience a sensation of subjective vertigo, which would be accompanied by unrestrained and nausea. As we mentioned above, an ear that has developed endolymphatic



**Figure 3 :** Brief exposures to low-frequency tones cause endolymphatic hydrops in animals (Salt, 2004) and tinnitus and acoustic emission changes consistent with endolymphatic hydrops in humans (Drexel et al. 2013). The anatomical pictures at the right show the difference between the normal (upper) and hydropic (lower) cochlear The endolymphatic space (shown blue) is enlarged in the hydropic cochlea, generated surgically in this case.

low frequencies – has to be considered. To date, all studies of low-frequency tone-induced hydrops have used very short duration (1-2 min) exposures. In humans, this is partly due to ethical concerns about the potential long-term consequences of more prolonged exposures (Drexel et al., 2013). Endolymphatic hydrops induced by prolonged exposures to moderate levels of low-frequency sound therefore remains a real possibility.

## 3. Excitation of Outer Hair Cell Afferent Nerve Pathways

Approximately 5-10% of the afferent nerve fibers (which send signals from the cochlea to the brain - the type II fibers mentioned above) synapse on OHCs. These fibers do not respond well to sounds in the normal acoustic range and they are not considered to be associated with conscious hearing. Excitation of the fibers may generate other percepts, such as feelings of aural fullness or tinnitus. Moreover, it appears that infrasound is the ideal stimulus to excite OHC afferent fibers given what has been learned about these neurons from *in vitro* recordings (Weisz et al. 2012; Lichenhan and Salt, 2013). *In vivo* excitation of OHC afferents has yet to be attempted with infrasound, but comparable fibers in birds have been shown to be highly sensitive to infrasound (Schemmly and Klinker, 1990). OHC afferents innervate cells of the cochlear nucleus that have a role in selective attention and alerting, which may explain the sleep disturbances that some people living

**“The million-dollar question is whether the effects of wind turbine infrasound stimulation stay confined to the ear and have no other influence on the person or animal.”**

near wind turbines report (Nissenbaum et al. 2012). The likelihood that OHC afferents are involved in the effects of low-frequency noise is further supported by observations that type II innervation is greatest in the low-frequency cochlear regions that are excited most by infrasound (Liberman et al. 1990, Salt et al. 2009).

#### **4. Exacerbation of Noise Induced Hearing Loss**

Some years ago we performed experiments to test a hypothesis that infrasound was protective against noise damage (Harding et al. 2007). We reasoned that low-frequency biasing would periodically close the mechano-electric transducer channels of the sensory organ (reducing electrical responses as shown in the biasing studies above), and consequently reduce the amount of time that hair cells were exposed to the damaging overstimulation associated with noise exposure. The experimental study found that just the opposite was true. We found that simultaneous presentation of infrasound and loud noise actually exacerbated noise-induced lesions, as compared to when loud noise was presented without infrasound. Our interpretation was that low-frequency sound produced an intermixing of fluids (endolymph and perilymph) at the sites of hair cell loss resulting in lesions that were larger. A possibility to be considered is therefore that long-term exposure to infrasound from wind turbines could exacerbate presbycusis and noise-induced hearing loss. Because these forms of hearing loss develop and progress slowly over decades, this could be a lurking consequence to human exposures to infrasound that will take years to become apparent.

#### **5. Infrasound Stimulation of the Vestibular Sense Organs**

Recent exchanges in this journal between Drs. Leventhall and Schomer concerning the direct stimulation of vestibular receptors by sound at low and infrasonic frequencies deserve comment. Dr. Leventhall asserts that both Drs. Schomer and Pierpont are incorrect in suggesting that wind turbine infrasound could stimulate vestibular receptors, citing work by Todd in which the ear's sensitivity was measured in response to mechanical low-frequency stimulation applied by bone

conduction. Leventhall fails to make clear that there are no studies reporting either vestibular responses, or the absence of vestibular responses, to acoustically-delivered infrasound. This means that for all his strong assertions, Leventhall cannot refer to any study conclusively demonstrating that vestibular receptors of the ear do *not* respond to infrasound. Numerous studies have reported measurements of saccular and utricular responses to audible sound. Indeed, such measurements are the basis of clinical tests of saccular and utricular function through the VEMP (vestibular-evoked myogenic potentials). Some of these studies have shown that sensitivity to acoustic stimulation initially declines as frequency is lowered. On the other hand, *in vitro* experiments demonstrate that vestibular hair cells are maximally sensitive to infrasonic frequencies (~1 – 10 Hz). Thus, sensitivity to acoustic stimulation may increase as stimulus frequency is lowered into the infrasonic range. Direct *in vivo* vestibular excitation therefore remains a possibility until it has been shown that the saccule and other vestibular receptors specifically do not respond to this stimulation.

Low-frequency tone-induced endolymph hydrops, as discussed above, could increase the amount of saccular stimulation by acoustic input. Hydrops causes the compliant saccular membrane to expand, in many cases to the point where it directly contacts the stapes footplate. This was the basis of the now superseded “tack” procedure for Ménière's disease, in which a sharp prosthesis was implanted in the stapes footplate to perforate the enlarging saccule (Schuknecht et al., 1970). When the saccule is enlarged, vibrations will be applied to endolymph, not perilymph, potentially making acoustic stimulation of the receptor more effective. There may also be certain clinical groups whose vestibular systems are hypersensitive to very low-frequency sound and infrasound stimulation. For example, it is known that patients with superior canal dehiscence syndrome are made dizzy by acoustic stimulation. Subclinical groups with mild or incomplete dehiscence could exist in which vestibular organs are more sensitive to low frequency sounds than the general population.

**“For years, they have sheltered behind the mantra, now shown to be false, that has been presented repeatedly in many forms such as ‘What you can’t hear, can’t affect you.’”**

#### **6. Potential Protective Therapy Against Infrasound**

A commonly-used clinical treatment could potentially solve the problem of clinical sensitivity to infrasound. Tympanostomy tubes are small rubber “grommets” placed in a myringotomy (small incision) in the tympanic membrane (eardrum) to keep the perforation open. They are routinely used in children to treat middle ear disease and have been used successfully to treat cases of Ménière’s disease. Placement of tympanostomy tubes is a straightforward office procedure. Although tympanostomy tubes have negligible influence on hearing in speech frequencies, they drastically attenuate sensitivity to low frequency sounds (Voss et al., 2001) by allowing pressure to equilibrate between the ear canal and the middle ear. The effective level of infrasound reaching the inner ear could be reduced by 40 dB or more by this treatment. Tympanostomy tubes are not permanent but typically extrude themselves after a period of months, or can be removed by the physician. No one has ever evaluated whether tympanostomy tubes alleviate the symptoms of those living near wind turbines. From the patient’s perspective, this may be preferable to moving out of their homes or using medical treatments for vertigo, nausea, and/or sleep disturbance. The results of such treatment, whether positive, negative, would likely have considerable scientific influence on the wind turbine noise debate.

#### **Conclusions and Concerns**

We have described multiple ways in which infrasound and low-frequency sounds could affect the car and give rise to the symptoms that some people living near wind turbines report. If, in time, the symptoms of those living near the turbines are demonstrated to have a physiological basis, it will become apparent that the years of assertions from the wind industry’s acousticians that “what you can’t hear can’t affect you” or that symptoms are psychosomatic or a nocebo effect was a great injustice. The current highly-polarized situation has arisen

because our understanding of the consequences of long-term infrasound stimulation remains at a very primitive level. Based on well-established principles of the physiology of the ear and how it responds to very low-frequency sounds, there is ample justification to take this problem more seriously than it has been to date. There are many important scientific issues that can only be resolved through careful and objective research. Although infrasound generation in the laboratory is technically difficult, some research groups are already in the process of designing the required equipment to perform controlled experiments in humans.

One area of concern is the role that some acousticians and societies of acousticians have played. The primary role of acousticians should be to protect and serve society from negative influences of noise exposure. In the case of wind turbine noise, it appears that many have been failing in that role. For years, they have sheltered behind the mantra, now shown to be false, that has been presented repeatedly in many forms such as “What you can’t hear, can’t affect you.”; “If you cannot hear a sound you cannot perceive it in other ways and it does not affect you.”; “Infrasound from wind turbines is below the audible threshold and of no consequence.”; “Infrasound is negligible from this type of turbine.”; “I can state categorically that there is no significant infrasound from current designs of wind turbines.” All of these statements assume that hearing, derived from low-frequency-insensitive IHC responses, is the only mechanism by which low frequency sound can affect the body. We know this assumption is false and blame its origin on a lack of detailed understanding of the physiology of the ear.

Another concern that must be dealt with is the development of wind turbine noise measurements that have clinical relevance. The use of A-weighting must be reassessed as it is based on insensitive, IHC-mediated hearing and grossly misrepresents inner ear stimulation generated by the noise. In the scientific domain, A-weighting sound measurements would be

unacceptable when many elements of the ear exhibit a higher sensitivity than hearing. The wind industry should be held to the same high standards. Full-spectrum monitoring, which has been adopted in some reports, is essential.

In the coming years, as we experiment to better understand the effects of prolonged low-frequency sound on humans, it will be possible to reassess the roles played by acousticians and professional groups who partner with the wind industry. Given the present evidence, it seems risky at best to continue the current gamble that infrasound stimulation of the ear stays confined to the ear and has no other effects on the body. For this to be true, all the mechanisms we have outlined (low-frequency-induced amplitude modulation, low frequency sound-induced endolymph volume changes, infrasound stimulation of type II afferent nerves, infrasound exacerbation of noise-induced damage and direct infrasound stimulation of vestibular organs) would have to be insignificant. We know this is highly unlikely and we anticipate novel findings in the coming years that will influence the debate.

From our perspective, based on our knowledge of the physiology of the ear, we agree with the insight of Nancy Timmerman that the time has come to "acknowledge the problem and work to eliminate it".

## Biosketches



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# Wind turbines and adverse health effects: Applying Bradford Hill's criteria for causation

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## Abstract

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.

**Keywords:** Adverse health effects, Bradford Hill criteria, evidence of causation, industrial wind turbines


## INTRODUCTION

Proof of causation typically requires the rigor of a scientific standard. Consequently, the evidence required

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Submitted: 06-Aug-2021,      Revised: 22-Sep-2021,  
Accepted: 24-Sep-2021,      Published: 23-Oct-2021

Quick Response Code:		Access this article online	
		<a href="http://www.environmentalmed.org">www.environmentalmed.org</a>	
DOI:		10.4103/ed.ed_16_21	

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**How to cite this article:** Dumbrille A, McMurtry RY, Krogh CM. Wind turbines and adverse health effects: Applying Bradford Hill's criteria for causation. *Environ Dis* 2021;6:65-87.

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to make a scientific determination about causality has a higher standard than the Precautionary Principle that is recommended by the World Health Organization (WHO).<sup>[1]</sup> 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<sup>[2]</sup> and have been

experimental conditions, with a 1-week interval between experiments. Test conditions were 30 min exposure to either 110 dB tone, a boiler noise filtered in 1/3 octave band centered on 10 Hz at 105 dB, or no sound stimulus. There were significant increases in anxiety measures in the 110 dB tone group and an increase in body vibration (especially head, ears, and neck) and annoyance. The boiler group experienced similar sensations. There were no significant differences in physiological variables between the control or test groups.<sup>[155]</sup>

Additional examples of clinical studies are included in Appendix 2. They include examination of effects of noise with the acoustical characteristics of wind turbine noise on sleep disturbance,<sup>[156,157]</sup> annoyance,<sup>[158]</sup> and other AHE.<sup>[159,160]</sup> Some studies found no association with complaints and proximity to wind turbines. For example, a Polish study by Mroczek *et al.* found that proximity of wind farms did not result in the worsening of the quality of life using the Norwegian version of the SF-36 general health questionnaire and the visual analog scale. The authors commented that the results may indicate the influence of other contributors such as economic factors that were not taken into consideration during the analysis.<sup>[161]</sup>

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,<sup>[162]</sup> pigs,<sup>[163]</sup> LFN: chick embryo,<sup>[164]</sup> and high-frequency vibration: rats<sup>[165]</sup> [Appendix 2 for additional AHE: in animals and details].

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.

## DISCUSSION

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.<sup>[6]</sup> 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.”<sup>[6]</sup>

The application of the stringent BH criteria gives compelling evidence that IWTs cause significant health problems in a nontrivial fraction of residents living and working near them. Despite the resources available to Health Canada for the Wind Turbine Noise and Health study, the public was advised that the study would not determine causality. At the same time, the Erickson v. MOE ERT decision states: “*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.*”<sup>[44]</sup> And the results of a review commissioned by the Ministry of Environment in Ontario, Canada stated that the audible sound from wind turbines is expected to result in a nontrivial percentage of persons being highly annoyed, and that the annoyance can be expected to contribute to stress-related health impacts.<sup>[17]</sup> Global research published in peer reviewed journals and conference papers, reports from exposed neighbors, case reports, government hearings, testimony during various judicial and other proceedings, and the almost 6,000 incident reports/complaints documented by the Ontario Ministry of the Environment support the determination of causality. These findings have been repeatedly observed by different persons, in different places, and under different circumstances and times. The thousands of adverse event reports by residents, alone, provide strong evidence for a causal relationship and acknowledgment of the seriousness of the problems. It has been argued that the adverse event reports are under-appreciated as a source of evidence and are more compelling than the formal studies because of the following: sheer volume, the similarity of health problems across reports and countries, the fact that individuals are capable of recognizing both the exposure and outcomes, and the fact that relief occurs upon relocating or when staying somewhere other than the subject's own home.<sup>[5,36,67,71,166]</sup> The reports are consistent with controlled

studies and other systematically-gathered data. Many of the published adverse event reports include those with rigorously documented case crossover observations and experiments. These factors move the collective evidence beyond plausible doubt.

Most reports describe a core list of symptoms, such as those observed by Harry, 2007 and Piepont, 2009.<sup>[164,166]</sup> The range of symptoms commonly reported by individuals is consistent globally, and includes sleep disorders, headaches, mood disorders, inability to concentrate, tinnitus, effects on vestibular (balance) and heart, and vibratory sensations. In some cases, there is variable expression and latency of symptoms in different people. A number of plausible causes have been proposed such as amplitude modulation; lack of night time abatement; audible LFN; inaudible LFN/infrasound; tonal noise; electrical pollution/stray voltage; and visual impacts such as shadow flicker and flashing lights.

People with vestibular sensitivities may have a predisposition to AHE, but the effects go beyond a few rare individuals who are extremely susceptible.

Neither the frequency of events nor the safe distance from turbines can be defined with certainty. Case reports are not all publically available and typically do not provide information regarding how many people experienced events but did not report them. Studies indicate that serious health effects occur in between 5% and 10%.<sup>[118,167]</sup> and up to 20% of exposed individuals.<sup>[168]</sup> Most studies report an even greater number of individuals suffer from the health effects of noise annoyance and sleep disturbance. Typically, there is an increase in the number of incident reports from those living nearer to the IWTs.

Although some may consider annoyance insignificant, an increased health risk from chronic noise annoyance has been acknowledged as a health/AHE.<sup>[169,170,169]</sup> The Superior Health Council of Belgium 2013 commented that annoyance and disturbed sleep can lead to “undue stress, which may adversely affect the health and well-being of those concerned.”<sup>[119]</sup> WHO-related research acknowledged an increased health risk from chronic noise annoyance: The LARES study states that a central effect of noise is annoyance and concluded that the result “confirms the thesis that for chronically strong annoyance a causal chain exists between the three steps: health-strong annoyance-increased morbidity.”<sup>[171]</sup> LARES also concluded that the “results of the LARES study – with regard to criteria for causal relations – confirmed, on an epidemiological level, an increased health risk from chronic noise annoyance.”<sup>[171]</sup>

The WHO states “Noise is an underestimated threat that can cause a number of short-and long-term health problems.”<sup>[172]</sup> Among these problems are “sleep disturbance, cardiovascular effects, poorer work or school performance, hearing impairment including tinnitus, aberrations in social behavior such as aggressiveness and passivity, pain and hearing fatigue, speech problems, and hormonal responses (stress hormones) and their consequences on human metabolism, and immune system problems.”<sup>[172,173]</sup> These effects are similar to those reported by those living near wind turbines. The WHO also cites sleep disturbance from environmental noise at 40 dBA as having health impacts.<sup>[177]</sup>

The placement of IWTs near family homes and noise compliance monitoring is typically based on predictive noise modeling measured in dBA.<sup>[169,174,176]</sup> The WHO indicates that the “yearly average of night noise level outside at the façade” can be used as a noise indicator,<sup>[174]</sup> resulting in peak levels not being measured. In some cases, even the average sound levels are exceeded at some residences located near IWTs. The use of dBA does not include low-frequency audible noise (20–200 Hz) and inaudible infrasound (0–20 Hz) emitted by IWTs, yet wind turbines were known to emit lower frequency sound and vibration energy decades ago.<sup>[176,178]</sup> LFN has been shown to cause physiological effects (e.g., to the cochleo-vestibular system in animals). In 2004, LFN was reported as a recognized “special environmental noise problem,” especially for sensitive people residing in their homes, and that the A-weighted level is very inadequate in that it underestimates annoyance for frequencies below about 200 Hz.<sup>[177]</sup> There is evidence that wind turbines generate low-frequency sound and vibration energy, resulting in reports of the occurrence of adverse effects.<sup>[172,173,182,180,106,179]</sup> More recently, Basner *et al.* emphasized that “non-auditory health effects of environmental noise are manifold, serious and, because of the widespread exposure, very prevalent,” and commented that noise levels from different noise sources cannot be merged into one indicator of decibels.<sup>[179]</sup> Cooper explained the variation in identified audible noise when wind turbines are operating, which was found to be a modulation of the amplitude occurring at a blade pass frequency. An amplitude modulated signal is associated with the output speed of the gearbox being modulated at the blade pass frequency. The level of the true amplitude modulation does not affect the overall A-weighted level so is not generally measured; the modulation is related to LFN.<sup>[181]</sup>

As reliance on dBA lacks measurements of the variable IWT-audible/inaudible tonal and amplitude modulation noise emissions, there is a lack of consideration of risks

of sleep disturbance and AHE in sensitive individuals. As concluded by Pedersen and Wøye, there is a need to consider the unique environment when planning a new IWT project in order to avoid AHE.<sup>199</sup> This includes effects of emissions from off-shore turbines, as LFN is readily propagated above water and through it.

To date, no large-scale epidemiological studies have focused on the health effects of long-term exposure to infrasound and LFN produced specifically by wind turbines. To strengthen the understanding of the health effects and validate our conclusions of causation, long-term studies are required that are performed in the field using actual non-averaged-audible and inaudible noise levels, as well as EMF/RF energy. Ideally, these should be large-scale, controlled, and blinded “on-off” studies involving all age groups. Measurement of LFN, EMF, and other potential emissions out to a distance that exceeds the travel of those emissions would aid in determining the cause of the effects.

## CONCLUSION

Incontrovertible proof of causation has tended to be an elusive goal. The debate of determining causality associated with placing IWTs near family homes is similar to past controversies around the debate of causality from the use of tobacco products and from worker exposures to asbestos and coal. The “best available evidence” is the current standard, and it is our contention that the Bradford Hill criteria are that standard.

Based on our analysis of clinical, biological, and experimental evidence and its concordance with the nine BH criteria, we conclude that there is a high probability that emissions from IWTs, including infrasound and LFN, result in serious harm to health in susceptible individuals living and/or working in their proximity. These effects can be attributed to IWT-related events such as recurring sleep disturbance, anxiety and stress, and likely others.

With the growing weight of evidence indicating this causation and the rapid proliferation of IWT installations globally, preventative actions should be taken, and policies implemented that are more cautiously protective of public health, safety, and welfare rather than wait for absolute certainty. More stringent regulation is needed to recognize, monitor, analyze, and document effects on the health of local residents and animals. Of concern is the lack of determination of the safe exposure cumulative dose of noise, including LFN and infrasound, for adults, the elderly, and particularly for fetuses and young children. There are no evidence-based guidelines for setbacks

of IWT; rather regulations have a wide variance across jurisdictions. The concern is compounded by the lack of centralized vigilance monitoring for those who have constant, long-term exposure while living in their homes. Our findings provide compelling evidence that there is a pressing need for risk assessment before deployment of IWT into rural community settings that consider more effective and precautionary setback distances. A margin of safety sufficient to prevent pathogenic LFN from being detected by the human vestibular system is paramount before proceeding with political or economic policies.

As written by Hill: “All scientific work is incomplete—whether it be observations 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.”<sup>191</sup>

## Acknowledgments

We acknowledge the editorial contributions of Dr. Susan Cole and Les Stanfield.

## Financial support and sponsorship

Nil.

## Conflicts of interest

There are no conflicts of interest.

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## On infrasound generated by wind farms and its propagation in low-altitude tropospheric waveguides

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**Key Points:**

- Wind turbines interact with the atmosphere and produce infrasound
- Wind-farm infrasound can propagate long distances
- Wind-farm infrasound could be used to probe the lower atmosphere

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**Citation:**  
Marillo, O. S., Arrowsmith, P., Blom, and Jones (2015), On infrasound generated by wind farms and its propagation in low-altitude tropospheric waveguides, *J. Geophys. Res. Atmos.*, 120, 9855–9868, doi:10.1002/2014JD022821.

Received 6 NOV 2014  
Accepted 18 AUG 2015  
Accepted article online 21 AUG 2015  
Published online 3 OCT 2015

**Abstract** Infrasound from a 60-turbine wind farm was found to propagate to distances up to 90 km under nighttime atmospheric conditions. Four infrasound sensor arrays were deployed in central New Mexico in February 2014; three of these arrays captured infrasound from a large wind farm. The arrays were in a linear configuration oriented southeast with 13, 54, 90, and 126 km radial distances and azimuths of 166°, 119°, 113°, and 111° from the 60 1.6 MW turbine Red Mesa Wind Farm, Laguna Pueblo, New Mexico, USA. Peaks at a fundamental frequency slightly below 0.9 Hz and its harmonics characterize the spectrum of the detected infrasound. The generation of this signal is linked to the interaction of the blades, flow gradients, and the supporting tower. The production of wind-farm sound, its propagation, and detection at long distances can be related to the characteristics of the atmospheric boundary layer. First, under stable conditions, mostly occurring at night, winds are highly stratified, which enhances the production of thickness sound and the modulation of other higher-frequency wind turbine sounds. Second, nocturnal atmospheric conditions can create low-altitude waveguides (with altitudes on the order of hundreds of meters) allowing long-distance propagation. Third, night and early morning hours are characterized by reduced background atmospheric noise that enhances signal detectability. This work describes the characteristics of the infrasound from a quasi-continuous source with the potential for long-range propagation that could be used to monitor the lower part of the atmospheric boundary layer.

### 1. Introduction

Significant efforts have been made to study and characterize the sound from wind turbines (WTs) [Hubbard and Shepherd, 1991; Doolan *et al.*, 2012] as sound production may be linked to turbine performance and also as sound may annoy nearby residents [Møller and Pedersen, 2011; O'Neal *et al.*, 2011]. The study of wind-farm (WF) sound is especially important considering the increase in the number and size of WFs and individual turbines installed worldwide. Furthermore, there are concerns of the effect of large WFs on the dynamics of the atmosphere from local [Baidya Roy *et al.*, 2004] to global scales [Keith *et al.*, 2004; Kirk-Davidoff and Keith, 2008]. At local scales, the characterization of the interaction of the atmospheric boundary layer (ABL) flow with WFs has important implications for the design and operation of WFs [Porté-Agel *et al.*, 2014] with respect to energy conversion efficiency.

In terms of sound generation and propagation, the conditions of the atmosphere drive turbine's operation and determine sound propagation. WTs produce sound in the audible and infrasonic (<20 Hz) bands. Infrasound displays low atmospheric attenuation and dispersion and has the potential for long-range propagation, hundreds to thousands of kilometers [Drob *et al.*, 2003]. The propagation and detection of WF infrasound at large distances (tens of kilometers) require specific conditions to be met: (1) the infrasonic signal to be above background noise levels and (2) the formation of a waveguide to contain the infrasonic energy. This work starts by providing an overview of the operation of modern WTs, the generation of aerodynamic sound, and its interaction with the ABL.

#### 1.1. Wind-Farm Sound and the Atmospheric Boundary Layer

##### 1.1.1. Wind Turbine Operation

WTs capture kinetic energy from the atmospheric wind to produce electric energy. The central aerodynamic component of WTs is the rotor, which is composed of a hub and one or more blades. The blade length, the chord (line between leading and trailing edges), the pitch angle (angle between blade chord and the rotor

rotational plane), and the angle of attack ( $\alpha$ , angle between the incoming wind and the chord) can describe the blade's geometry. WTs have different geometries (e.g., horizontal or vertical axes, one or more blades with different lengths, and different elevations for the rotor), operational configurations (e.g., fixed or variable rotor angular velocity ( $\omega$ ) and downwind or upwind facing blades), and control mechanisms (e.g., pitch and yaw controls), which are well summarized by *Arturo Soriano et al.* [2013].

Modern WTs have a horizontal axis with three blades oriented upwind and rotate at variable  $\omega$ . By allowing the rotor to rotate at different speeds, depending on the incoming wind speed ( $w$ ), the amount of extracted energy can be maximized as the efficiency of the energy conversion depends on the blade's tip speed ratio,  $\lambda = v_{tip}/w$ , where  $v_{tip} = \omega r$  is the velocity of the blade's tip and  $r$  is the radius of the rotor [Hou, 2013]. Parameter  $\omega$  can change but is kept within limits, which depend on the turbine characteristics and atmospheric conditions, to ensure the safety of the machinery. Parameter  $\omega$  can be controlled by modifying the pitch angle [Mujjadi and Butterfield, 2001]. Maximum, minimum, and rated wind speeds ( $w_{rmax}$ ,  $w_{rmin}$ , and  $w_r$ , respectively) are defined for the operation of WTs with variable  $\omega$ , which can operate in four different states: (1) if  $w_{rmin} < w < w_r$ ,  $\omega$  changes to maximize energy extraction; (2) if  $w_r < w < w_{rmax}$ ,  $\omega$  is kept at rated angular velocity ( $\omega_r$ ) by changing the pitch angle; (3) if  $w < w_{rmin}$ ,  $\omega$  may change but the turbine does not produce energy; and (4) if  $w > w_{rmax}$ , the pitch angle is modified to significantly slow or stop the rotation of the blades, the turbine does not produce energy. WTs are designed to operate at state 2 as long as possible so the rated output power is attained for the maximum amount of time.

### 1.1.2. Wind Turbine Sound

WTs produce mechanical and aerodynamic sounds that can be audible and/or infrasonic. Three atmosphere-turbine interactions are important for the generation of aerodynamic wind turbine sound: (1) blade and airflow gradients (thickness sound), (2) blade and inflow turbulence, and (3) turbulent boundary layer and trailing edge. *Hubbard and Shepherd* [1991] provide a comprehensive study of these interactions and show that radiation patterns for WF sound have typically the highest intensity in the upwind and downwind directions.

#### 1.1.2.1. Thickness Sound

As a blade rotates it encounters flow gradients (e.g., the wake of the supporting tower for downwind rotors or low wind speed due to highly stratified wind profiles) that create abrupt changes in lift and drag that produce sound [Hubbard and Shepherd, 1991] (also known as thickness sound (TS) [van den Berg, 2005]). TS is characterized by energy peaks at the blade-passing frequency  $f_{TS}$  and its harmonics.

$$f_{TS} = N \frac{\omega}{2\pi}, \quad (1)$$

where  $N$  is the number of blades. As short pulses produce this type of sound, harmonics of this main frequency are usually observed. *Jung et al.* [2008] describe the observations of TS ( $f_{TS} = 0.863$  Hz and  $\omega = 1.806$  rad/s or 17.3 revolutions per minute (rpm)) from a 1.5 MW turbine at short distance (98 m) where up to the eighth harmonic was observed.

#### 1.1.2.2. Inflow Turbulence Sound

The interaction of the turbine blades with turbulence embedded in the airflow produces rapid changes in the blade load that creates sound. The presence of this type of noise depends on the relative size of the turbulence compare to the blade, and it is nonperiodic. This type of sound has broadband spectrum with peak amplitude at [Grosveld, 1985]

$$f_{IF} = \frac{St0.7r\omega}{H - 0.7r}, \quad (2)$$

where  $H$  is the turbine height,  $r$  is the blade length, and  $St (= 16.6)$  is the Strouhal number. *Hubbard and Shepherd* [1990] show complete frequency spectra for inflow turbulence sound for WTs with different blade lengths recorded few hundreds of meters from the source.

#### 1.1.2.3. Trailing Edge Sound

The turbulent boundary layer on the surface of a blade generates pressure fluctuations that are scattered by the trailing edge and produce broadband sound. The energy for this broadband sound is centered above the infrasound band and accounts for most of the audible energy radiated by modern WTs

construction of a more general equation (4) (e.g., pulses with different amplitudes and slightly different  $f_s$ ) and its estimation for WFs with a large number of turbines.

We have described and analyzed the characteristics of a quasi-continuous source of infrasound with the potential for propagation at distances in the order of several tens of kilometers. As WFs become larger, WTs also increase in size, shifting their aerodynamic noise to lower frequencies. This additional source of low-frequency background noise may affect the detection and location capabilities for infrasound arrays sitting near large WF deployments. For example, 157US (Pirion Flat, CA) is an installation of the International Monitoring System that sits approximately 35 km from a large wind-farm development (San Geronio Pass Site). It is possible that the sound from this wind park limits the detection capabilities of the array, especially for low-amplitude signals. However, with the proper characterization of the WF sound, and its propagation, its effects on infrasound records can be reduced. As the location of the source is known and the WF sound can be well characterized, the sound from wind farms can also be used to test the capabilities of infrasound instrumentation under a persistent signal. For example, WF sound could be used to assess detection capabilities of a sensor array or test spatial wind reduction filters with a persistent source under different atmospheric conditions.

## 5. Conclusions

We found that under specific atmospheric conditions, especially during the nighttime hours, sound generated by wind farms can propagate distances of several tens of kilometers. This propagation is the result of various interacting factors: (1) stable atmospheric conditions in the atmospheric boundary layer at the wind-farm site create strong wind gradients that enhance the production of wind farm sound with TS characteristics, (2) the stable atmosphere also creates favorable conditions for the generation of sound waveguides in the lower troposphere that allow for propagation of sound, and (3) stable atmospheric conditions at the receiver imply lower atmospheric turbulence and lower atmospheric noise. Increasing detectability, especially for lower-frequency long-propagated signal that start merging into the background noise. We have described and characterized a source of infrasound signal that can propagate distances on the order of tens of kilometers and can be used to study changes in the lower troposphere and also can be used to test infrasound instrumentation such as different array topologies or spatial wind filters under continuously changing conditions.

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## Acknowledgments

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## RESEARCH ARTICLE

10.1002/2014JD022821

## Key Points:

- Wind turbines interact with the atmosphere and produce infrasound
- Wind farm infrasound can propagate long distances
- Wind-farm infrasound could be used to probe the lower atmosphere

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Citation:  
Marcillo, O., S. Arrowsmith, P. Blom, and K. Jones (2015), On infrasound generated by wind farms and its propagation in low-altitude tropospheric waveguides, *J. Geophys. Res. Atmos.*, 120, 9855–9868, doi:10.1002/2014JD022821.

Received 6 NOV 2014

Accepted 18 AUG 2015

Published online 3 OCT 2015

## On infrasound generated by wind farms and its propagation in low-altitude tropospheric waveguides

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**Abstract** Infrasound from a 60-turbine wind farm was found to propagate to distances up to 90 km under nighttime atmospheric conditions. Four infrasound sensor arrays were deployed in central New Mexico in February 2014; three of these arrays captured infrasound from a large wind farm. The arrays were in a linear configuration oriented southeast with 13, 54, 90, and 126 km radial distances and azimuths of 166°, 119°, 113°, and 111° from the 60 1.6 MW turbine Red Mesa Wind Farm, Laguna Pueblo, New Mexico, USA. Peaks at a fundamental frequency slightly below 0.9 Hz and its harmonics characterize the spectrum of the detected infrasound. The generation of this signal is linked to the interaction of the blades, flow gradients, and the supporting tower. The production of wind-farm sound, its propagation, and detection at long distances can be related to the characteristics of the atmospheric boundary layer. First, under stable conditions, mostly occurring at night, winds are highly stratified, which enhances the production of thickness sound and the modulation of other higher-frequency wind turbine sounds. Second, nocturnal atmospheric conditions can create low-altitude waveguides (with altitudes on the order of hundreds of meters) allowing long-distance propagation. Third, night and early morning hours are characterized by reduced background atmospheric noise that enhances signal detectability. This work describes the characteristics of the infrasound from a quasi-continuous source with the potential for long-range propagation that could be used to monitor the lower part of the atmospheric boundary layer.

### 1. Introduction

Significant efforts have been made to study and characterize the sound from wind turbines (WTs) [Hubbard and Shepherd, 1991; Doolan *et al.*, 2012] as sound production may be linked to turbine performance and also as sound may annoy nearby residents [Møller and Pedersen, 2011; O'Neal *et al.*, 2011]. The study of wind-farm (WF) sound is especially important considering the increase in the number and size of WFs and individual turbines installed worldwide. Furthermore, there are concerns of the effect of large WFs on the dynamics of the atmosphere from local [Baidya Roy *et al.*, 2004] to global scales [Keith *et al.*, 2004; Kirk-Davidoff and Keith, 2008]. At local scales, the characterization of the interaction of the atmospheric boundary layer (ABL) flow with WTs has important implications for the design and operation of WFs [Porté-Agel *et al.*, 2014] with respect to energy conversion efficiency.

In terms of sound generation and propagation, the conditions of the atmosphere drive turbine's operation and determine sound propagation. WTs produce sound in the audible and infrasonic (<20 Hz) bands. Infrasound displays low atmospheric attenuation and dispersion and has the potential for long-range propagation, hundreds to thousands of kilometers [Drob *et al.*, 2003]. The propagation and detection of WF infrasound at large distances (tens of kilometers) require specific conditions to be met: (1) the infrasonic signal to be above background noise levels and (2) the formation of a waveguide to contain the infrasonic energy. This work starts by providing an overview of the operation of modern WTs, the generation of aerodynamic sound, and its interaction with the ABL.

#### 1.1. Wind-Farm Sound and the Atmospheric Boundary Layer

##### 1.1.1. Wind Turbine Operation

WTs capture kinetic energy from the atmospheric wind to produce electric energy. The central aerodynamic component of WTs is the rotor, which is composed of a hub and one or more blades. The blade length, the chord (line between leading and trailing edges), the pitch angle (angle between blade chord and the rotor

construction of a more general equation (4) (e.g., pulses with different amplitudes and slightly different  $f_s$ ) and its estimation for WFs with a large number of turbines.

We have described and analyzed the characteristics of a quasi-continuous source of infrasound with the potential for propagation at distances in the order of several tens of kilometers. As WFs become larger, WFs also increase in size, shifting their aerodynamic noise to lower frequencies. This additional source of low-frequency background noise may affect the detection and location capabilities for infrasound arrays siting near large WF deployments. For example, 157US (Pirion Flat, CA) is an installation of the International Monitoring System that sits approximately 35 km from a large wind-farm development (San Geronio Pass Site). It is possible that the sound from this wind park limits the detection capabilities of the array, especially for low-amplitude signals. However, with the proper characterization of the WF sound, and its propagation, its effects on infrasound records can be reduced. As the location of the source is known and the WF sound can be well characterized, the sound from wind farms can also be used to test the capabilities of infrasound instrumentation under a persistent signal. For example, WF sound could be used to assess detection capabilities of a sensor array or test spatial wind reduction filters with a persistent source under different atmospheric conditions.

## 5. Conclusions

We found that under specific atmospheric conditions, especially during the nighttime hours, sound generated by wind farms can propagate distances of several tens of kilometers. This propagation is the result of various interacting factors: (1) stable atmospheric conditions in the atmospheric boundary layer at the wind-farm site create strong wind gradients that enhance the production of wind farm sound with TS characteristics; (2) the stable atmosphere also creates favorable conditions for the generation of sound waveguides in the lower troposphere that allow for propagation of sound; and (3) stable atmospheric conditions at the receiver imply lower atmospheric turbulence and lower atmospheric noise. Increasing detectability, especially for lower-frequency long-propagated signal that start merging into the background noise. We have described and characterized a source of infrasound signal that can propagate distances on the order of tens of kilometers and can be used to study changes in the lower troposphere and also can be used to test infrasound instrumentation such as different array topologies or spatial wind filters under continuously changing conditions.

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# Preliminary Results: Exploring Why Some Families Living in Proximity to Wind Turbine Facilities Contemplate Vacating Their Homes—A Community-Based Study

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**How to cite this paper:** Krogh, C.M., McMurtry, R.Y., Dumbille, A., Hughes, D. and Gillis, L. (2020) Preliminary Results: Exploring Why Some Families Living in Proximity to Wind Turbine Facilities Contemplate Vacating Their Homes—A Community-Based Study. *Open Access Library Journal* 7: e6118.  
<https://doi.org/10.4236/oalib.1106118>

**Received:** January 29, 2020

**Accepted:** February 18, 2020

**Published:** February 21, 2020

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## Abstract

In Ontario, Canada, between 2006 and the end of 2016, government records provided by the former Ontario Ministry of Environment and Climate Change documented that neighbors living near industrial wind turbine (IWT) facilities filed 4574 noise complaints/incident reports. In some cases, these records also included occurrences of adverse health effects being experienced by some of those living near the IWT facilities [1]. The risk of harm associated with living near IWT energy facilities is controversial and reported globally [1] [2] [3] [4]. Some families have been billeted by, or negotiated financial agreements with wind energy developers [2], and some took the step to vacate/abandon their homes [2] [3] [4] while others have felt forced to do so [3] [4]. While the action of vacating/abandoning a family home is internationally reported [1] [2] [3] [4] research about these occurrences is limited. Utilizing the Grounded Theory (GT) methodology, an ethics approved community-based study was conducted to investigate these occurrences. Participants in the study included those who had vacated/abandoned their homes in the past, or at the time of the interview were contemplating to do so, or decided to remain. Between October 2017 and January 2018, sixty-seven (n=67) consenting participants were interviewed. This article presents preliminary results which will be augmented by additional submissions to peer reviewed scientific journals for their consideration for publication.

## Subject Areas

Civil Engineering

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## Keywords

Wind Turbines, Grounded Theory, Personal Interviews, Vacated and Abandoned Homes, Adverse Health Effects

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## 1. Objectives and Methods

### 1.1. The Research Questions

To gain an understanding of why some families living in proximity to an IWT facility contemplated vacating their homes, several research questions were identified:

- 1) *What are the particular circumstances which influenced whether to vacate or not vacate a family home?*
- 2) *How did families arrive at their decision?*
- 3) *Were there consequences related to their decision?*
- 4) *Did these circumstances influence physical, mental and social well-being?*

### 1.2. Study Objectives

The objectives of the study were to:

- 1) Explore the events which influenced families living within 10 km from industrial wind energy facilities to vacate/abandon their homes, contemplating to do so, or remain in their homes;
- 2) Gain an understanding of the outcomes related to these housing decisions; and
- 3) Generate a substantive theory associated with the vacated/abandoned home topic.

### 1.3. The Grounded Theory Methodology

The study employed a qualitative research methodology—specifically the Grounded Theory (GT) approach which included the four-phase process proposed by Casillo-Montoya, 2016:

- 1) Ensuring interview questions align with research questions;
- 2) Constructing an inquiry-based conversation;
- 3) Receiving feedback on interview protocols, and
- 4) Piloting the interview protocol [5].

Before proceeding with the study, the four-phase process was reviewed and incorporated into the vacated home study design.

The following is a brief overview of the methodology employed. This overview will be expanded in a subsequent article.

## 2. Methods Overview

The ethics approval process included provisions such as: the invitation to participate; participant inclusions/exclusions; materials such as the informed consent process including descriptions of the study's purpose and risk/benefits, details relating to the personal (face-to-face) interview, the study process, data own-

ership and protection of the confidentiality of personal information. Participants were also advised at any time, even if they had signed a consent form, they could decline to answer any question and could change their mind and withdraw participation in the study. If the family did not wish to continue participating in the study, all collected data would be immediately destroyed. Once these points were explained to participants, the consent form was signed by the participants and the interviewer. Both participants and interviewers received a signed copy for their records prior to conducting the interview.

In addition to the requirement to ensure participants were fully informed prior to their participation, they were advised of the intention to submit one or more articles for publication in peer reviewed scientific journals.

If consent were given by the participant(s), the interviewer recorded the interview and a DVD copy was provided to the participant(s) at the conclusion of the interview. In the absence of consent for the audio recording, it was intended the interviewer would take detailed notes; however, all participants consented to the interview being recorded.

Audio files were transcribed to text files by a transcription service (<https://gotranscript.com/>). NVivo 12 software for qualitative research was leveraged to facilitate coding and data analysis (<http://www.qsrinternational.com>).

Trained interviewers conducted face-to-face interviews with few exceptions. Due to weather conditions, travel distances and schedules, a few interviews were conducted by telephone.

A brief questionnaire collected background and demographic information. With the completion of the questionnaire, depending on the whether the participant had vacated their home in the past or was contemplating doing so, the interviewer initiated the discussion by asking:

*Can you discuss the events that led you to decide to vacate your home?*

Or:

*Can you discuss the events that led you to think about vacating your home?*

All collected data were protected and stored in a secure and locked location.

During the tabulation of the collected information, access to all of the collected data including the audio recordings and demographic questionnaires were limited to study investigators.

### **3. Invitation to Participate**

A target of twenty-five (n-25) participants was established. However, due to the interest in this study, within a few weeks of its announcement sixty-seven (n-67) participants volunteered to be interviewed. This represents an exceedance of 272%.

In addition to the 67 participants, 98 (n-98) family members were living in the family homes for a total of 165 (n-165). Some participants indicated concerns that others such as their children, grandchildren, relatives, visitors and guests, had experienced a variety of adverse health effects when in the family home. While these reports have not been specifically tabulated in the study findings, some of these observations will be presented in future articles.

#### 4. Data Analysis

The GT iterative process identified numerous themes and sub-themes which evolved as the interviews progressed. Following the interview of the sixty-seventh participant, theoretical saturation was reached and the invitation to participate was closed.

Research indicates a coding paradigm consisting of 5 elements could assist with data analysis by “suggesting what to look for when coding” [6]. Data analysis indicated a relationship with this coding paradigm. This approach was considered appropriate for the vacated home study and its structure adopted.

**Table 1: Five elements and their application to the vacated/abandoned home study** describes the 5 elements proposed by Rose et al., 2015 and their application to the vacated home study.

Proposed by Rose et al., 2015 <sup>1</sup>		Why some families living in proximity to wind turbine facilities contemplate vacating their homes	
<b>Element 1</b>	The central phenomenon that is the focus of the study.	<b>Element 1</b>	The central phenomenon/event is the siting of an IWT facility within 10 km of rural family homes.
<b>Element 2</b>	The causal conditions that contribute to the phenomenon.	<b>Element 2</b>	The causal conditions are described in the themes and sub-themes such as environmental interference, altered perceptions and living conditions which participants associated with an operational IWT facility within 10 km of their family home.
<b>Element 3</b>	The context in which the phenomenon is embedded.	<b>Element 3</b>	The context is embedded in a government policy with research participants becoming informed and taking action through various processes such as filing complaints and participating in legal/judicial processes.
<b>Element 4</b>	The actions and interactions taken by people in response to the phenomenon.	<b>Element 4</b>	The actions and interactions taken resulted in participants contemplating housing decisions such as vacating/abandoning a family home; contemplating to do so; preemptively vacating; periodically and intermittently vacating; or deciding to remain.
<b>Element 5</b>	The consequences of those actions and interactions.	<b>Element 5</b>	The consequences of these actions and interactions taken in Element 4 include participants' sentiments and expressions of an “aftermath” such as: profound losses; effects related to social justice, rights, personal security; grief, displacement, anger, bitterness, mistrust, stress and anxiety; financial losses and hardship and impact on employment; and effects on relationships.

<sup>1</sup>Susan Rose, Nigel Spinks & Ana Isabel Canhoto, 2015. Chapter 6: Management Research: Applying the principles© 2015. Figure 2. Coding paradigm (adapted from Corbin and Strauss 1990, Strauss and Corbin 1998, Corbin and Strauss 2008).

## 5. Results: Highlights and Outcomes

While the study methodology did not include a structured survey instrument or a research question specific for collecting health symptoms, comments about health arose spontaneously and consistently across participants. This factor was considered by participants as the impetus for decisions on housing choices. Participant data supported that the central phenomenon/event was the siting of an IWT facility within 10 km of rural family homes (*Element 1*) which participants associated with (*Element 2*)—the causal conditions of environmental interference, altered living conditions and adverse health effects or awareness of its potential (n-67). This relationship will be expanded in future articles.

### 5.1. Diagnosed Medical Conditions and Diseases

Some participants voluntarily provided documentation of their medical conditions and diseases which were diagnosed by their physicians and physician specialists. These diagnoses included conditions which existed prior to living near a wind energy facility (*i.e.* a pre-existing condition). While IWT-specific research associated with pre-existing medical and disease conditions is lacking, there was concern that these could potentially be exacerbated by living near IWT facilities. This topic will be discussed in a future article.

### 5.2. Vacated/Abandoned Their Homes in the Past

Twenty-eight (n-28) of the 67 study participants had vacated/abandoned their homes in the past.

#### Example 1

*... they started up the wind turbines around us... As soon as they were all up and running we immediately suffered from sleep disturbance ... it was the loud noise, it was like a whooshing noise you could hear it inside the house and it was vibration which was terrible ... you could hear and feel it.*

#### Example 2

*I had symptoms of electrical sensitivity which I had not experienced that way in the house before. The only thing that had changed in the environment was the turbines going up.*

#### Example 3

*... the first instance was the building of the [location protected] wind turbines ... my whole intestinal tract started to quiver ... As the days and weeks progressed, I found that I was having difficulty with my ears...*

### 5.3. Contemplating to Vacate/Abandon Their Homes

Thirty-one (n-31) of the 67 study participants were contemplating to vacate/abandon their homes.

#### Example 1

*... when it was announced that wind turbines were coming ... I'm concerned about my health and the fact that I developed a condition since the turbines*

started that is related to—what's the term when your body fights against itself—autoimmune disease since the turbine started.

**Example 2**

*Initially, when neighbors decided to put turbines in. Because of my knowledge and my previous studying about the possible health effects, and the effects to animals I already thought before they turned the soil that there may be issues coming ahead, and that was three years ago.*

**Example 3**

*We started having this ringing in our ears, buzzing, like a buzzing noise in our cars ... we had three different electricians come ... one electrician told us, "This is a frequency coming into your home. You need to put a for sale sign up and get out of here."*

#### **5.4. Deciding to Remain**

Four participants (n=4) decided to remain.

**Example 1**

*I know people that have vacated their homes because of the side effects ... If it does become an issue, we certainly would. A health issue or affecting either one of us, we certainly would.*

**Example 2**

*We pulled the plug on building a new home ... That was because as some of the information that I had learned made both my husband and I were wary of building a new home close to wind turbines ...*

#### **5.5. Preemptively Vacated/Abandoned Their Homes**

Four participants (n=4) expressed awareness of the potential risk of adverse health effects and took preemptive action and vacated/abandoned their homes prior to an IWT facility initiating operations.

**Example 1**

*Basically knowing the health issues ... it just solidified it more and more for us then, we just need to move away from all of these. Not just from turbines but from the strafe.*

**Example 2**

*... we became involved in the issues with turbines in the early 2000s more because the turbines were going to be put in around us ... Probably the first real concern was the health issues, some of the things that we had seen.*

#### **5.6. Periodically and/or Intermittently Vacating/Abandoning a Family Home**

As the interviews progressed, the iterative process led to additional findings which participants associated with an operating IWT facility. Comments revealed that some participants intermittently/temporarily vacated their homes to obtain temporary and/or partial relief from the occurrence of adverse health effects.

### 5.6.1. Vacated/Abandoned Their Homes in the Past

#### Example 1

*When I left my home, whether that be for [location protected] in the morning or quite often in the middle of the night, I left my home and then I slept in my vehicle away from the turbines and I would recover from all these symptoms.*

#### Example 2

*Leaving the house four to five nights all the time, sleeping in my vehicle in the cold in the winter. I would be in my vehicle five, six hours during the night away from the turbines by myself.*

#### Example 3

*... we were not permanent residents of our homes. We were constantly leaving when the symptoms and the effects of the wind project on us were so great we didn't stay.*

### 5.6.2. Contemplating to Vacate/Abandon Their Homes

#### Example 1

*We left for three months ... we went away ... just to try it. Just to see what it was like and it did help. Since then, it helped last year, we have a place in [location protected] that we're going to go to get away from the turbines because we just can't stand the turbines.*

#### Example 2

*We've left home many times for the day just because of the noise here ... I remember one morning ... it was shortly after seven in the morning and we left home that day because we couldn't stand it ...*

#### Example 3

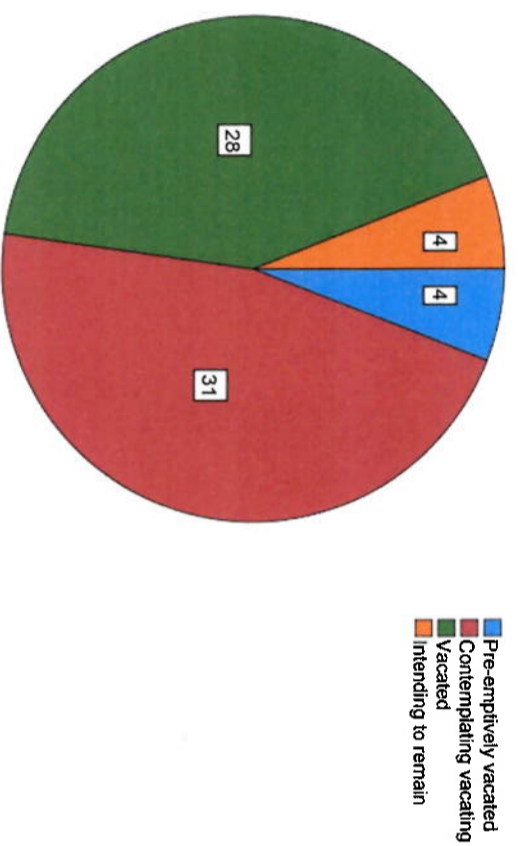
*... one winter was just so bad at times, we just kept going for drives to get out of the house for a bit, just to try to get some relief ...*

The motivation to periodically/intermittently vacate a home will be discussed in a future article.

## 6. Conclusions

Of the 67 (n-67) study participants: 28 (n-28) had vacated/abandoned their home; 31 (n-31) were contemplating to do so; 4 (n-4) preemptively vacated their home before the facility started operating; and 4 (n-4) decided to remain. **Figure 1** illustrates the home status of the 67 participants at the time of the interviews.

Some of the study participants' physicians, including physician specialists diagnosed medical and disease conditions, some of which were diagnosed prior to the presence of an IWT facility, i.e., a pre-existing condition. While IWT-specific research relating to such pre-existing conditions is lacking, some participants expressed concern regarding a potential exacerbation of their symptoms. It is proposed the potential risk factors associated with pre-existing medical/disease conditions should be investigated as soon as possible.



**Figure 1.** Home status at the time of interview.

The iterative interview process led to additional findings which participants associated with the start up of an IWT facility. Some participants from both categories of having vacated a home in the past or contemplating to do so had periodically and intermittently vacated their homes during the day and/or night. Both groups indicated the reason for this was to obtain temporary and/or partial relief from the occurrence of adverse health effects.

Data analysis supports the theory that housing decisions were motivated by the presence of an IWT facility within 10 km of family homes and the participants' observations of an association or a potential risk of adverse health effects.

These preliminary results will be augmented by additional submissions to peer reviewed scientific journals for their consideration for publication. Topics will include results of the data analysis relating to the elements described in [Table 1](#). *Five elements and their application to the vacated/abandoned home study.*

### Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

### Funding

MAGENTICA RESEARCH GROUP.

Not for Profit (Corporations Canada).

Partially funded by private donation.

### Ethics Review

Chesapeake Research Review, LLC ("Chesapeake IRB").

Note: Chesapeake Research Review, LLC ("Chesapeake IRB") and Schulman Associates Institutional Review Board, Inc. ("Schulman IRB") have merged to create Advarra, Inc. ("Advarra IRB").

### Acknowledgements

We wish to acknowledge everyone who participated in this important research and who shared their experiences when living in proximity to wind energy facilities. We thank them for welcoming our interviewees into their homes. Without their participation and their willingness to describe the profound impact on their lives when contemplating vacating a family home, this research would not have taken place. Our research team is honored to have been given the opportunity to bring these findings forward. We thank our interviewees, who volunteered their time and travelled considerable distances in order to conduct the interviews and those who provided the funding to make this study possible.

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## Wind turbine infrasound: Phenomenology and effect on people

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### ARTICLE INFO

#### Keywords:

Infrasound  
Phenomenology  
Wind turbine  
Structural resonance  
Neurological effect

### 1. Introduction

Global efforts to improve sustainability have led to the rapid growth in the use of renewable energy sources such as wind energy (Desimukh et al., 2019). This, in turn, has led to increasing numbers of wind turbines near residences and increasing exposure of the occupants to wind turbine infrasound. There are strongly partisan and contradictory findings on whether this poses a health risk. There are those who believe that since infrasound cannot be heard, it cannot do any damage. However, there is growing international evidence that it annoys some people and that this may lead to long-term health problems. This work provides an interpretive review of the multi-disciplinary research in the fields of acoustic theory, wind turbine noise, structural coupling with infrasound and the role of the central nervous system (CMS) in the human experience (Fig. 1). It provides a new perspective on the way in which wind turbine infrasound interacts with dwellings based on the fundamental properties of the sound waves. It also provides an explanation for why a small proportion of residents have a strong adverse reaction to the persistent, episodic infrasound and proposes a simple mitigation strategy. In doing so, it advances the understanding of wind as an important source of renewable energy.

Airborne sound is a sinusoidal variation in pressure that travels as a longitudinal wave through the air with a particular frequency, wavelength and amplitude. Amplitude is an objective measure of the sound pressure level (SPL) and 'loudness' is the subjective perception of the sound by the ear. The amplitude is extremely small; the average sound from a television has a pressure variation of 0.02 Pa or 20 millionths of the ambient pressure of 101.3 kPa (Le Pichon, Blanc and Hauchecorne,

2010). Perfect hearing is defined as the ability to hear airborne sounds with frequencies ranging from 20 Hz to 20,000 Hz, which corresponds to wavelengths of approximately 17 m to 17 mm respectively. The ear is particularly sensitive to sounds above 100 Hz, so early sound research focused on sounds at the higher end of the frequency spectrum and their associated effect on hearing loss. Sound below 100 to 250 Hz is called low frequency noise (LFN) and sound below about 20 Hz is called infrasound (Baltassas et al. 2016; Mühlhans, 2017). The latter is the focus of this research. There are both natural and anthropogenic sources of infrasound. Natural sources include the eruption of volcanoes, sound produced by large animals (such as whales, elephants and rhinoceroses), thunder, avalanches and ocean waves. Anthropogenic sources include explosions, trains, submarines, machinery (such as compressors, motors and wind turbines) and the vibration of large structures such as bridges. Infrasound has several unique properties that can be broadly categorised as, firstly, phenomenological properties and, secondly, properties relating to its effect on people.

Audible sound becomes uniformly softer with distance, losing energy to the atmosphere and obstacles and dispersing its energy as it expands to larger volumes. This is not quite the case with infrasound, which can get louder over certain distances. Because it is a plane wave, rather than a spherical wave, centred on the source, it does not suffer the geometrical effects of being spread over a volume that increases as the square of the distance. Consequently, the rubric of sound pressure level decreasing with inverse of the square of the distance is approximately true for audible sound but is not true for infrasound. Infrasound has very long wavelengths that do not interact with small objects, and it suffers very little diminution over distance. For example, 1 Hz sound is

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<https://doi.org/10.1016/j.scs.2022.104308>

Received 30 July 2022; Received in revised form 16 October 2022; Accepted 18 November 2022

Available online 19 November 2022

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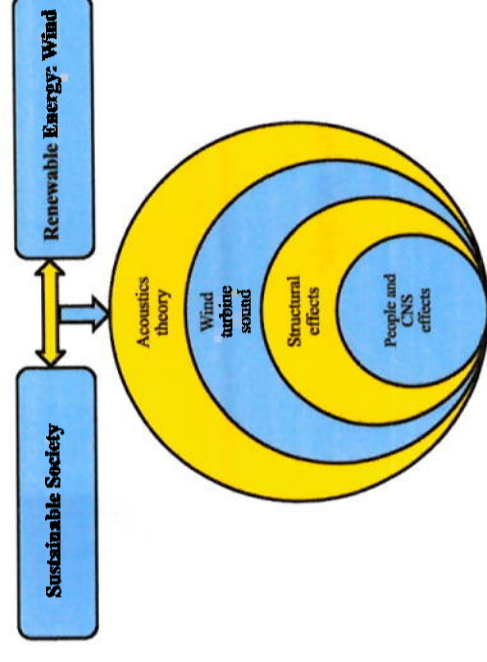


Fig. 1. Research framework: an interpretive inter-disciplinary review on wind energy as an important aspect of a sustainable society.

experimentally measured to be absorbed at 0.003 dB/100 km compared with 100 Hz sound which is absorbed at 30 dB/100 km (McComas et al., 2018). The eruption of Mount Etna in 2016 is a commonly cited example of the persistence of infrasound over long distances; it was detected 1,200 km away with a sound pressure level that was 20% of its value at 5 km away (Bedard and Georges, 2000; Marchetti et al., 2019).

Lightweight structures are capable of responding to infrasound because the natural frequency of vibration of their elements can approach an infrasound frequency (Granzotto, Di Bella, and Piana, 2020). Its energy can therefore be transmitted into sound at harmonics of the dominant infrasound frequencies and can also produce parasitic vibrations in coupled structures. Vardaxis, Bard and Persson Wayne (2018) note that laboratory tests on sound transmission through building elements are not as good as field tests because they do not capture the interaction of the whole building structure in sound propagation. There is an added difficulty in studying the behaviour of infrasound, namely that most standard microphones are not capable of detecting sound frequencies below about 20 Hz, so micro-barometers must be used (CCA, 2015). The transmission of infrasound over large distances is well known and there is a global monitoring system (IMS) which consists of a network of 60 stations using micro-barometer arrays to detect explosions as part of the Comprehensive Nuclear-Test Ban Treaty (CTBT) (Bedard and Georges, 2000; Sutherland and Bass 2004; Le Pichon, Blanc and Hauchecorne, 2010). Another problem is that sound monitoring equipment commonly uses an 'A-rating' process that emphasizes the frequencies to which the human ear is most sensitive. This results in over-weighting 1,000 to 7,000 Hz sound, under-weighting 20 to 1,000 Hz sound and completely filtering out anything below 20 Hz. Despite this, A-rating is still commonly used to measure environmental sound and is the basis for dismissing claims of the presence of infrasound (Boretti, Ordys and Al Zubaidy, 2018).

Reports on the effects of infrasound on people are contradictory, and, in the case of wind turbines, have produced strong partisans. This disagreement is only possible because there is no clear and consistent explanation of the data. This is the second focus in this research. The ear is less sensitive to infrasound than it is to higher frequencies and many researchers believe that 'if the sound cannot be heard, it cannot be harmful' (Zagubien and Wolniewicz, 2020). If this logic were correct, then by analogy infrared light would not be harmful to humans because it is not visible. In fact, infrasound is audible providing it is sufficiently loud (at a high enough sound pressure level) and it can also be sensed by the vestibular system and by cells in the skin as a vibration (CCA, 2015; Møller and Pedersen, 2004; Bahatsas et al., 2016; Mubihans, 2017). Magnetic resonance imaging (MRI) shows activity in the auditory cortex

of people exposed to 8 Hz infrasound at a loudness of 20 phon (Baeza Moyano and Gonzalez Lezcano, 2022; Boretti, Ordys and Al Zubaidy, 2018). There are many reports of infrasound causing physiological and psychological harm to people. Mubihans (2017) provides a very comprehensive review that debunks many common myths about infrasound. The rapid expansion of wind turbine installations has raised concern about the potential health risks to nearby residents (Deshmukh et al., 2019) and the Council of Canadian Academies undertook a comprehensive review of this area (CCA, 2015). The findings of this report are:

- The sound signature from wind turbines is complex; it covers a wide range of frequencies (including infrasound), the outdoor SPLs vary depending on distance, wind speed and wind direction and amplitude modulation can result in low frequency 'swishing' or 'thumping' noises.
- There is evidence that exposure to wind turbine noise causes annoyance. This may be influenced by other factors such as attitude towards wind turbines, economic aspects and visual impacts. Evidence suggests that the infrasound and LFN components of the sound are the most likely cause of long-term annoyance.
- There is limited evidence that exposure to wind turbine noise causes sleep disturbance.
- Exposure to wind turbine noise does not appear to cause hearing loss, stress or other health effects such as tinnitus, vertigo, nausea, cardiovascular diseases, diabetes, etc. It is unclear whether these could be caused by pure annoyance.
- Epidemiological studies have limitations such as inadequate measurements, bias, poor controls and too short an exposure to the sound.

More recent work has confirmed many of these findings. The sound signature from wind turbines is discussed in Section 3.

van Kamp and van den Berg (2018, 2021) provide a detailed review of the literature on the effect of LFN and infrasound from wind turbines on the health of nearby residents, including annoyance, sleep disturbance, cardiovascular disease, metabolic effects, and mental and cognitive impacts. They also consider non-acoustic factors such as the visual impact of wind turbines, people's perceptions and attitudes about wind turbines and their involvement in planning wind turbine farms. They show that annoyance is the most common effect and that the louder the noise, the greater the annoyance. The annoyance may also be increased by visual impacts and by rhythmic pulses on the dwellings. The annoyance itself may be the root of sleep disturbance and other long term health effects. Vardaxis, Bard and Persson Wayne (2018) and Bahatsas et al. (2016) have shown that people are more annoyed by LFN and infrasound, than by higher frequency sounds, and that it may interfere with sleep and concentration. There are also studies showing that some individuals are more sensitive to infrasound than others (Burke, Uppenkamp and Koch, 2020; Jurado and Marquardt, 2020). However, the tests were conducted at much greater loudness levels than are typically present in buildings near wind turbine farms (Zagubien and Wolniewicz, 2020; Baeza Moyano and Gonzalez Lezcano, 2022).

Bahatsas et al. (2016) report that much of the published epidemiological research suffers from poor methodology such as short time exposure to LFN, poor or no control testing and a reliance on subjective data rather than objective medical data. Zagubien and Wolniewicz (2020) discuss the 'nocebo' effect where adverse health symptoms are produced psychosomatically by negative expectations. To eliminate these problems, this research focusses on studies using rats and on studies where responses to infrasound are measured objectively, for example using blood pressure and heart rate readings. The mechanism of the response of the autonomic nervous system (ANS) to infrasound is discussed in Section 4.

One of the most rigorous studies into the effects of wind turbine infrasound on people is reported in Matijala et al. (2021). They studied

two groups of people living near a wind turbine farm. The first group of people, called the 'symptomatic group', reported symptoms of stress that were thought to be caused by wind turbine infrasound. The second group of people, called the 'control group', experienced no discomfort from living near a wind turbine farm. The researchers measured the blood pressure and the heart rate of both groups in a series of tests where recorded and acoustically accurate wind turbine infrasound was randomly interspersed with other sounds and they compared the response with each individual's response to a 3-minute standard cold pressor test. They found no difference in the measured response of the two groups when they were unaware of their exposure to infrasound. However, when the two groups were told that they would be exposed to infrasound, the symptomatic group had a strong stress reaction while the control group had no reaction. The reason for this difference is discussed in the context of the ANS in Section 4.

In summary, this work elucidates the phenomenological behaviour of infrasound in order to provide an explanation for its interaction with the built environment. It then examines the effect of infrasound on the central nervous system in an effort to understand why it causes chronic noise stress in a small number of people. The impact of this work is, firstly, to resolve the controversies that rage around the subject and secondly, to provide a reasonable hope of mitigating a problem that causes severe distress to many people.

## 2. Materials and methods

A systematic literature review was conducted using the three-stage PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) method (Page et al., 2021). The first stage, planning and identification of the initial pool of literature involved the following steps:

- Selecting the initial eligibility criteria, namely, peer-reviewed academic articles, reports and books written in English with a focus on those published since 2012.
- Using Google Scholar and EBSCO Discovery search engines with search terms including a combination of the words infrasound, aperture, attenuation, transmission, buildings, health effect, exposure, central nervous system, autonomic nervous system, noise, wind turbine and soundscape.

In the second stage, the resulting literature was screened to check for relevance to the research themes: phenomenology of infrasound and its interaction with the built environment and the effect of infrasound on the central nervous system. Exclusion criteria were:

- Small studies concerning subjective, anecdotal evidence from small sample sets, and
- Studies on the health effects of exposure to loud noise, and
- Studies on sound above 250 Hz in frequency.

Citations of the remaining literature were used to identify more recent published studies. A total of 58 articles were used (Fig. 2). The final stage was synthesising the literature into the research themes. These are discussed in Sections 3 and 4.

## 3. The phenomenology of infrasound

Infrasound behaves very differently from audible sound; it travels long distances with far less attenuation and has different interactions with buildings. Infrasound from wind turbines is different from other infrasound sources because it is present over long periods of time, is episodic in nature and is becoming more prevalent as the number of wind turbines increases. Therefore, it is important to understand the effect of wind turbine infrasound on people. These aspects are discussed below. Table 1 summarizes the themes and citations for this section.

### 3.1. The behaviour of infrasound waves

At 20 °C, the speed of sound,  $c$ , in air is approximately 343 m/s and the wavelength,  $\lambda$ , and the frequency,  $f$ , are related by Eq. (1):

$$c = f\lambda \quad (1)$$

This means that 1 Hz infrasound has a wavelength of about 343 m while 10,000 Hz which is audible sound has a wavelength of about 34.3 mm. With such disparate wavelengths, it is not surprising that infrasound and audible sound behave differently and need to be treated differently. The spherical wave front of audible sound is curved, while infrasound is found to be planar. In order to capture infrasound, McComas et al. (2018) describe 5-element infrasound arrays placed on a 38 m aperture

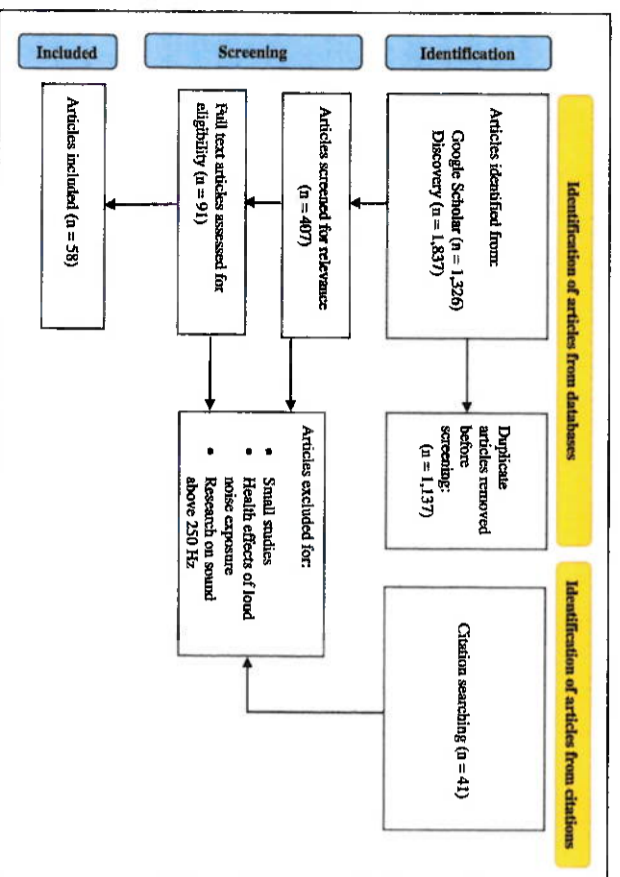


Fig. 2. PRISMA flow diagram of the method. (Source: Page et al., 2021).

**Table 1**  
Review of infrasound phenomenology.

Theme	Citations
Acoustics theory: wave behaviour, propagation, attenuation	Rullmans et al., 2016; Bedard and Georges, 2006; Evans, Bass and Sutherland, 1972; Javeloyes, Pendas-Recondo and Sanchez, 2021; Keith, Daigle and Stinson, 2018; Le Pichon, Blanc and Hauchecorne, 2010; Le Pichon, Ceranna and Vergoz, 2012; Marchetti et al., 2019; Marcellio et al., 2015; McComas et al., 2018; Muthibani, 2017; Nuryantini, Zakwandi, and Ariyuda, 2021; Sutherland and Bass, 2004
Infrasound in the environment: structural interaction, measurement	Babitsas et al., 2016; Bedard and Georges, 2006; Boczar et al., 2022; Boretti, Ordys and Al Zubaidy, 2018; CCA, 2015; Granotto, Di Bella and Piana, 2020; Jakobsen, 2005; Keith, Daigle and Stinson, 2018; Keith et al., 2019; Le Pichon, Blanc and Hauchecorne, 2010; McComas et al., 2018; Sutherland and Bass, 2004; Tounin, 2018; van Kamp and van den Berg, 2018; Vardavas, Bard and Persson Wäve, 2018
Wind turbine: sound signature, factors affecting transmission, amelioration in dwellings	Bertagnollo and Fischer, 2021; Boczar et al., 2022; Blumwiedler et al., 2012; Boretti, Ordys and Al Zubaidy, 2018; CCA, 2015; D'Amico, Van Remmerghem and Botreldocoren, 2022; Iestunukh et al., 2019; Jakobsen, 2005; Keith, Daigle and Stinson, 2018; Marcellio et al., 2015; O'Blund and Larsson, 2015; Okada, Yoshitaka and Hyodo, 2019; Tounin, 2012; Tounin, 2018; Weckendorf et al., 2016

and on a 120 m aperture and provide detail on the signal processing. The sensors are placed, in the horizontal plane, at the centre and on the periphery of a large circle. The diameter of this circle is termed the aperture. Measuring a passing infrasound wave has considerably improved precision if the simultaneous output of several microphones is used, each at a different location. This can also permit the azimuth of the sound source to be determined. Inside buildings, just one microphone is adequate.

When there is a point source of audible sound with power,  $P$ , and no obstructions, the sound spreads out radially from the source and the sound intensity,  $I$ , varies with distance,  $r$ , from the source according to the inverse square law:

$$I = \frac{P}{4\pi r^2} \quad (2)$$

The intensity decreases with distance is called distance attenuation or distance damping and is a conservation of energy effect; energy intensity decreases as the sound waves spread out. It is demonstrated in Nuryantini, Zakwandi and Ariyuda (2021) that Eq. (2) is approximately true over short distances and it assumes that there is no absorption of the sound wave energy (termed dissipation) by the air. This assumption is generally not quite correct; there is also 'classical' attenuation of sound wave energy through atmospheric absorption which is primarily Stokes-Kirchoff energy loss due to viscosity and heat conduction (Evans, Bass and Sutherland, 1972). The latter can be explained in terms of the perfect gas law; sound waves are a succession of pressure fluctuations, which may also be viewed as a succession of temperature fluctuations. High pressure regions have higher air particle collisions and are therefore regions of higher temperature. For a 10,000 Hz sound wave the temperature extremes occur over about 17 millimetres so that thermal conduction is more rapid and the wave energy dissipates more quickly than for lower frequencies. For a 1 Hz wave, the temperature extremes occur over about 172 metres so heat conduction in the air is relatively

small, as attenuation. This means that infrasound suffers much less energy loss through thermal effects compared with audible sound (Muthibani, 2017). There is additional sound energy absorption through molecular relaxation.

From Stokes' law, classical sound attenuation is approximately proportional to the square of the sound wave's frequency. Therefore, the attenuation of a 10,000 Hz sound is  $10^8$  times greater than the attenuation of a 1 Hz sound.

The Huygens-Fresnel principle states that every point on a wavefront may be regarded as a point source of secondary wavelets and Javeloyes, Pendas-Recondo and Sanchez (2021) provide an analysis of the theoretical propagation path of a wave viewed as an anisotropic (direction-dependent), rheonomic (time-dependent) cone structure. But the notion of a point source in infrasound is problematic; a very small sphere oscillating in volume with a period of one second would not be detected a hundred kilometres away. Infrasound that is produced from a conical surface, such as a loudspeaker, can only be detected a short distance away, so infrasound can be played to subjects using special headphones. Long-range infrasound propagation is more complex; it depends on the source, on atmospheric conditions and on the location of the source, both in terms of its height above ground and the nature of the surrounding terrain. It is a rule of thumb that wave trains are not affected by obstacles of smaller dimension than the wavelength. Because there are geometrically more small objects than large objects, higher frequencies are affected disproportionately. Infrasound from wind turbines has been measured at distances up to 90 km from the source and infrasound from explosive sources has been measured up to 2,000 km away (Keith, Daigle and Stinson, 2018). A semi-infinite hemisphere of air is not plausible in a troposphere less than 16 km thick so numerical modelling of infrasound attenuation is complex; it assumes that the infrasound behaves as a linear elastic wave that is affected by the characteristics of the atmospheric boundary layer (ABL) such as highly stratified winds and the creation of waveguides extending up some hundreds of metres (Marcellio et al., 2015). Le Pichon, Ceranna and Vergoz (2012) provide a detailed discussion of propagation models based on numerical solutions to the wave equation. These are used in the IMS infrasound detection network. The assumption that infrasound is a linear elastic wave leads to close agreement with empirical data. The attenuation coefficient,  $A_p$ , of the pressure wave at a distance  $R$  (in km) from the source is given by Eq. (3) (Le Pichon, Ceranna and Vergoz, 2012):

$$A_p(f, V_{eff, min}) = \frac{1}{R} 10^{\frac{\alpha(f, R)}{40}} + \frac{R^{\beta(f, V_{eff, min})}}{1 + 10^{\frac{\delta(f, R)}{10}}} \quad (3)$$

The parameters  $\alpha$ ,  $\beta$ ,  $\delta$ , and  $\sigma$  are determined by regression on measured data. The first term in Eq. (3) is the near-field attenuation and represents the decrease in SPL due to geometric spreading and exponential decay. The second term is the far-field attenuation due to the different layers of the atmosphere (troposphere, stratosphere, mesosphere and thermosphere) which act as a series of ducts on the sound waves. The phenomenon is analogous to the reflections of sound waves by ocean thermoclines in sonar systems. The attenuation coefficient,  $A_p$ , is a function of the wave frequency,  $f$ , and the variable,  $V_{eff, min}$  which is the ratio of the effective sound speed at 50 km altitude and the sound speed at ground level. Le Pichon, Blanc and Hauchecorne (2010) provide a comprehensive discussion. Fig. 3 is a plot of Eq. (3) for varying  $V_{eff, min}$  (the gray lines) and for  $V_{eff, min} = 1$  (the red line) for infrasound with a frequency of 1.6 Hz. The plot shows the surprising variation of sound pressure level with distance. In particular, the envelope of grey lines shows that at 5 km from the source the attenuation is about -15 dB, at 20 km the attenuation is about -35 dB, at 100 km the attenuation is about -80 dB, and at 150 km the attenuation varies from -30 to -80 dB. Therefore, depending on the conditions, it is possible for the infrasound to be louder at 150 km from the source than it is at distances of 20 to 100 km from the source. This is very different from audible sound, which

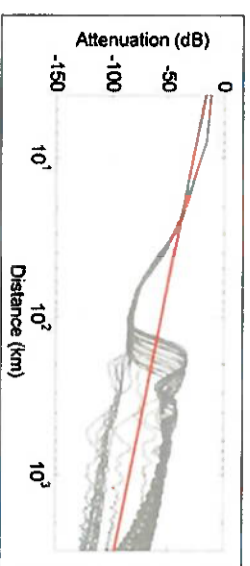


Fig. 3. Attenuation of 1.6 Hz sound with distance. (Source: Le Pichon, Ceramita and Vergez, 2012).

gets attenuated proportionately with the square of the distance from the source as expressed in Eq. (2).

### 3.2. Infrasound in the built environment

In the built environment, large structures such as bridges, dams and buildings vibrate at a natural frequency that is in the infrasound frequency spectrum. McComas et al. (2018) describe measurements of 10 Hz infrasound from a bridge and show that features such as highways can act as wave guides, providing enhanced transmission of the sound, while tall buildings can create acoustic shadows. van Kamp and van den Berg (2018) review studies on vibration in dwellings near wind turbines. They discuss the phenomenon of periodic pressure pulses coinciding with the natural frequency of vibration of the structure to create higher than expected SPLs in the dwelling as well as higher frequency, audible vibrations.

We propose that the profound attribute of infrasound in coupling with the lightweight structures of a building can be explained as follows. Structural members generally have some freedom of deflection; a floor can move up and down in the manner of a diaphragm and a wall or window will flex in and out in the same way. Such deflections require relatively small force compared with that required to move them laterally by an equal amount. The large dimensions of infrasound pressure regions will readily apply considerable forces to large surfaces, causing deflection. If the frequency of infrasound and structure agree, there will be large resonant deflections. Specifically, vibration of the floor will set up vibration of a bed on the floor and this vibration may be felt by a sleeping person, even if it is not audible. This vibration can, in turn, produce harmonics which may extend into the audible range. Further, parasitic oscillations of coupled objects may also transduce the subaudible frequency; for example, the shower door may vibrate with an audible rattle. Most lightweight structures in a built environment have low natural frequencies of vibration and are susceptible, in this way, only to infrasound. High frequency sound cannot couple with these elements (Vardavas, Bard and Persson Waye, 2018).

Infrasound has a peculiar ability to permeate a house, through the walls, doors and windowpanes or through open apertures. Consider the passage of sound through a diaphragm such as a floor, wall or windowpane. In particular, consider a large window, fixed and sealed at its edges. Sound pressure waves hitting the exterior glass cause the pane to vibrate which, in turn, produces pressure waves in the inside air. There is no other possible mechanism; if the distal surface of the diaphragm does not vibrate, the air in the room cannot vibrate from the sound. The window is relatively stiff and although it will deform in a simple mode (the whole diaphragm moves, with maximum deflection at the centre), it will not readily deform in higher modes because it is stiff. In order to deform appreciably, it requires approximately constant pressure over its whole surface. If it is pushed here and pulled there, its reluctance to bend will result in very little deformation at points of high or low pressure. High frequency sound, from a source orthogonal to the window, will necessarily be quite close (because it does not travel far) and will produce concentric circles of high and low pressure. If it strikes the window obliquely, the pressure pattern will be more jumbled and

the glass will move very little, being restrained by its stiffness. By comparison, low frequency sound has such large wavelength (17 m for 20 Hz sound) that the full window will fall within a similar pressure regime, whether the source is orthogonal or oblique. If a component frequency of the sound coincides with the natural frequency of vibration of the pane, the effect will be stronger. The same argument also applies to walls, roofs and floors. The bottom line is that infrasound can invade buildings much more readily than audible sound. The transmission of low frequency pressure waves is reduced when rigid materials such as brick and concrete are used in buildings (Granzotto, Di Bella and Piana, 2020).

If there are several open apertures in the walls, each will receive a succession of pressure waves and, by Huygens-Fresnel's principle, each aperture will seem to the auditor in the room to be the source of the sound. For audible sounds, the air in each aperture will not vibrate synchronously because the differing distances from the source to the aperture are significant compared with the short wavelengths. For infrasound, all the apertures will tend to be synchronous, so the vibration of the air in the room will be larger.

In summary, the behaviour of infrasound in the built environment is very different from the behaviour of audible sound. It can travel huge distances, invade structures, couple with the components of structures and transduce its energy into the audible range.

### 3.3. Wind turbine infrasound and its effect on nearby residences

Many sources of infrasound are intermittent, irregular and of short duration. The exception is infrasound from windmills which is episodic and persists over many hours. This section looks at the characteristics of wind turbine sound signatures and the typical SPL of infrasound from wind turbines.

There are several studies on the mechanism of sound production from wind turbines showing that it is generated primarily from aerodynamic effects and, to a lesser extent, by movement of the mechanical components (Bertagnolio and Fischer, 2021). The aerodynamics involves air flow around the blades in the form of trailing edge noise, tip noise, blunt trailing edge noise and stalled flow noise. These span a wide range of frequencies from infrasound (due to tip noise) up to about 16,000 Hz. High frequency sound does not travel far from the source so it will not affect people living a few kilometres away (Boczar et al., 2022; Deshmukh et al., 2019). Tonin (2012) and D'Amico, Van Renterghem and Botteeldooren (2022) describe impulsive sound from wind turbines at a frequency of about 1 Hz which is the blade passing frequency (BPF) and Boczar et al. (2022) present 2-dimensional power spectral densities (PSDs) from a single wind turbine showing both infrasound and 1FN.

Boczar et al. (2022) discuss the difficulty in measuring wind turbine infrasound, both in terms of isolating the source from other infrasound sources, such as the wind, and in terms of the equipment used to measure the acoustic signal. The standard IEC 61400-11 is used for measuring acoustic signals emitted by operating wind turbines in the audible range and the PN-EN 61400-11 standard, Annex A.2 is used to extend the measurements to the 1F sound.

Jakobsen (2005) provides an early review of all published measurements of infrasound from wind turbines and notes that there is difficulty comparing measurements because of all the variables (types of wind turbine, wind speed, proximity to other wind turbines, distance of the sensor from the wind turbine, etc.), some of which are not stated in the literature. He cites G-weighted infrasound levels 100 m from the source of about 70 dB from an upwind turbine and 80 to 100 dB from a downwind turbine with a distance attenuation of 3 to 6 dB per distance doubling. In more recent studies, Okada, Yoshida and Hyodo (2019) confirm that the highest SPLs of infrasound occur downwind from the turbine and D'Amico, Van Renterghem and Botteeldooren (2022) present PSDs showing the effect of wind speed. Ohlund and Larsson (2015) show that, in addition to wind speed and direction, wind turbine sound transmission is strongly affected by local climatic conditions such as

temperature, relative humidity and air pressure and the variation in these parameters with distance from the ground. Boczar et al. (2022) report power spectral density plots (PSDs) showing that wind turbines produce infrasound below 9 Hz, around 16 Hz and LFN at about 25 Hz and that increasing wind speed shifts the frequencies slightly higher. Blumendeller et al. (2022) present power spectral density plots (PSDs) measured simultaneously at a wind turbine farm, and outside and inside houses located just over 1 km away. They show that infrasound arises from the blade rotation at the blade passing frequency (BPF) and its multiples and that these are also present inside the houses. When the wind turbine stops, the infrasound tones disappear in the houses. In general, the infrasound SPL is lower inside the houses than it is at the wind turbine, however, just as van Kamp and van den Berg (2018) postulated, the indoor SPL is higher for certain infrasound frequencies due to resonance of the structures and different houses have different resonant frequencies. Blumendeller et al. (2022) note the need for more sound monitoring in the audible range to determine whether the effect of infrasound coupling with the structure can produce higher frequency resonances at significant SPLs. There is some evidence to suggest that infrasound in structures causes pictures on walls and objects on shelves to vibrate and rattle which may annoy occupants (Tonin, 2018; Krahe et al., 2019; Jakobsen, 2005) and lead to a lack of 'acoustic comfort' (Vardaxis, Bard and Persson Waye, 2018).

In summary, the sound signature from wind turbines is very variable and complex. However, there is ample evidence that wind turbines produce infrasound and that it couples with nearby buildings, in some cases amplifying resonant infrasound frequencies. It may also produce higher frequency sound and this is an area where more research is needed. Table 1 summarizes the themes and citations that are reviewed in this section.

#### 4. The effect of infrasound on people

##### 4.1. A review of the effect on infrasound on people and animals

Clearly no infrasound problem could exist without a biological response to it. The explanation for the biological response has not received much consideration in the literature, other than dismissing it as a 'nocebo' effect or a by-product of assorted socio-economic factors. As mentioned in the introduction, people are more annoyed by infrasound from wind turbines than from other sources and there are many reports of its adverse effect on health (Baeza Moyano and Gonzalez Lezcano, 2022; Michaud et al., 2016). van Kamp and van den Berg (2018, 2021) and Tonin (2018) review this field and discuss whether two pathologies, namely Vibroacoustic Disease (VAD) and Wind Turbine Syndrome (WTS) occur in people living near wind turbines and having long-term exposure to infrasound. VAD is associated with thickening of cardiovascular structures together with depression, irritability and decreased cognitive skills. WTS symptoms include sleep disturbance, headache, tinnitus, ear pressure, dizziness, vertigo, nausea, visual blurring, tachycardia, irritability, problems with concentration and memory and panic episodes. Tonin (2018) cites a 2015 Australian Senate Select Committee on Wind Turbines that concluded there was credible evidence from people living near wind turbines complaining of adverse health symptoms. Annoyance and sleep disturbance seem to be the most common symptoms and subjective data from surveys suggests that these get worse as the house gets closer to the wind turbine source (Turunen et al., 2021a; van Kamp and van den Berg, 2018, 2021). The Council of Canadian Academies study confirms the finding that wind turbine infrasound can cause annoyance and sleep disturbance (CCA, 2015). Michaud et al. (2016) note that annoyance increases with increase in SPL and with increasing duration of noise, suggesting that some people become sensitized to the irritation while others become habituated.

Conversely, there are many studies that have investigated the effect of infrasound on people and failed to find measurable health effects. Szychowska et al. (2018) played different sounds to people in an

anechoic chamber and asked them to rate their annoyance. When the testers could see wind turbine images simultaneously with the sound, they were more annoyed than when they were just exposed to the sound. Similarly, as mentioned in the introduction, Majala et al. (2021) present a very careful study, playing infrasound to a group of people with WTS symptoms and an asymptomatic control group and measuring their autonomous nervous system (ANS) response using blood pressure and heart rate. The control group were unaffected by the infrasound and the WTS group only exhibited symptoms when they were told that they were being exposed to wind turbine infrasound (whether it was actually present or not). The infrasound exposure was at 89 dB for several minutes.

Baeza Moyano and Gonzalez Lezcano (2022) review several cases of people living near wind turbine farms who suffered from annoyance and interrupted sleep and discusses the evolutionary value of responding to noise as a source of danger. However, they also note that the percentage of people displaying symptoms is small compared with all people living near wind turbines. This is confirmed in a study by Turunen et al., 2021b who found that only about 5% of residents reported adverse symptoms. Both studies conclude that infrasound may cause a wide range of symptoms in some people, but, aside from annoyance, there is no clear evidence that it does cause the symptoms. The study by Turunen et al., 2021b included a few children who appeared to suffer from wind turbine infrasound related symptoms but the findings were not statistically significant. Zagubien and Wolniwicz, (2020) found that children in school were not affected by wind turbine infrasound and opined that this might be because they were less likely to expect that turbine noise might be problematic. In adults, personal factors and social variables are just as likely to produce symptoms such as annoyance. Peri, Becker and Tal (2020) notes that there may be cultural differences in the perception of wind turbines, probably due to differing familiarity; people who have had little experience of wind turbines are more likely to fear that their noise will be problematic.

Baeza Moyano and Gonzalez Lezcano (2022) point out that laboratory studies have mixed results but that some people appear to be hypersensitive to infrasound, in agreement with Michaud et al. (2016). The studies themselves need to avoid common errors such as exposing people to infrasound for short periods of time (Krahe et al., 2019), using SPLs that are much greater than those near wind turbines and producing symptoms psychosomatically by negative expectations (the 'nocebo' effect). Objective measures such as EEG, ECG, blood pressure, heart rate and nystagmus (eye movement) provide more reliable data than subjective questionnaires asking how the testers feel. Laboratory tests where a narrow sample of infrasound frequencies is used, may fail to capture the entire sound signature in a house near a wind turbine.

##### 4.2. An explanation of chronic noise stress symptoms

Prolonged exposure to loud noise is known to cause neurological disorders such as cognitive decline and hearing loss in both people and rats (Samad et al., 2022; Haider et al., 2020). Like other stressors, noise stress causes activation of the Sympathetic-Adreno-Medullar (SAM) axis leading to the production of stress hormones and a cascade of unpleasant consequences. This syndrome is detailed by Kryter (1972). If the noise persists, most people adapt to it with a mediation response based on homeostasis with activation of the Hypothalamus-Pituitary-Adrenal (HPA) axis. For a detailed description see Goody et al. (2018) and Russell and Lightman (2019). For those who cannot adapt, the stress becomes progressively more serious. The factors that allow only some people to develop protective adaptation are very complex (Hillis and Del Giudice, 2019). In extreme tests with rats, sustained levels of stress hormones and neurotransmitters damaged the immune system, organs and tissues, parts of the brain atrophied and there was increased chronic low-grade inflammation and psychological deterioration which manifested as symptoms such as cardiovascular problems, diabetes, cancer, autoimmune malfunction, depression and anxiety (Mariotti, 2015).

Haider et al. (2020) and Seidman and Sandring (2010) review the physiological and psychological effects. There is evidence of similar brain damage in rats exposed to infrasound and LFN (Huet-Bellio et al., 2017).

It is important to know that the human nervous system has a subsystem called the reticular activation system whose function is to assess subconscious inputs. In particular, the importance of any sound cannot be assessed until the sound has been processed. Obviously, survival down the ages required that our forebears could be alerted to danger when they were asleep and whether or not they were concentrating on the sounds around them. The point is that humans hear everything around them at all times. Consequently, sleep will not insulate them from a persistent noise if they find it disturbing. Rabellino et al. (2019) describe this as the Innate Alarm System (IAS).

The SPL of wind turbine infrasound is not usually above 70dB, which would not normally be classified as "loud" (because the ear is less sensitive to infrasound than it is to audible sound), but it is persistent and there is evidence that some people are sensitized to it. Latremolier and Woolf (2009) describe the sensitization of the central nervous system (CNS) when it is repeatedly exposed to stressors, the properties of the neurons change so that the person reacts even when the source of stress is removed.

The process that occurs is that the sufferers are probably able to perceive some rhythmic input that they associate with windmills. Possibly, but not probably, some of the sufferers might be able to hear infrasound. What is more likely is that the sufferers perceive some interaction between structures in the house and the infrasound. Mostly, windmills are not placed in high occupancy areas; so the environmental sound level is usually very low, perhaps 10-15 dB. The probable sequence of events is that, in very quiet surroundings, some vibration in the house is transferred directly through the coupled floor and bed to the sleeping person or some vibration is transmitted by the structure into the audible range. This disturbs the person, who becomes increasingly irritated, and this leads to loss of sleep. Over a period of time, this experience is repeated until the prospect of another disturbed night causes distress. After many such nights, the sufferer learns that the advent of the soft sounds will condemn him to considerable distress. He then enters the syndrome of classic phobias. This is well discussed by Frameno et al. (2021) and Samra and Abdijadid (2018). A similar phenomenon is observed after severe earthquakes such as those in Japan in 2011 and in New Zealand in 2010 (Honma et al., 2012; Kemp et al., 2011). The stress caused some people to become hypersensitive to small vibrations and to report significant mental health problems such as anxiety, paranoia, sleep problems, depression and dizziness (Braghthole et al., 2019).

The arachnophobia does not fear that the picture of a spider will leap from the page and do harm to him. The claustrophobe does not fear that the walls will actually close about him and crush him to death. What they fear is the unpleasant sensations that are caused by contemplating spiders or confined spaces. This fear is entirely real, even if the spider on the page is not, and the fear can be measured by biometric responses such as elevated heart rate.

This explains the behaviour described in Majjala et al. (2021), which on the face of it is inexplicable. In this authoritative experiment, excellently reproduced samples of windmill infrasound acoustic signals were played to two cohorts of test subjects; one cohort claimed to be sensitised to windmill noise and the other did not. Here, test subjects could not hear the actual infrasound profile of windmills as experienced in the house of the subject. This was because the experiment lacked structures to transduce the infrasound into the audible range. Clearly the experience of infrasound over an extended period in a quiet house that happened to have structures that transduced the sound. The people with the established phobia were just as frightened by the suggestion that there was infrasound in the room as arachnophobes would have been if they were told that there were spiders in the room or claustrophobes told

that the walls could slide together until the subject could not move. One of the authors is an arachnophobe and the other is a claustrophobe, so we have real experience of this phenomenon. Not surprisingly, the subject people with WTS reacted strongly when falsely told that wind turbine infrasound was present. The reaction was clearly shown to be genuine by biometric responses.

It seems therefore that sensitivity to wind turbines follows the same pattern as other phobias. Initially, the person becomes aware of the audible sound from the wind turbines in the quiet rural environment. Thereafter, they sense infrasound vibration transmitted through floors and beds while sleeping and/or hear higher frequency noise from harmonics or parasitic coupling in the structure. Over time, the person becomes irritated and suffers a cascade of stress symptoms such as disturbed sleep. The sufferer then learns to fear the experience and becomes hypersensitive and the adverse response can be triggered merely by seeing a moving wind turbine or by being told that a wind turbine is present.

Table 2 summarizes the themes and citations that are reviewed in this section.

## 5. Discussion and conclusions

The key to understanding the phenomenology of infrasound lies in its extremely large wavelengths and its extremely low attenuation over very long distances. A significant portion of the infrasound from wind turbines can be measured in nearby residences, with dominant infrasound episodes at the BPF. While the level of infrasound is below the threshold of hearing, some residents become sensitized either to the infrasound vibration through floors and beds or to higher frequency, audible sound in the structure, caused by resonance. When this happens, they suffer the symptoms of chronic stress. The autonomous nervous system is involved in much the same way as it is for other phobias.

There is no suggestion that the solution to infrasound sensitivity is to remove all sources of infrasound from the built environment - this is as ludicrous as suggesting the elimination of all spiders to solve arachnophobia, or all small spaces to solve claustrophobia. Wind turbines

**Table 2**  
Review of the effect of infrasound.

Topic	Citations
Biological response to infrasound (in people and animals)	Baeza Moyano and Gonzalez Lezcano, 2022; Balhaus et al., 2016; CCA, 2015; Borella, Ordys and Al Zubaidy, 2018; Burke, Uppenkamp and Kochl, 2020; Dreshnukh et al., 2019; Huet Bellio et al., 2017; Jurado and Margardt, 2020; Krahe et al., 2019; Latremolier and Woolf, 2009; Moller and Pedersen, 2004; Mulhans, 2017; Rabellino et al., 2019; Szyrowska et al., 2018; Seidman and Sandring, 2010; Zagubien and Wohltewicz, 2020
Wind turbine infrasound physiological and psychological effect on people	Baeza Moyano and Gonzalez Lezcano, 2022; Balhaus et al., 2016; Dreshnukh et al., 2019; CCA, 2015; Jakobsen, 2005; Krahe et al., 2019; Majjala et al., 2021; Michand et al., 2016; Mulhans, 2017; Peet, Becker, and Tal, 2020; Szyrowska et al., 2018; Tonin, 2018; Turunen et al., 2021a and b; van Kamp and van den Berg, 2018; van Kamp and van den Berg, 2021; Vardoux, Bard and Persson Waye, 2018; Zagubien and Wohltewicz, 2020
Chronic noise stress, the ANS and phobia	Goodoy et al., 2018; Haider et al., 2020; Honma et al., 2012; Huet-Bellio et al., 2017; Kemp et al., 2011; Kyver, 1972; Marotti, 2015; Russell and Lighman, 2019; Snaad et al., 2022; Samra and Abdijadid, 2018; Seidman and Sandring, 2010

provide a valuable source of renewable energy and are likely to become more prevalent in the future.

This work has explained infrasound behaviour and its effect on people. Future research is needed to determine which frequencies of wind turbine sound signatures are most annoying to nearby residents and whether these can be eliminated through better design of the blades. Solid house construction using concrete and brick, is likely to have less active coupling with infrasound and will therefore generate fewer resonant frequencies, but this is hardly a solution for those who are currently suffering a very real problem.

Boretto, Ordys and Al Zubaidy (2018) suggest that active infrasound cancellation (anti-sound by playing the same sound waves out of phase to cancel them) might be an effective remediation. However, this seems impractical as it is very difficult to create infrasound within an entire structure. A sensible and inexpensive solution would be to monitor problematic houses with sound equipment and accelerometers to measure audible noise and inaudible vibration. This would detect low frequency tympanic vibration of floors. Remediation would involve installing bracing to eliminate the annoying vibrations. Weckendorf et al. (2016) review the bracing design approaches used for damping vibrations in timber floors. Ground floors are easier to brace than upper floors. If an upper floor problem is identified, the bed could be moved to an area where the floor vibrates less. This remediation might be done by the owners of wind turbine farms and would probably be an inexpensive but rewarding public relations exercise.

In order to become more sustainable, there is a global effort to increase the use of renewable energy sources, such as wind. Therefore, wind turbine installations will increase in the future and more residents will be exposed to this source of persistent infrasound. The debate on whether or not the infrasound poses significant health risks to residents has reached an impasse. By addressing the needs of nearby residents, future research can move in a more constructive direction, which will improve the perceptions of wind turbines and ultimately benefit their uptake.

#### Declaration of Competing Interest

The authors declare that they have no known conflicting financial interests or personal relationships that could have appeared to influence the work reported in this paper.

#### Data Availability

No data was used for the research described in the article.

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Review

# Infrasound and Human Health: Mechanisms, Effects, and Applications

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## Featured Application

This review contributes to assessing the health risks associated with occupational exposure to environmental infrasound by linking sound attributes to specific microvascular and cellular mechanisms. It also describes the opportunities provided by low-intensity infrasound, under carefully regulated conditions, for use as a non-invasive biomedical instrument for tissue engineering and therapeutic intervention.

## Abstract

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 human-made 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.

**Keywords:** infrasound; mechanotransduction; PIEZO1; TRPV4; inflammation



Academic Editor: Gino Iannace

Received: 13 January 2026

Revised: 29 January 2026

Accepted: 2 February 2026

Published: 3 February 2026

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## 1. Introduction

Sound consists of rhythmic fluctuations in air pressure superimposed against a constant atmospheric background [1]. These oscillations vary in frequency, forming the sound's spectral composition. Complex non-sinusoidal acoustic patterns predominate in the environment; they lead to several-integer multiples of the determined fundamental frequency, the so-called harmonics.

When sufficiently intense, sound can be perceived as noise or felt as vibration [2]. Although sound intensity depends on the amplitude of pressure variations, particle displacement—the movement of air particles—increases as frequency decreases, meaning low-frequency waves induce more pronounced mechanical movement than high-frequency waves of equal pressure [1,2].

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 [3,4]. 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.

To understand the effects of infrasound on biological mechanisms and its public health relevance, we review and summarize the current knowledge of infrasound's physiological and psychological impacts, discuss associated risks and therapeutic applications, and identify remaining research gaps. This manuscript employs several definitions. Primarily, we discuss frequency. We explain frequency in terms of infrasound, which is defined as sound below 20 Hz in humans [3]. Furthermore, we discuss the term amplitude. This refers to the change in the value of a measure, specifically, in this case, changes in pressure. Additionally, we discuss sound pressure. Sound pressure is a measurement of the change in the pressure of the air around the space where a sound is being produced. Finally, we measure sound intensity. Sound intensity is a measure of the energy per unit volume in a given space caused by sound. Sound intensity is proportional to the pressure of sound in that field.

We conducted a focused literature search across PubMed, Scopus, Web of Science, and Google Scholar to identify peer-reviewed studies on infrasound and its health outcomes. We used a combination of keywords, including infrasound, low-frequency noise, wind turbine, sound pressure level (SPL), mechanotransduction, PIEZO1, TRPV4, microcirculation, cardiovascular, neuroinflammation, cognition/memory, and occupational exposure. We screened titles and abstracts for relevance and selected eligible articles based on the following criteria: a clear characterization of the exposure (frequency, SPL/weighting, and duration); the reporting of outcomes from *in vitro*, animal, or human studies; and endpoints that are mechanistic, clinical, or occupationally relevant. Additionally, we conducted backward and forward citation searches of key papers and recent reviews to identify foundational and influential studies omitted from the initial database search.

## 2. Cellular and Molecular Responses

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

studied the effects of infrasound on rat cardiac fibroblasts and demonstrated that low-SPL infrasound (80–86 dB) actually suppressed pathological processes in the fibroblasts. Specifically, low SPL exposure inhibited angiotensin II-induced proliferation and collagen synthesis, acting through the microRNA-29a/TGF- $\beta$ /Smad3 and Nr1h2/HO-1 pathways. These findings raise the intriguing possibility that infrasound may exert bidirectional effects depending on dose and cellular context, being harmful at high intensities but potentially protective at lower, sub-threshold SPLs [24]. Biological tissues and organs vary in their mechanical and viscoelastic properties, structural organization, and the distribution of mechanosensory receptors. These differences can produce distinct, frequency-dependent responses to infrasound and low-frequency vibrations. Consequently, the resonant frequencies of different tissues and organs may contribute to the diverse biological effects reported in the literature. This may help explain why some tissues respond differently under similar exposure conditions. Mechanistic evidence indicates that resonance-related vibratory phenomena can affect hemodynamic, neurological, and musculoskeletal pathways differently, depending on factors such as frequency, intensity, and the mode of vibration delivery [25].

### 3.1.2. 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 [26].

The translation of these findings to intact humans is complex. Controlled laboratory studies from the 1980s onward have yielded heterogeneous results. Danielsson and his co-workers reported increases in diastolic blood pressure in healthy volunteers during acute exposure to 6–16 Hz infrasound at high SPLs, without concomitant changes in heart rate [27]. Likewise, Qibai et al. found that an hour of exposure to infrasound at 2.1 Hz (110 dB) or 4.1 Hz (120 dB) in healthy volunteers resulted in an increase in systolic and diastolic blood pressure, and an increase in heart rate was generally observed at 120 dB, but at 110 dB, the heart rate response was inconsistent (increase or decrease). Discomfort, headache, ear pressure, and fatigue were also reported by participants [28]. In an early study, Moller et al. observed no cardiovascular changes when subjects were exposed to short-term near-threshold levels (<20 dB above auditory threshold). However, annoyance and sensations of ear pressure were common [29]. Birnie reported small, non-significant increases in blood pressure under unspecified infrasonic exposures, again accompanied by subjective symptoms [30]. These early experiments suggested that only high-intensity infrasound (>100 d(B)Z) elicits measurable cardiovascular responses in humans, whereas near-threshold exposures are more likely to cause annoyance than physiological changes. Unfortunately, short-term studies are not sufficient to draw conclusions about long-term cardiovascular effects.

More recent and methodologically rigorous studies have focused on infrasound and low-frequency noise generated by wind turbines. Health Canada's large cross-sectional survey of over 1200 adults living near turbines found no association between exposure time and blood pressure or heart rate [31]. This study was conducted in 2012 and is based on data from dwellings in the vicinity of smaller wind turbines with rated electrical power outputs ranging from 660 kW to 3 MW. In a 72 h, double-blind, crossover study of noise-sensitive adults exposed to simulated wind turbine infrasound (1.6–20 Hz; 90 dB peak), no cardiovascular effects, including effects on heart rate, were detected [32]. However, those studies do not consider the current state of knowledge regarding the impact of infrasound on cellular mechanotransduction, as reflected in blood pressure and heart rate

measurements. 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 [33].

Nonetheless, there is evidence for acute vascular effects. Deng et al. reported that exposure to short-term low-frequency noise (70–100 Hz  $\leq$  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 [34–36].

Despite decades of research, many gaps remain, particularly regarding the intensity threshold of infrasound exposure-related effects, the differences between animal and human studies, the precise cellular mechanosensory pathways, and the associated markers of vascular health and blood flow at the microcirculatory level. Recent microvascular modeling has established standard reference values for blood velocity in microvessel exchanges. This enables healthy and diseased states to be distinguished using biophysical flow indicators [37]. To gain a clearer understanding, future studies should use precisely calibrated chambers, double-blind designs, and advanced mechanical analyses. In addition, standard cardiovascular and microcirculatory markers should be used to properly elucidate the true impact of infrasound on cardiovascular functions. Research using Laser Doppler Flowmetry during local thermal hyperemia has demonstrated that skin microvascular reactivity is highly sensitive to endothelial dysfunction. This underscores the importance of microcirculatory assessments in detecting early vascular impairment [38]. Normative datasets for sublingual microcirculation obtained through SDF imaging in healthy pediatric populations further demonstrate the robustness and physiological sensitivity of microvascular imaging methods [39]. Complementary findings from adult cohorts using incident dark-field imaging show age- and sex-specific variations in sublingual microcirculatory parameters, broadening the reference framework for assessing vascular function across populations [40].

### 3.2. Central Nervous System

#### 3.2.1. Animal Studies

Infrasound exposure (particularly when delivered at high SPL) has repeatedly been linked in animals and in vitro models to neuronal apoptosis and oxidative stress, while human data remains less clear-cut. Here, we summarize findings from diverse experimental paradigms, comparing rodent studies, cellular assays, and limited human research, and evaluating mechanistic pathways, neurofunctional outcomes, and potential protective responses.

Extensive rodent experiments have demonstrated that infrasound exposure induces hippocampal neuronal apoptosis alongside oxidative imbalance. For example, rats exposed to 8 Hz at 140 dB for 2 h/day across three days exhibited increased neuronal apoptosis in hippocampal regions, correlating with impaired spatial learning and memory [41]. In mice, repetitive exposure to 16 Hz infrasound at 130 dB for 2 h per day for 8 days increased inflammatory cytokine levels in the CNS and elevated oxidative stress, leading again to impaired memory and spatial learning due to neuronal damage in the prefrontal cortex and hippocampus [42]. Mechanistically, epigallocatechin gallate (EGCG), an antioxidant, has been shown to suppress infrasound-induced neuronal apoptosis in rat hippocampi, confirming oxidative stress as a causal mediator [43]. Together, these findings support a model in which infrasound triggers mitochondrial dysfunction, reactive oxygen species (ROS) generation, and apoptotic cascades involving p53 upregulation and Bcl-2 suppression.

Evidence on synaptic plasticity indicates that high-intensity acoustic stimulation can disrupt long-term potentiation (LTP), a core mechanism underlying learning and memory. In one study, a single 1 min of exposure to 110 dB audible sound spanning approximately 3–15 KHz inhibited hippocampal Schaffer-CA1 LTP for 24 h, while spatial learning ability remained unaffected [44]. Although this sound exposure did not involve infrasound, these data suggest that similarly intense acoustic inputs may impair synaptic strengthening, most likely through alterations in postsynaptic signaling mechanisms.

Emerging evidence also points to disturbances in intracellular calcium homeostasis. For example, exposure in the 90–130 dB range was shown to alter free intracellular calcium levels and modify NMDAR1 expression in hippocampal neurons, implicating calcium dysregulation and impaired glutamatergic signaling as key mechanisms [45]. Complementary *in vitro* work further demonstrated that cultured hippocampal neurons developed axonal degeneration following infrasound exposure, potentially reflecting cytoskeletal compromise or excitotoxic damage [46]. Animal studies have shown further vulnerabilities in the auditory system. In chinchillas, simultaneous exposure to low-frequency sound (30 Hz, 100 dB SPL) and high-intensity auditory noise (4 KHz octave band, 108 dB) caused greater damage to outer hair cells throughout the cochlea than exposure to auditory noise alone. These findings suggest that low-frequency components can exacerbate noise-induced cochlear damage and raise concerns about possible synergistic effects on the inner ear [47].

At the cellular level, rodent studies consistently implicate oxidative stress as a central driver of neuronal injury. ROS accumulation, mitochondrial dysfunction, and downstream apoptotic cascades appear to dominate. The protective effect of antioxidants such as EGCG reinforces this interpretation [43]. Beyond oxidative stress, neuroinflammatory processes have emerged as key contributors: astrocyte activation during infrasound exposure impairs learning and memory, while the pharmacological blockade of astroglial connexin-43 hemichannels mitigates these deficits, highlighting the role of glial-driven inflammation in neuronal survival [48]. Similarly, activation of the FGF2/FGFR1 pathway suppresses astrocyte-derived inflammatory cytokine production and neuronal loss, whereas antagonism of FGFR1 exacerbates injury by activating NF- $\kappa$ B [49]. Together, these data converge on astroglial NF- $\kappa$ B signaling and the release of proinflammatory mediators (IL-1 $\beta$ , TNF, and IL-6) as critical pathways.

Some studies also highlight adaptive capacity. Environmental enrichment before infrasound exposure provided robust neuroprotection in rats, preserving memory performance following 16 Hz, 130 dB exposure. This effect was accompanied by lower hippocampal oxidative stress, reduced pro-inflammatory cytokines, enhanced antioxidant defenses, and decreased apoptosis, with molecular shifts favoring cell survival (increased Bcl-2, reduced p53) [50]. Such findings suggest that preconditioning strategies may buffer the brain against infrasound-induced injury.

### 3.2. Human Studies

Animal studies largely highlight CNS changes, whereas human data remain limited. In a randomized pilot trial, bedroom-based infrasound exposure (6 Hz, 80–90 dB) over 28 consecutive nights induced detectable changes in resting-state brain networks, though behavioral or cognitive correlates were not clearly documented [51]. 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 [52]. An earlier report noted that infrasound near the auditory threshold heightened pressure sensations and annoyance, but impaired performance only in one of nine tasks [30]. Interestingly, some brief exposure studies even suggested tran-

sient improvements in working memory, though these effects proved inconsistent across replications [53].

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 [29,54]. 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 [55].

Across rodent and cellular models, the evidence is remarkably consistent: high-intensity infrasound produces oxidative stress, neuronal apoptosis, synaptic impairment, and neuroinflammation. By contrast, human studies tend to show weaker or absent effects at moderate or near-threshold levels. This discrepancy may reflect differences in exposure intensity, interspecies sensitivity, adaptive mechanism, or methodological heterogeneity. Notably, brief human exposures have even been linked to transient cognitive enhancement [53]. In rodents, extreme intensities ( $\geq 130$  dB) reliably generate profound neurotoxicity levels [56].

### 3.3. Other Systems

#### 3.3.1. Animal Studies

The biological effects of infrasound on organ systems beyond the cardiovascular and CNS domains have been investigated in a variety of animal, human, and technical studies. Although the evidence is still fragmented and often derived from high-intensity exposures, several consistent patterns emerge. Below, the findings are discussed by system, highlighting major outcomes, mechanistic insights, and limitations in the current literature.

The data collectively provide strong evidence that sensory structures respond to infrasound; however, they also highlight that the effective levels are often higher than what is typically encountered in everyday environments. This situation is currently changing. Recent studies published by Professor Ken Mattsson and the Colas et al. group indicate that sound pressure levels (SPLs) have been significantly underestimated under various atmospheric conditions and near several wind turbines. Current plans for 7 MW-class wind turbines suggest a further increase in sound pressure levels, reaching up to 120 dB (Z) [57]. More direct pathological evidence comes from animal work. In rats, repeated exposure to 130 dB infrasound resulted in slowed gastric emptying, mucosal injury, and increased nitric oxide synthase activity; partial recovery occurred after exposure ceased [58]. These findings align with the broader pattern of oxidative and inflammatory responses described in other organ systems. Endocrine effects have been less studied, but intriguing signals exist. For example, chronic exposure in rats increased corticosterone levels and activated brown adipose tissue metabolism without causing overt glucose intolerance [59]. This points toward possible activation of stress axes and thermogenic pathways. Immune effects are mostly inferred indirectly from studies showing oxidative stress and inflammatory markers in gastrointestinal, hepatic, or reproductive tissues. Dedicated cellular and clinical studies are still missing.

Older experiments reported frequency- and duration-dependent changes in hepatocytes, with longer or more intense exposures producing irreversible alterations [60]. These findings suggest a vulnerability of hepatic tissue, possibly mediated by oxidative stress

and mitochondrial dysfunction. However, given the age of these studies and the lack of biochemical or omics-level validation, conclusions must be cautious.

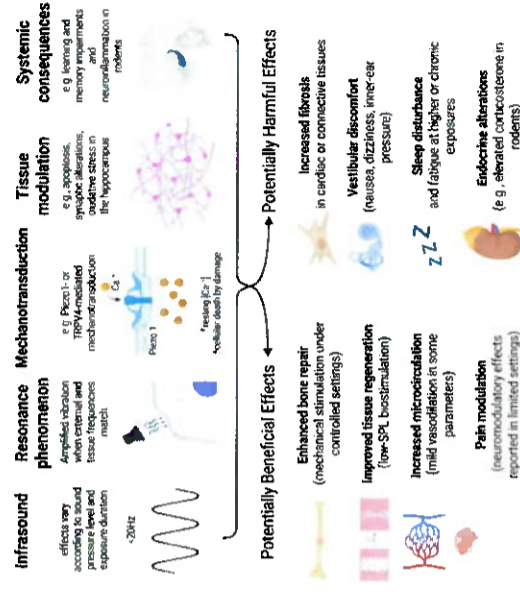
Male reproductive toxicity has been demonstrated in rodents. Repeated exposure reduced sexual behavior, suppressed testosterone, and altered the expression of steroidogenic genes [61], while other work described ultrastructural damage to testes [62]. Oxidative stress and apoptotic pathways are the most plausible mechanisms. No equivalent data exists in humans, and no *in vitro* germ-cell or Leydig cell studies have been published, leaving a major translational gap.

Animal studies suggest that infrasound may affect physical performance. In rats, endurance capacity decreased after repeated exposure, especially in animals with lower baseline ability, suggesting that infrasound may accelerate fatigue under certain conditions [63]. While this may reflect muscular strain, it is equally plausible that vestibular disturbance or altered proprioceptive feedback contributed to reduced performance.

### 3.3.2. Human Studies

In the auditory domain, psychophysical studies in humans as early as the 1970s demonstrated that infrasound is perceptible at sufficiently high sound pressure levels, with clear thresholds across the 0.5–16 Hz range [64]. Subsequent integrative work has reinforced the steep dependence of audibility on SPL [65]. Vestibular studies add an important dimension: controlled laboratory exposures have shown significant increases in postural sway and the induction of vertical nystagmus around 7 Hz at high SPLs [66]. Reports of non-auditory sensations, such as chest or abdominal vibration, support the claim that exposures are strong enough [67]. Evidence in humans is essentially absent, and there are no dedicated *in vitro* studies to clarify whether muscle fibers themselves are mechanically vulnerable. The respiratory literature is sparse. Early human studies reported minimal changes in breathing patterns during infrasonic exposure, although some participants reported discomfort or nonspecific symptoms at higher SPLs [68]. Systematic measurements of lung function or airway physiology remain lacking, and no controlled animal or cell culture models have yet clarified potential mechanistic pathways. There are also changes in the bronchial mucous membranes, as described by Alves Pereira in 2007. The images for this are in presented an earlier paper. The new PIEZO research now confirms that lung tissue also has a large number of PIEZO channels, i.e., it is sensitive to overstimulation [37,69].

According to current knowledge, the importance of external factors, particularly repeated exposure to low-frequency sounds and vibration during pregnancy, must be considered significantly more harmful than previously assumed. High sensitivity is related to various stages, particularly those of embryonic development, which are physiologically dependent on undisturbed capillary flow. Examples of specific phases of increased sensitivity include, e.g., vasculogenesis. After the differentiation of endothelial progenitor cells [70] and their fusion into a primary capillary plexus [71], the growth direction of the vascular tree is essentially regulated by blood shear stress and thus by mechanotransduction [72]. Together, these data illustrate how infrasound-triggered cellular and molecular mechanisms result in dysfunction across various organ systems, as summarized in Figure 1.



**Figure 1.** 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.

#### 4. Psychological and Behavioral Responses

Infrasound exposure, particularly from wind turbines used for electricity production, has been associated with a range of psychological and behavioral effects, although the underlying mechanisms remain complex and context-dependent. Experimental studies have demonstrated that expectation and framing can influence symptom perception [73,74]. For instance, participants exposed to wind turbine sound containing sub-audible infrasound reported fewer symptoms and lower annoyance when provided with positive information about infrasound, whereas negative expectations increased symptom reporting, consistent with nocebo effects [74,75]. Surveys of individuals reporting low-frequency noise complaints highlight a similar pattern, with many respondents describing sensations of vibration, sleep disturbance, and secondary effects such as headaches and palpitations, despite measured sound levels often being below hearing thresholds [76]. Laboratory investigations further emphasize that perceptions of infrasound vary widely between individuals: small changes in sound pressure at infrasonic frequencies can lead to large differences in perceived annoyance, and sensations beyond hearing (such as ear pressure, vibration, and discomfort) may occur even when tones are inaudible [77,78].

Beyond subjective reports, recent research has examined potential objective correlates of prolonged exposure to infrasound in humans. Long-term studies with controlled exposure to inaudible infrasound (6 Hz, 80–90 dB) found no significant effects on global cognitive performance, psychiatric symptoms, or sleep quality, though subtle trends in self-reported physical weakness were noted [47]. 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 [79].

Functional connectivity analyses revealed changes in specific brain networks, including the default mode, sensorimotor, and executive control networks, which were associated with self-reported somatic symptoms and annoyance [80]. These results suggest that while infrasound may not broadly impair psychological function in healthy individuals, it can modulate brain activity and bodily perception in ways that correlate with subjective annoyance. These findings, together with behavioral studies on expectation effects, highlight the

that both extracellular medium properties and cellular mechanosensors mediate microbial responses [17]. Finally, investigations in plant systems revealed that infrasound-induced changes in water structure and cell hydration may serve as sensitive signals of intracellular metabolic activity, indicating that physical cues can propagate molecular responses across diverse organisms [18]. Together, these findings reveal the multifaceted nature of infrasound, demonstrating its capacity to influence cellular processes through interconnected mechanical, biochemical, and biophysical mechanisms.

### 3. Systemic Effects on Organs and Tissues

#### 3.1. Cardiovascular System

##### 3.1.1. Animal Studies

Results from animal studies indicate that exposure to infrasound at high sound pressure levels (SPLs) can significantly affect components of the cardiovascular system. In contrast, human studies (particularly those conducted under controlled laboratory or epidemiological conditions) yield conflicting and complex results and often do not yield definitive conclusions.

Research focusing on rodent models has provided considerable insight into the myocardial effects of high SPL infrasound. *Rei et al.* (2007) [19] exposed rats to 5 Hz infrasound at 130 dB for 2 h daily over 1, 7, and 14 days, and evaluated hemodynamic, molecular, and ultrastructural indices at the end of each exposure period. The study showed a time-dependent change in the heart's function and structure. Left ventricular systolic pressure, together with  $+dp/dt$  and  $-dp/dt$ , showed a progressive increase and a decrease, respectively. Mitochondrial swelling and intracellular calcium levels also significantly and progressively increased during the exposure period. Inhibition of SERCA2 (Sarco/endoplasmic reticulum  $Ca^{2+}$ -ATPase 2) protein expression showed a unique pattern of predominance: after a one-day increase, there was a significant decrease after prolonged seven- and fourteen-day exposures. The varied muscular and ultrastructural disorganization was then accompanied by disrupted calcium homeostasis and impaired excitation-contraction-sarcomere coupling and relaxation mechanisms, which certainly deserve more attention [19].

Subsequent studies showed that exposure to infrasound induced apoptosis in neonatal rat cardiomyocytes by altering the expression of proteins involved in apoptosis pathways, including upregulation of Bax and caspases, the pro-apoptotic proteins, and downregulation of Bcl-2, the anti-apoptotic protein [20]. The same research group further demonstrated that exposure to infrasound increased oxidative stress by reducing PPAR- $\gamma$  expression and antioxidant enzyme activity, leading to cardiomyocyte damage. The pharmacological stimulation of PPAR- $\gamma$  significantly reduced these damages, as evidenced by decreased oxidative injury (lower lipid peroxidation), preservation of mitochondrial ultrastructure, and reduced cardiomyocyte apoptosis [21]. Overall, these findings indicate that increased intracellular calcium concentration, impaired mitochondrial function, activation of apoptotic pathways, and oxidative stress are among the most important mechanisms underlying myocardial damage from infrasound exposure.

Other animal studies corroborate these observations. *Lousinha et al.* (2018) demonstrated that rats exposed to infrasound developed coronary perivascular fibrosis, while dexamethasone attenuated the effect, implicating inflammatory pathways in the fibrotic response [22]. Similarly, *Antunes et al.* (2013) reported myocardial fibrosis in rats chronically exposed to low-frequency noise ( $\leq 500$  Hz, including infrasonic components), within the conceptual framework of "vibroacoustic disease" [23].

In contrast to the findings described above regarding infrasound-induced cardiomyocyte damage through increased apoptosis and oxidative stress [20,21], *Jin and co-workers*

specific organs or tissues [4]. 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 [5].

Resonance can intensify mechanical strain, promoting tissue deformation, mechanical transduction, 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 [6,7].

In order to maintain the integrity of cells and tissues in organisms in terms of structure, function, and communication, the unimpeded transmission of mechanical forces into biological and biochemical information is one of the most important fundamentals. At the cellular level, mechanical oscillations such as infrasound activate mechanosensitive ion channels, e.g., PIEZO1, TRPV4, and Connexin 43 (Cx43) hemichannels, by inducing membrane tension or substrate deformation [6]. These channels open to cation influx (mainly  $\text{Ca}^{2+}$ ), initiating signaling cascades that modulate proliferation, differentiation, and apoptosis [6]. PIEZO1 efficiently transduces low-frequency stimuli within the 0.5–50 Hz range, including infrasound [7]. TRPV4 is robustly activated around 16 Hz, particularly in glial cells [8,9]. Finally, Cx43 hemichannels, downstream of PIEZO1 or TRPV4, mediate ATP and glutamate release, sustaining intercellular communication [10]. Crosstalk among these channels forms a coordinated mechanosensitive network through which infrasound can influence tissue physiology and cellular homeostasis.

It is important to remember the dual nature of PIEZO channels in their context. PIEZO channels often participate in pro-inflammatory signaling, but, depending on the environment, they can also promote anti-inflammatory or homeostatic effects, mainly influenced by mechanical factors. For example, in endothelial cells, activation of PIEZO channels by laminar shear stress helps maintain vascular integrity. Conversely, when oscillatory forces dominate, pro-inflammatory responses tend to prevail, weakening vascular integrity and immune regulation [11].

At the cellular level, the effects of infrasound can influence multiple pathways, including proliferation, apoptosis, and intracellular signaling. For instance, studies on rat bone marrow mesenchymal stem cells (BMSCs) demonstrated that infrasound enhances proliferation and inhibits apoptosis, effects mediated in part through activation of the Notch signaling pathway and upregulation of the survival of a key anti-apoptotic protein [12,13]. In parallel, neuronal studies revealed that infrasound exposure induces oxidative stress and apoptosis in the hippocampus, which could be mitigated by antioxidant compounds that modulate the expression of Bcl-2, Bax, and caspase-3, underscoring the role of reactive oxygen species and apoptotic signaling in infrasound-induced cellular injury [14]. Furthermore, infrasound was found to alter blood–retinal barrier permeability by increasing the activity of calcium-activated potassium channels in retinal microvascular endothelial cells, demonstrating that infrasound can directly affect ion channel dynamics and cellular excitability [15]. These results emphasize that infrasound can actively reshape key regulatory pathways governing cell survival and functional integrity.

Infrasound has also been proven to impact glial and microbial cells. Astrocytes in the rat hippocampus responded to infrasound with increased A1 reactive astrocyte formation and elevated glutamate release via Cx43 hemichannels, effects that were modulated by the FGF2/FGFR1 pathway and microglial activation, highlighting the involvement of neuron–glia interactions in central nervous system injury [13,16]. Similarly, microbial studies demonstrated that mechanical vibration at infrasound frequencies can either stimulate or inhibit bacterial growth depending on the duration and frequency of exposure, suggesting

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 [89,90].

## 7. Concluding Remarks

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.

**Author Contributions:** Conceptualization, M.D. and C.L.; literature review and synthesis, M.D., E.D.P.R.; writing and original draft preparation, M.D. and E.D.P.R.; writing, review, and editing, U.B.-S., J.Z. and C.L.; supervision, C.L.; project administration, C.L. All authors have read and agreed to the published version of the manuscript.

**Funding:** This research received no external funding.

**Institutional Review Board Statement:** Not applicable.

**Informed Consent Statement:** Not applicable.

**Data Availability Statement:** Not applicable.

**Acknowledgments:** The authors would like to thank Bernhard Scherzinger and Marcel Brennekamp for their helpful technical discussions and insights that contributed to the development of this review.

**Conflicts of Interest:** The authors declare no conflicts of interest.

## Abbreviations

The following abbreviations are used in this manuscript:

IS	Infrasound
SPL	Sound pressure level
TRPV4	Transient receptor potential vanilloid 4
Cx43	Connexin 43
Hz	Hertz
ROS	Reactive oxygen species
NF-κB	Nuclear factor kappa B
TNF	Tumor necrosis factor
IL-1β	Interleukin 1 beta
IL-6	Interleukin 6
LTP	Long-term potentiation
AD	Alzheimer's disease
PPAR-γ	Peroxisome proliferator-activated receptor gamma

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# Wind turbines: Vacated/abandoned homes study – Exploring research participants' descriptions of observed effects on their pets, animals, and well water

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## Abstract

**Background:** Neighbors living within 10 km of industrial wind turbines have reported occurrences of adverse health effects and contemplated vacating their homes. Some participants described concerns for wildlife and effects on their pets, animals, and well water. While sources such as the scientific literature, social media, and Internet websites have reported these effects, research is limited.

**Methods:** This ethics-reviewed study used the qualitative grounded theory methodology and interviewed 67 consenting participants, 18 years or older who had previously lived, or were currently living within 10 km of wind turbines. Audio files were transcribed to text, and the data were coded and analyzed using NVivo Pro (version 12.6) software.

**Objectives:** The objectives of this study were to explore participants' descriptions of effects related to their pets, animals, and well water and to generate a theory.

**Results:** Data analysis revealed primary themes of environmental interference and altered living conditions and associated sub-themes of effects on animals and well water.


**Discussion:** Internationally and in Ontario neighbors have reported effects on their pets and domestic animals, concerns for wildlife, and a loss of potable well water. It is recommended that members of the public, government authorities, policy-makers, researchers, health practitioners and social scientists with an interest in health policy acknowledge the potential for these effects and seek resolution for those negatively affected.

**Keywords:** Wind turbines, grounded theory, vacated homes, adverse effects, animals, pets, well water

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Submitted: 06-Jun-2023, Revised: 23-Jul-2023, Accepted: 25-Jul-2023,  
Published: 29-Mar-2024

Access this article online	
Quick Response Code:	Website: <a href="http://www.environmentalmed.org">www.environmentalmed.org</a>
	DOI: 10.4103/ed.ed_2_23

## INTRODUCTION

The risk of adverse health effects (AHEs) associated with living within 10 km of industrial wind turbines (IWTs)

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**How to cite this article:** Krogh CM, McMurtry RY, Johnson WB, Punch JL, Dumbrielle A, Alves-Perreira M, et al. Wind turbines: Vacated/abandoned homes study – Exploring research participants' descriptions of observed effects on their pets, animals, and well water. *Environ Dis* 2024;9:1-12.

is unresolved and continues to be debated globally. Descriptions of these effects are reported to have occurred in neighbors and workers who live or work in proximity to these facilities.<sup>[1-4]</sup>

Participants describe concerns for wildlife, occurrences of AHEs, and effects on their well water and pets and animals. In some instances, unusual animal behavior included aggressiveness, birthing problems, and a decline in fertility of their farm animals.

This ethics-reviewed study used the qualitative grounded theory (GT) methodology to conduct a study in Ontario, Canada. It explored the events that motivated individuals and families living within 10 km of a wind power plant (WPP) to contemplate vacating/abandoning their homes. In addition to this manuscript five others manuscripts have been published: preliminary findings<sup>[1]</sup>, an overview of findings<sup>[2]</sup>, an exploration of the study's use of a qualitative methodology, specifically the Grounded Theory<sup>[3]</sup>, the effects of a government policy that resulted in participants becoming informed and taking action<sup>[4]</sup>, and AHEs and medical diagnoses provided by participants' physicians and physician specialists.<sup>[5]</sup>

## METHODOLOGY

Reproduced from<sup>[4]</sup> a pilot study was conducted prior to initiating this research. Its results supported that this study's approach was suitable for the vacated home study. Our study methodology conformed to the CONSOLIDATED criteria for REporting Qualitative research (COREQ) checklist. Two additional processes that are not identified in COREQ were included in our methodology to further strengthen study rigor – a process controller and a scrutinizer. The process controller documented schedules, the interview process, and data records. The scrutinizer maintained the integrity of the data collected.

Government hearings and legal proceedings, media, and international citations had reported AHEs and that some had vacated their homes. To gain an understanding of why some families living in proximity to a WPP/TWT facility contemplated vacating their homes, several research questions were identified:

1. What are the particular circumstances which influenced whether to vacate or not vacate a family home?
2. How did families arrive at their decision?
3. Were there consequences related to their decision?
4. Did these circumstances influence physical, mental, and social well-being?

Participants were required to be 18 years of age or older, proficient in the English language and to have lived or were currently living within 10 km of a WPP. Invitations were distributed to key informants such as community leaders and neighbors as these individuals were likely to generate rich data.<sup>[6]</sup> There were no restrictions on the distribution of the invitation. The purpose of the study was summarized and participants were advised that there would be an opportunity to describe the circumstances that may have influenced “whether to vacate or remain in their home.”

The intention was to explore the “extent of these occurrences and the impact or lack of impact” of living within 10 km of a WPP. Prior to consent, all participants were advised that even if they had signed the consent form, they could decline to answer any question and decline to continue with the interview. If this occurred, all their information would be immediately destroyed. There were no participant withdrawals and the individual interviews were conducted as scheduled.

With the informed consent of all participants, trained interviewers began each interview with a single, nonleading question, i.e., to discuss the events that led them to contemplate vacating their home. Face-to-face interviews were held with each participant in their homes with few exceptions. In some cases due to travel issues such as distances or inclement weather, some interviews were conducted by telephone. Participants were advised that the interviews would last 1 h; however, the interviewers did not limit this and some interviews exceeded an hour. All 67 participants agreed to have their interviews recorded and were offered an audio copy at its conclusion. The audio files were converted to text and NVivo Pro (version 12.6, QSR International [Americas] Inc., Burlington, MA, USA) software was used to analyze and code the data. The GT's iterative methodology was followed, and the interviews concluded with the 67<sup>th</sup> participant when saturation occurred and no new information was forthcoming.<sup>[1-4]</sup> Statistical and demographic information and the home status of participants are available at Krogh *et al.*, 2020.<sup>[3]</sup>

## Clinical trial registry

No clinical trials were involved.

## Themes: Sub-themes and the 5 Elements

Rose *et al.* comment that Strauss and Corbin proposed a “coding paradigm intended to help with data analysis by suggesting what to look for when coding” and provided a version of this approach, i.e., the 5 Elements.<sup>[7]</sup>

Krogh *et al.* found that this approach and the use of a systematic method to transcribe, code, and analyze the data acquired during the interviews were applicable to the vacated/abandoned home study.<sup>[13]</sup>

The application of the 5 Elements is illustrated in Figure 1: themes and sub-themes and their relationship to the 5 Elements

Within the context of this study, the 5 Elements proposed by Rose *et al.* were associated with the analyzed data.

- Element 1: The “central phenomenon” – The focus of the study is the siting of IWTs within 10 km of participants’ homes.
- Element 2: The “causal conditions that contributed to the phenomenon” include findings of the primary and sub-themes of the effects of environmental interference and altered living conditions, as described in Figure 1, Element 2.
- Element 3: The “context in which the phenomenon is embedded” is associated with a government policy. Participants became informed and took action through governmental and other processes, as described in Figure 1, Element 3.
- Element 4: The “actions and interactions taken by people in response to the phenomenon” resulted in participants contemplating housing decisions, as described in Figure 1, Element 4.
- Element 5: The “consequences of those actions and interactions

taken in Element 4” include an “aftermath,” as described in Figure 1, Element 5.

This report analyses the sub-theme of effects on pets, animals, and well water as described in Element 2. The results of Elements 4 and 5 will be addressed in separate manuscripts.

As proposed by Castillo-Montoya, every effort was made to accurately represent the voices of participants by the use of verbatim quotations throughout this manuscript.<sup>[18]</sup>

To maintain participant confidentiality, the authors have intentionally avoided reporting details that could identify specific individuals, geographical locations, sitting distances, or the details of the WPP/IWT projects.

## RESULTS AND DISCUSSION

### Effects on wildlife, pets, and animals

Table 1 provides participants’ descriptions of concerns for wildlife and effects on their pets and animals.

Birds and bats, domestic animals and wildlife,<sup>[16,19]</sup> terrestrial organisms,<sup>[16]</sup> and aquatic animals and marine life<sup>[17,18]</sup> are reported to be affected by noise. Reports of IWTs adversely affecting animals, birds and bats, and other species are also available.<sup>[16,20]</sup> Baerwald *et al.* found that “90% of bat fatalities involved internal hemorrhaging consistent with barotraumas,”



Figure 1: Themes and sub-themes and their relationship to the 5 Elements<sup>[9]</sup>

and that only about half of the fatalities were from direct contact with IWT blades.<sup>[21]</sup> The Wildlife Society Technical Review commented that:

Impacts of wind energy facilities on wildlife can be direct (e.g., fatality and reduced reproduction) or indirect (e.g., habitat loss and behavioral displacement).<sup>[22]</sup>

In 2010, it was documented that horses from a Portuguese horse-breeding farm were affected by a WPP:

Between 2000 and 2006, 13 healthy thoroughbred Lusitanian horses were born and raised on Mr. R's property. All horses (N=4) born or raised after 2007 developed asymmetric flexural limb deformities. WT began operations in November 2006. No other changes (constructions, industries, etc) were introduced into the area during this time.<sup>[23]</sup>

Some judicial proceedings have ruled that IWTs affect some animal species. For example, Cuff reported that in a legal settlement to reduce deaths of "eagles, hawks and other raptors hacked by turbine blades," a wind energy producer agreed to pay \$2.5 million and "replace 2400 wind turbines within 4 years."<sup>[27]</sup>

During an Ontario Environmental Review Tribunal (ERT), it was noted that the WPP/IWT developer had received a

permit from the Ontario Ministry of Natural Resources to "kill, harm and harass" the Blanding's Turtle – an endangered species.<sup>[29]</sup> However, despite receipt of this permit, the Tribunal ruled that since the project will "cause serious and irreversible harm to animal life, a species at risk and its habitat," proceeding with the project would not be consistent with the approval purposes of the Environmental Protection Act, or serve the "public interest."<sup>[28]</sup> In another case, it was reported that the renewable energy provider pleaded guilty to criminal charges after "at least 150 eagles" had been killed at WWP sites in eight states and was ordered to pay over \$8 million dollars (US) in fines and restitution. Federal prosecutors commented that the company had an advantage over its competitors who took steps to "protect eagles or to obtain permits to kill the birds."<sup>[29]</sup>

Environmental impacts can occur during the use of wind energy:

As with all energy supply options, wind energy can have adverse environmental impacts, including the potential to reduce, fragment, or degrade habitat for wildlife, fish, and plants. Furthermore, spinning turbine blades can pose a threat to flying wildlife such as birds and bats.<sup>[30]</sup>

Myklebust and Raftery indicate that while it was "too soon" to conclude that IWTs have caused human AHEs

Table 1. Participants' descriptions of concerns for wildlife and effects on their pets and animals

Each example is by a different participant

- We are responsible people. We tried to do everything in a responsible way and we couldn't keep these horses in this contamination anymore - we've moved our family out.
- The effect of wind turbines is not a good ingredient for humans or animals. Wind turbines do affect us it's a reality of the impact of an industrial entity impacts humans, animals. My cats - I don't have full evidence but I think they have been impacted. The side effects of the wind turbines. My cats are disturbed as much as me. The quality of our life is slipping.
- Unbearable agony at watching your pets, horses, livestock suffer and not being able to get them away from it that only gets worse when one has to leave for temporary respite and is unable to provide the same for the animals.
- I have my animals. I would be abandoning my animals [if the participant abandoned the property]. I would have to find new homes for them. It just doesn't seem responsible to me that way. Then victimize the animals, you can't just pick up and take [large animals] any place.
- Animals are important because of our concern about wind turbines.
- When a person's home and health are threatened and the animals that they love are threatened, that's not good for [the animals'] health and their well being. I was concerned for my animals' health. I had goats... it became awful when birthing season came... the babies were either stillborn or mummified. It was extremely upsetting to be exposed to that, and to know that they had pain and were suffering, and there was nothing I could do.
- Cows were suddenly being stillborn because he [the bull] was by the substation.
- We had to put our bunny down. He was very challenged staying upright. I'm assuming it's vertigo because her [the dog's] head will sway and she'll throw up. Our pets were feeling it... Our dog got an infection, stomach aches, muscle leg aches.
- My dog started [having seizures]. She would only seizure when the wind was blowing from the Southeast or the East. She started other things like her coat started getting really shabby and she started gaining weight and just being looking unhealthy! I kept track of everything I know it was the turbines. I absolutely know in my heart that it was the turbines. We eventually lost her. Our 2 horses, one was [age], and the other was [age]. They would no longer go in the shelter. I'm sure the wind mills affected my one filly. She was a nice, calm and cool and then she just got a little more ecstatic as time went by. When she was facing the windmills, she just went in circles. I could never control her again after that.
- [before IWT] Normally when you put your combine in the shed, the mice would come and eat the leftovers. There were no mice, the cars they didn't even go into the barn or the shed [after IWT].
- Our horses would jump the fences. That had something to do with turbines.
- We lived with [a family member]. We still had our horses and it was brutal leaving them every night in everything that was going on [participant sobbing].
- When I let them [participants' dogs] out the door that's on that side [of the wind turbines], they'll stop on the doorstep and kind of look out at the woods in the direction that these things are their cars are peked and seemed they're interested in something.
- It was the land we were concerned about and of course the wildlife.
- They [government] were allowed to go ahead with the killing and harassing of wildlife and rare species.

Table 2. Participants' descriptions of effects on their well water

Each example is by a different participant

- When they [WWT developer] started drilling and digging, the animals got sick... part of the water system in the aquifer that they were blasting... caused the drinking water for my animals to be not good for them - not potable. I struggled for many, many weeks during the initial drilling to make sure that the animals stayed safe. We lost some anyway, they just did!
- After they started construction, there have been as far as I know to this day, [more than a dozen] wells impacted. The developer is still [saying] that they're not responsible, that it's all coincidental... their position and their argument is to put the blame on the well owners.
- The ministry [Ontario Ministry of Environment] appears to be sitting on their hands. They've said that they're very concerned about it [well water problems], they're looking at it closely but it's going to take them three months to come back with an analysis of the problem. They're using turbidity as their chief measurement. I've done hundreds of turbidity checks myself in my career. I can do at least two dozen in an hour.
- [A neighbor] told me that their well water was rained. [They] could feel a vibration in the ground a vibration from these large turbines that they're disturbing the underground water - as we know this is what happened in [Ilocosano]. My well water is disturbed. I have grey water in my toilet bowl all the time. I can change the filters, but it's there again, the turbines are operational and they're constantly disturbing the water.
- We had beautiful hard water but it was fresh and clean. You couldn't drink the water afterwards... [after IWTS]. We had to replace the toilets twice. We had to fix our own well. We put in an ultraviolet.
- [Ontario Hydro, they even changed the smart meter. They put new grounds on that pole and they said with that turbine over there, that the hydro could come right through the water table and right around near your house.

and animal deaths, it was “dangerous to assume that wind turbines are safe for animals or humans living in close proximity” and there was a need for caution before building “wind turbines in areas near wildlife, livestock, and people.”<sup>[131]</sup> The U. S. Geological Survey’s “frequently asked questions” comment that:

A key challenge facing the wind industry is the potential for turbines to adversely affect wild animals both directly, via collisions, and indirectly due to noise pollution, habitat loss, and reduced survival or reproduction. Among the most impacted wildlife are birds and bats, which by eating destructive insects provide billions of dollars of economic benefits to the country’s agricultural sector each year.<sup>[132]</sup>

By using hair cortisol levels, Agnew *et al.* found that “hair of badgers living <1 km from a wind farm had a 264% higher cortisol level than badgers” at distances greater than 10 km. This demonstrated that affected badgers “suffer from enhanced hypothalamic–pituitary–adrenal activity and are physiologically stressed.” Since no differences were found between the “cortisol levels of badgers living near wind farms operational since 2009 and 2012,” indications are that the badgers do not “become habituated to turbine disturbance.”<sup>[133]</sup> A review by Dumbtrie *et al.* summarized some of the reported animal-related adverse effects associated with IWTS such as reproduction and teratogenic effects and deformities in Canada, Denmark, Japan, Portugal, and the USA, and mortalities in Canada, France, and Taiwan. Examples of reported effects included teratogenic effects in cattle such as missing eyes and tails; cancer deaths; cows not calving properly, aborting and bleeding nostrils; teratogenic effects in chickens such as “crossed beaks, missing eyeballs, deformities of the skull, joints of feet/legs bent at odd angles.”<sup>[134]</sup> Ontario neighbors reported that cattle exhibited unusually “aggressive and erratic behavior” and “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.” Other reported effects that were “temporally coincidental with the installation of IWTS and associated generating stations” included goats-reduced fertility (Canada) and mortalities (Taiwan); Fawn-mortalities (Canada); and milk-miscarriages and birth defects (Denmark).<sup>[135]</sup>

Research participants’ concerns for wildlife and their descriptions of adverse effects on their family pets and domestic animals that they considered were associated with living near WPPs are consistent with similar descriptions by the international community.

**Effects on well water**

Table 2 provides participants’ descriptions of effects on their well water.

**Well water disruption in Ontario, Canada, and internationally**

In 2019, groundwater Canada advised that many rural Ontario families are “completely dependent on groundwater.”<sup>[136]</sup> Study participants described IWTS-related water issues that are similar to the adverse effects being described by Ontario neighbors.<sup>[135-38]</sup> For example, in 2018, Clarke commented that in Ontario:

There are 19 families who have registered a well interference complaint with the MOECC. Each of these families has experienced distinct, observable changes in their well water, which expresses itself as cloudy and often includes dark particulates.<sup>[138]</sup>

In another case, it was reported that to avoid possible contamination of groundwater, the Ontario Ministry of Environment requested that the IWTS developer seals the foundations of more than “300 utility poles” associated with a transmission line.<sup>[139]</sup>

Ontario's "protection framework" includes testing procedures, and promises "swift, strong action on Adverse Water Quality Incidents."<sup>[40]</sup> The Ontario Ministry of the Environment stresses that:

Protecting water at its source is a crucial first step in Ontario's approach to delivering safe drinking water. When you turn on your tap, you can be confident that your drinking water is among the best protected in the world.<sup>[41]</sup>

Achieving timely acknowledgment and resolution of their well water issues has been challenging for affected Ontario families. It was reported that in 2016, some Ontario neighbors believed that IWT construction-related pile driving resulted in black shale and hazardous materials leaching into their well water. The local Medical Officer of Health (MOH) assured concerned neighbors by explaining that since "sediments are not soluble in water, they cannot be absorbed by the body and pose no health hazard."<sup>[42]</sup> Subsequently, during a 2019 IWT noise conference presentation, the MOH concluded that:

There is no evidence that wind turbine construction or operation results in the contamination of groundwater and no scientifically plausible mechanism has been offered by which groundwater contamination with translocated sediments or associated health hazards could theoretically occur.<sup>[43]</sup>

Baseline testing conducted prior to IWT construction, and testing during construction reported that at least one local well had a "14,000 times increase in black shale particles."<sup>[43]</sup> Several years after black shale had appeared in well water, analyses found that sediments were raising more concerns than before including "excessive sediment, problematic gases and potentially infection-causing biofilm," and that these were among the problems "plaguing water-well owners" in the area.<sup>[44]</sup> Findings included that:

The sediments that have been continuously discharging into a number of water wells since wind farms were constructed in North Chatham-Kent have been found to contain Kettle Point Black Shale.

Furthermore:

Kettle point black shale is a material considered an Environmental Hazard in Canada because it has been shown the material contains heavy metals such as arsenic, mercury, lead, and uranium.<sup>[45]</sup>

In 2019, the Ontario Government launched a "Health Hazard" investigation during which an independent panel of scientists was charged with the investigation of

approximately 200 privately owned water wells across the affected area.<sup>[46]</sup> However, concerns were raised by some of the affected neighbors that there were several "serious shortcomings" and a need to include members from the disciplines of "hydrogeology, seismology, and geochemistry for black shale."<sup>[45]</sup>

The local Ontario Member of Provincial Parliament (MPP) commented that "clean energy technology is contaminating farmers' wells" by the leaching of black shale into well water. The bedrock is made of "kettle point black shale" and pile-driving contaminates the groundwater by breaking up the "toxic shale." As a result, residents are unable to "drink, bathe, or wash their clothes." MPP Nicholls noted that the water wells are being "poisoned as the government continues to allow the pile driving." He asked whether the government would do the right thing by stopping the groundwater contamination and placing a moratorium on IWTs until scientific evidence disproves the claim that IWTs are "polluting the environment."<sup>[46]</sup>

A professional opinion advised that regarding IWT-related complaints of well water disruption, there was:

A distinct relationship between the wind tower project and the impaired wells. This is the time to suspend the project until we know more. Otherwise, blindly barging ahead will result in more damage.<sup>[48]</sup>

Additional testing was conducted in late 2022 by a former member of the Expert Panel who had provided advice during the Ontario all-hazard investigation of well water. A summary indicated there was an apparent deterioration of the general quality of private wells in the affected area occurring between 2017 (prior to IWT construction) and 2021 when sampling was completed. It was recommended that more sampling and analysis of sediment was warranted and that:

Whatever might be responsible for the decrease in water quality apparently did not affect wells outside of the industrial wind complex.<sup>[47]</sup>

An Ontario neighbor advised Ontario's Ministry of Health (MOH) that people were angry and had "little trust in almost any government agency." This mistrust resulted in numerous homeowners refusing to participate in further water testing. While there were valid questions about the process, there was a "complete lack" of communication and an inability to obtain answers. The neighbor proposed that in order to encourage participation in future testing, the Ministry communicates on the process and provides an avenue for questions and answers.<sup>[48]</sup>

Following Ontario's all-hazard investigation of well water,<sup>[47]</sup> additional testing raised toxicity concerns.<sup>[48]</sup> A deputation includes a bar chart that represents a plot of metal concentrations as determined for the solid particulates ("sediments") extracted from water samples collected from 9 private wells in northern Chatham-Kent. The wells are located within the footprints of three industrial wind turbine complexes where residents have reported increased turbidity of their domestic water during and following wind turbine construction. Previous analyses have shown that the grain sizes of sediments sampled from several wells are mostly 10 µ or less. The concentrations of metals within the sediments are similar to those documented for the Kettle Point black shale geological formation that forms the bedrock beneath the aquifer and that is also known to be present within the aquifer.<sup>[49]</sup> Should the metals in the fine-grained sediments prove to be bio-accessible the risk of toxicity associated with consumption of the well water could be quite high.<sup>[50]</sup> Appendix 1 provides the bar chart of selected Metals in solid fraction units: µg/kg.

Internationally similar concerns relating to WPP/IWT disruption of well water have also been expressed. For example, in Scotland, neighbors living near a WPP reported suffering from severe vomiting and diarrhea. Testing revealed that the water supply was bacterially contaminated.<sup>[51]</sup> It was also reported that the "biggest windfarm" in Scotland contaminated the public water a supply with cancer-causing chemicals<sup>[52]</sup> and that a report indicated WPPs had contaminated water supplies.<sup>[53]</sup> Another report claimed that well water had deteriorated with the onset of construction of the WPP.<sup>[54]</sup> Another report from Europe claimed that the power company knew about the polluted water supply.<sup>[55]</sup> In another case, it was reported a development of a WWP was stopped due to complaints by residents that the "work was polluting" their water supply.<sup>[56]</sup> In California, it was believed that an IWT project may have changed the "hydrology of the desert"<sup>[57]</sup> and in Vermont concerns were raised on how to "maintain and protect water quality" of the Lowell Mountains.<sup>[58]</sup>

The Northern Ireland Environment Agency comments that:

The development of a wind farm has the potential to impact on groundwater quality, groundwater quantity, and/or the established groundwater flow regime.<sup>[59]</sup>

The Agency also presents in Figure 1 that 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.<sup>[59]</sup>

The United States Bureau of Land Management advises that there is a potential for IWTs to affect surface and groundwater and that:

Soil erosion can be aggravated locally through ground surface disturbance. The impact of soil erosion includes soil nutrient loss and degradation of water quality in nearby surface water bodies. The magnitude of the impact depends on the project size, erosion potential of the soil, local terrain, vegetation covers, and the distance from a site to nearby surface water bodies.<sup>[60]</sup>

Furthermore:

A wind energy project can impact surface water and groundwater in several different ways, including the use of water resources, changes in water quality, alteration of the natural flow system, and the alteration of interactions between the groundwater and surface water.<sup>[61]</sup>

Dodds, a Ph. D. and licensed professional geologist provided an opinion regarding the risk of effects on groundwater and residential well water associated with IWT construction. It stated that one of the best management practice advances is "controlled drainage" and the proposed construction will cause cumulative adverse impacts on forests, habitat, and water resources such as "increased stormwater discharge to receiving streams." In addition, installation of electrical collection lines will result in "uncontrolled drainage of intercepted groundwater to receiving streams."<sup>[61]</sup> Dodds also provided direct and rebuttal testimony stating that:

If the route to seeps and springs or to residential wells is changed, then the groundwater may not be sufficient to continue providing water to specific seeps, springs, or residential wells.<sup>[62]</sup>

The importance of clean water is acknowledged by the United States Environmental Protection Agency: clean water is "vital to our health, communities, and economy."<sup>[63]</sup> Clean water is also considered the "most important thing you take into your body."<sup>[64]</sup> The World Health Organization also acknowledges the importance of safe water:

Safe and readily available water is important for public health, whether it is used for drinking, domestic use, food production or recreational purposes. Improved water supply and sanitation, and better management of water resources, can boost countries' economic growth and can contribute greatly to poverty reduction.<sup>[65]</sup>

An Australian Senate Committee cites the Australian National Health and Medical Research Council that states:

Consumers are the ultimate assessors of water quality. Consumers may not be able to detect trace concentrations of individual contaminants, but their ability to recognize change should not be discounted. In some cases, consumer complaints may provide valuable information on potential problems not detected by testing water quality or monitoring treatment processes. Water quality testing has limitations and there are many possibilities for contamination of water in reticulation systems after treatment. All consumer complaints should be investigated to ensure that otherwise undetected problems that might compromise drinking water safety have not occurred. Meeting reasonable consumer expectations and maintaining confidence in the water supply is vitally important.<sup>164</sup>

## CONCLUSIONS

Participants living within 10 km of IWTs described concerns for wildlife and the effects they observed on their pets, animals, and well water. These descriptions are similar to those by international neighbors. Some authorities and researchers have expressed concerns regarding the potential risks of these effects that have been associated with WPPs/IWTs.

It is recommended that members of the public, authorities, policy-makers, decision-makers, and WPP/IWT developers respond to the potential risks to animals and humans to disturbances of groundwater, streams, aquifers, and residential wells associated during the construction and onset of WPP/IWT operations. Priority should be given to restore clean well water and resolve the issues to the satisfaction of those neighbors who have been affected.

The GT methodology was used to develop a substantive theory regarding the housing decisions of participants living within 10 km of a WPP. Results from the participant's interviews support the theory that these decisions were motivated by the potential for, or the experience of adverse effects including those related to pets, animals, and well water that participants attributed to living in proximity to the WPPs.

## Author contributions

All authors have contributed to this manuscript by providing their input, comments, support and agreement to this manuscript's publication.

## Ethics review

Chesapeake Research Review, LLC ("Chesapeake IRB"), Pro00022827, dated on September 25, 2017.

Note: Chesapeake Research Review, LLC ("Chesapeake IRB") and Schulman Associates Institutional Review Board, Inc. ("Schulman IRB") have merged to create Advarra, Inc. ("Advarra IRB").

## Data availability statement

The data generated and/or analyzed during this study are included in this published article.

## Financial support and sponsorship

Magentica Research Group Not for Profit (Corporations Canada) is partially funded by private donation.

## Conflicts of interest

There are no conflicts of interest.

## Acknowledgments

This article is dedicated to those who participated in this vacated home study. The study would not have taken place without their willingness to share the events that took place during the contemplation of vacating their homes when living within 10 km of IWTs. Their observations and candid insights led to an understanding of the effects associated with their pets, animals, and well water. We thank our interviewers, who volunteered their time and traveled considerable distances in order to conduct the interviews. Finally, we thank those who encouraged us to conduct the vacated home study and who provided the funding for the Ethics Review, the coding software, and costs associated with Open Access publishing that enabled the conduct of this study and its publication. We also dedicate this manuscript to two of our co-authors who have recently died. We wish to acknowledge their contribution to this research. Mr. James was a respected acoustician whose numerous contributions are valued nationally and internationally. On behalf of Appellants, he testified under oath during numerous judicial proceedings. He was a consummate professional and a beloved friend to many of his colleagues, authors, and others who were fortunate enough to know him personally. Mr. Ambrose had a long and successful career as a principal investigator in acoustics and held paramount the safety, health and welfare of the public. He co-authored two ground-breaking peer-reviewed acoustic papers and for the next decade provided professional consulting to numerous communities on the effects of wind turbine noise. Both gentlemen are deeply missed.

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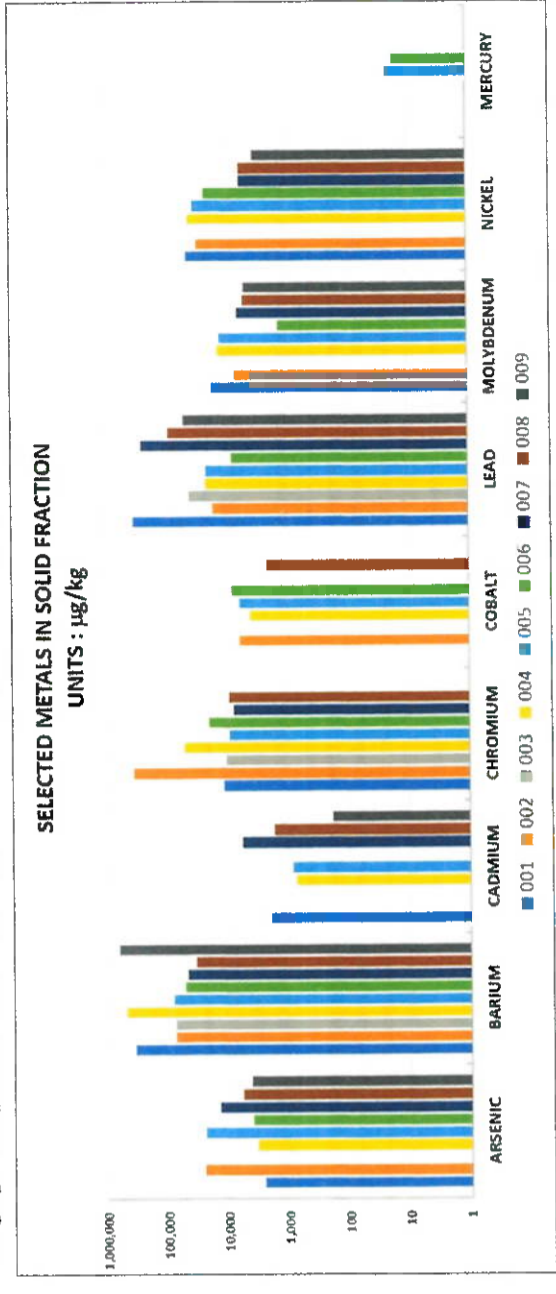
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**APPENDIX**

The graph was prepared and provided to the author by Dr Keith Benn, P. Geo.



Appendix 1: Selected Metals in Solid Fraction Units: µg/kg

# Noise pollution and public health curricula: a missing link in environmental health preparedness

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Academic Editors: John Capimian, Matteo Charles Malvezzi

## Abstract

Environmental noise is a pervasive yet under-recognized public health hazard. Robust evidence links transport and community noise exposure to a range of adverse health outcomes, including sleep disturbance, cardiovascular disease, cognitive impairment, and reduced quality of life. Yet, despite its clear health burden, noise pollution remains marginal in global health agendas and is inconsistently integrated into education and training. Recent reforms to public health curricula, particularly in the United States, have contributed to a broader erosion of environmental health content, with noise largely absent or reduced to a subtopic within occupational health. This educational gap has significant implications: graduates often lack competencies in community exposure assessment, epidemiological interpretation, policy evaluation, and intersectoral interventions. Addressing the underrepresentation of noise in public health training is therefore a critical step toward mainstreaming noise as a determinant of health. Embedding core competencies on noise pollution in MPH curricula would enhance professional readiness, promote equity, and better align public health capacity with the scale of the problem.

**Keywords:** *noise pollution, higher education, public health, professional practice*

**Citation:** Aletta F. Noise pollution and public health curricula: a missing link in environmental health preparedness. *Academia Global and Public Health* 2025;1. <https://doi.org/10.20935/AcadPHHealth8070>

## 1. Why noise matters for public health

Environmental noise is a pervasive pollutant with well-established impacts on human health. Unlike many other environmental hazards, it is not directly ingested or inhaled but enters the body through auditory and non-auditory pathways, exerting both acute and chronic effects on physiological systems [1]. Decades of research have demonstrated that environmental noise—particularly from transport sources such as road traffic, railways, and aircraft—is associated with a range of adverse outcomes, including sleep disturbance, cognitive impairment, cardiovascular disease, and reduced quality of life [2]. The World Health Organization (WHO) has recognized noise as the second most significant environmental stressor in Western Europe after air pollution [3]. Despite this robust evidence base, noise pollution remains under-addressed in many national and global public health fora [4]. For instance, noise is rarely featured in major public health monitoring frameworks or burden of disease estimates beyond Europe, and few countries have developed comprehensive noise action plans with the same urgency seen in air quality or climate adaptation strategies. In practice, responsibility for noise regulation often lies with environmental or transport authorities, and its health implications are insufficiently mainstreamed into public health planning, education, and advocacy.

This marginalization raises important questions about the epistemic and institutional conditions that shape public health priorities. A number of factors may explain why noise pollution remains comparatively underemphasized within public health teaching and research. First, the attribution of health effects to noise is often complicated by its collinearity with other urban exposures

(particularly air pollution) making causal connections sometimes challenging and often relegating noise to a secondary consideration in environmental epidemiology. Second, historical framings of “quiet” have been tied to socio-economic privilege, with noise sometimes treated as an aesthetic or lifestyle concern rather than a population-level environmental health determinant, which can obscure its equity implications. Third, political-economic pressures surrounding transport and industrial activity may implicitly discourage expanding public health scrutiny into domains where regulatory implications are costly or socially contentious. Finally, contemporary public health pedagogy has tended to prioritize mechanistic physiological pathways over broader social, cultural, and infrastructural determinants, thereby disadvantaging environmental stressors—such as noise—whose impacts are mediated by context, place, and lived experience. Together, these epistemic orientations may have contributed to noise pollution’s relatively weak integration into environmental health narratives despite its well-established disease burden.

However, a contributing factor that has received little attention in the literature is the limited integration of noise pollution into public health education and training. Although environmental health is commonly taught in Master of Public Health (MPH) programmes and other health-related degrees, syllabi tend to focus on air and water pollution, food safety, and chemical hazards, with only limited references to environmental noise. The result is a cohort of emerging public health professionals and scholars who are often unaware of the scope and seriousness of noise-related health burdens.

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## 2. Declining environmental health content in public health curricula

The recent literature has shown that the gap in public health training does not necessarily apply to noise pollution *per se*, but rather to environmental factors more broadly. For instance, Levy et al. [5] highlighted a growing concern in public health education: the steady erosion of environmental health (EH) content in Master of Public Health (MPH) programmes. The authors argued that this decline undermines the capacity of the future public health workforce to respond to pressing challenges such as climate change, pandemics, and systemic environmental injustices. In a United States context, they traced much of the problem back to the 2016 revisions of the Council on Education for Public Health (CEPH) accreditation standards, which shifted from requiring five core content areas—including EH—to a competency-based model. In this new framework, EH is treated only as a learning objective rather than a core competency, possibly signalling to institutions that EH content is less critical. The result has been fewer standalone EH courses, fewer MPH programmes offering EH concentrations, and a risk that many graduates enter the workforce without sufficient EH training. The consequences of this shift extend well beyond academia. A substantial proportion of the governmental public health workforce—particularly in preventive medicine and environmental practice—relies on foundational EH knowledge to carry out its mission. The lack of rigorous EH education risks leaving professionals ill-prepared to address issues ranging from food safety and water quality to climate resilience and environmental justice. While these observations are specific to national (U.S.) circumstances, other countries around the world face similar prospects.

The COVID-19 pandemic starkly illustrated how the environment shapes health outcomes, especially for vulnerable and marginalized communities disproportionately exposed to environmental hazards [6]. However, the question of EH training in medical education is not new. Gehle et al. [7] previously argued that despite the significant role environmental factors play in global disease burden, training on environmental health is largely absent from medical education in the U.S. This lack of exposure results in physicians being underprepared to recognize, prevent, or manage environment-related illnesses, ultimately leading to missed opportunities for prevention and early intervention. Surveys of medical students and practicing physicians consistently reveal insufficient instruction in EH, with many graduates reporting inadequate preparation to handle environmental exposures in clinical practice. The 2009 revisions to the Liaison Committee on Medical Education standards, which introduced “public health sciences” into curricula, created an opportunity to integrate EH training, but this has not yet been widely realized, both in the U.S. and globally. The authors highlight how EH competencies are crucial for all physicians, not just those in preventive or occupational medicine. They proposed integrating EH into existing curricula rather than adding new courses, given the crowded nature of medical education. Strategies include embedding EH content into basic science modules (e.g., toxicology in biochemistry), organ system teaching, patient care courses, and clinical clerkships. Leonard et al. [8] similarly highlighted the urgent need to strengthen EH education and training, given the combined pressures of pollution, biodiversity loss, and climate change. Current curricula for public health practitioners, clinicians, and allied professionals often

lack systematic coverage of these themes, leaving the workforce underprepared for the ecological determinants of health. They reviewed international experiences and showed that training can be reoriented without requiring major new resources by integrating ecological and environmental content into existing curricula. They proposed problem-based, practice-oriented learning approaches that connect natural sciences, epidemiology, and social sciences, and that can be tailored to different groups: public health specialists, healthcare workers, and professionals outside health (e.g., planners, architects, engineers).

## 3. Positive (but limited) impact of EH training in public health practice

Although clinicians generally recognize the importance of environmental factors on public health, studies have consistently found gaps in environmental health assessment in routine clinical practice [9, 10]. Limited training and time constraints are major barriers to incorporating environmental health assessments into practice [9]. Research indicates that health professionals have moderate levels of environmental health knowledge and skills, with variations across different professional profiles [10]. Improving environmental health training can enhance the competencies of current professionals and their institutions, potentially leading to better integration of environmental health considerations in public health and clinical practice [11].

Environmental health master’s programmes in public health and healthcare have generally shown positive outcomes, with graduates applying new competencies in their workplaces and experiencing career progression [12, 13]. However, evidence of their impact on professional practice and the healthcare sector is limited, particularly in low- and middle-income countries [12]. Effective pedagogies include social participation, reflection, and learner-centred approaches [13]. Some studies have identified gaps in curricula, such as leadership and context-sensitive competencies [14]. To address these challenges, schools of public health have undertaken curriculum reviews, using student and alumni surveys to guide changes [15]. While master’s programmes show promise in developing healthcare professionals, there is a need for more rigorous studies assessing their outcomes and impact, particularly in diverse global contexts [12, 13].

## 4. Where is noise pollution?

Looking at noise pollution more specifically, it seems to be present as a topic but unevenly embedded in MPH training globally. In many countries it appears as one topic among “physical agents” within the Environmental and Occupational Health (EOH) or Industrial/Occupational Hygiene tracks, rather than as a standalone public health module. Where dedicated offerings do exist, they are typically electives rather than core requirements. As a result, a sizeable share of graduates finishes an MPH with at best survey-level exposure to environmental noise—aware of it conceptually, but without practical competence in community exposure assessment, epidemiology of health outcomes, or policy evaluation. Regional patterns are discernible. In North America, noise is most consistently taught inside EOH/Industrial Hygiene curricula, often with a strong occupational emphasis (e.g., measurement, hearing conservation, controls) and variable attention to

community/transport noise and health equity. In Europe, coverage is shaped by the regulatory ecosystem (e.g., the Environmental Noise Directive and WHO Environmental Noise Guidelines), so noise commonly appears in broader Environment and Health modules that pair it with air pollution and radiation; standalone noise courses are less common, but policy and mapping concepts surface more frequently. Across the Asia–Pacific region, countries like Australia and parts of Southeast Asia include noise in environmental health or physical hazard subjects; legal/policy content sometimes frames noise as part of environmental regulation. In Latin America and Africa, explicit noise teaching is patchier and usually embedded within general environmental health or occupational safety content; standalone community-noise training is uncommon and often project-driven.

From an informal review of publicly available syllabi and materials, in terms of scope, noise-related teaching within MPH training tends to cover sources and pathways, exposure metrics, basic instrumentation and dosimetry, occupational standards and controls, and to a lesser extent, community guidelines and urban policy responses. The health content commonly emphasizes auditory outcomes (e.g., hearing loss, tinnitus) and selected non-auditory effects (e.g., sleep disturbance, cardiovascular risk), but there is less systematic coverage of environmental justice, life-course impacts, children's health, mental well-being, and intersectoral interventions (e.g., transport planning, building acoustics, urban design). Practical competencies—community sound measurement, simple mapping, interpretation of modelled exposures, and integration into Health Impact Assessment—are offered in some programmes but are far from universal. Two structural drivers are likely to have shaped this landscape. First, noise often competes for curriculum time with high-visibility topics (air quality, climate, chemicals), so it is crowded out unless a programme has an occupational hygiene stream or an urban/environmental planning interface. Second, faculty expertise and local policy salience matter: where cities regularly produce noise maps and action plans, programmes are more likely to teach community-noise methods and policy evaluation; where regulation focuses on workplace hazards, teaching tilts toward industrial noise.

This trajectory, while cautiously positive, is still very uncertain. Planetary health, urban health, and environmental justice frames are pulling noise into broader conversations about healthy, low-carbon, and quiet(er) cities, and low-cost sensors and open data make community-level learning more feasible. Still, there is a clear gap between public health needs and typical MPH training. A pragmatic way forward is to define a minimum competency set for MPH graduates: for instance programmes should aim to achieve the following: (1) explain the burden and mechanisms of noise-related disease; (2) design or interpret basic community exposure assessments; (3) appraise regulations and city-level action plans; (4) propose multi-sector interventions with environmental co-benefits; (5) engage communities and stakeholders in prioritizing quiet area protection. Embedding these competencies into core MPH modules would make noise teaching more consistent and practice-ready across regions. Practical integration of noise-related content does not necessarily require standalone courses; several opportunities exist within existing MPH structures. Noise exposure assessment can be embedded into introductory environmental epidemiology modules by pairing air pollution monitoring exercises with basic sound level measurement and interpretation. Policy-oriented courses can incorporate case studies comparing

EU Environmental Noise Directive mapping requirements with WHO guideline implementation. Urban health or environmental justice modules could integrate analyses of noise inequities using GIS-based exposure datasets. These modular integrations might offer feasible, low-cost pathways for schools to strengthen competencies without expanding curricular load.

## 5. A call to action

The persistent underrepresentation of noise pollution in public health curricula constitutes a structural barrier to its recognition and management as a major determinant of health. If future professionals are not trained to understand noise conceptually, epidemiologically, and methodologically, it is unlikely to gain traction in the research agenda, health impact assessments, or policymaking frameworks. Closing this educational gap is therefore not only a pedagogical necessity but also a matter of equity and accountability in public health. Calls from across the field underscore the urgency of this task. Levy et al. [5] advocate for accreditation standards that explicitly incorporate environmental health competencies, for certification and credentialing bodies to consistently reflect these domains, and for educators to reinvent curricula with innovative, evidence-based content. Their position frames environmental health not as an optional technical element, but as central to advancing equity, justice, and resilience in the face of environmental crises. Similarly, Gehle et al. [7] has argued for seamless integration of environmental health training throughout medical and public health education, ensuring that all graduates acquire at least foundational competencies to address environmental determinants of disease. Leonardi and colleagues [8] extend this perspective by highlighting the ecological challenges of pollution, biodiversity loss, and climate change, and by stressing that training efforts must not be confined to future professionals alone. Current practitioners and decision-makers also require upskilling, as their daily choices already shape paths of environmental sustainability and population health.

Despite this evidence, noise continues to receive less policy and research attention than other environmental stressors [16–18]. While the EU Environmental Noise Directive and the WHO Environmental Noise Guidelines provide frameworks for action, implementation remains inconsistent, and data gaps limit comprehensive assessment of the burden of disease. Stronger national and international policies are needed to regulate sources, promote positive and sustainable soundscapes, and ensure effective urban planning [19, 20]. At the individual level, people can also lower their own noise footprint by adopting lifestyle changes, prioritizing low-noise products, and seeking quieter environments, but systemic change must be led by governments and institutions [21, 22]. Ultimately, the absence of more structured teaching on noise pollution is symptomatic of a broader neglect of environmental health in public health training. Integrating noise more explicitly into MPH and related programmes would not only raise its visibility within the professional community but also strengthen the capacity of the workforce to respond to one of the most pervasive, yet often overlooked, environmental health risks of our time.

Keeping an eye on the bigger picture, although the United Nations Sustainable Development Goals (SDGs) aim to address major drivers of health, equity, and sustainability, noise pollution is not explicitly identified in any of the 17 goals or their targets despite its

clear relevance to human well-being and sustainable development outcomes [23]. Environmental noise effects cut across multiple SDG priorities (e.g., SDG 3—Good Health and Well-being; SDG 11—Sustainable Cities and Communities; and more), yet the SDG framework does not currently include noise in its indicators or targets. This omission frames noise as a “forgotten” environmental barrier to sustainable development and highlights the need to integrate acoustic environments into global health and sustainability frameworks if progress toward interrelated SDGs is to be fully realized.

## Funding

This research received no external funding.

## Conflict of interest

The author declares that they have no competing interests.

## Data availability statement

All data supporting the findings of this publication are available within this article.

## Additional information

Received: 2025-10-09

Accepted: 2025-12-12

Published: 2025-12-19

*Academia Global and Public Health* papers should be cited as *Academia Global and Public Health 2025*, ISSN pending, <https://doi.org/10.20935/AcadPHHealth8070>. The journal's official abbreviation is *Acad. Glob. Public Health*.

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# Noise pollution from wind turbines and its effects on wildlife: A cross-national analysis of current policies and planning regulations

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## ARTICLE INFO

## ABSTRACT

**Keywords:**  
Renewable energy  
Noise pollution  
Planning regulation  
Wind turbines  
Anthropogenic noise  
Protected areas

The quest for cleaner energy has caused governments to expand renewable energy infrastructure, including wind turbine farms. However, wind turbines (WTs) can also pose a risk to certain wildlife species, with wildlife-related research predominantly focusing on the potential harm caused to birds and bats from impact injuries. New evidence suggests that WT noise (WTN) impacts on wildlife can also be detrimental to wildlife, but rarely receive attention from planners. Potential types of WTN impact, including damage to wildlife physical wellbeing, vital survival mechanisms, social and reproductive processes, and habitat continuity. This article reviews the current literature on WTN effects on wildlife, and analyzes the planning guidelines relating to WTN and wildlife in three selected locales where WT infrastructure is being expanded: California, Germany, and Israel. Findings indicate that none of them have clear zoning limitations or obligatory environmental impact assessment (EIA) guidelines that require addressing the WTN effects on wildlife. However, some steps taken by planning authorities suggest potential for improvement. These include language in California planning recommendations addressing the potential effects of WTN on wildlife; a German survey of local bird species' sensitivity to noise (including a WTN section); and increasing non-obligatory recommendations that encourage distancing WTs from protected areas. The study concludes that WTN effects on wildlife could be mitigated by gathering additional scientific data on WTN impacts, mapping species presence and auditory sensitivity to provide information for planners and advisors, and mandating the use of better science-informed practices and technologies for WTN reduction, such as long-term monitoring, zoning, and micro-siting.

## 1. Introduction

Anthropogenic noise has dramatically increased in recent decades because of population growth, urbanization, expanding transportation networks and intensifying resource extraction [1], making it an intense, widespread disturbance. A growing body of evidence suggests that anthropogenic noise may detrimentally affect wildlife populations, communities, and ecosystems. The current, substantial development of renewable energy infrastructure, specifically wind turbines (WTs), has created a relatively new concern that wind turbine noise (WTN) might adversely affect wildlife. This requires the attention of scientists and planners alike. While impact injuries that WT blades cause to birds and bats have received much attention in the literature (e.g. Refs. [2–4]), the effects of WTN on wildlife remains insufficiently explored [5,6].

While wind energy is considered a cleaner alternative to fossil fuels and plays an important role in the mitigation of climate change, WTs often meet resistance on local and national levels. They have been criticized for alleged direct and indirect impacts on multiple counts, including the wellbeing of neighboring residents, landscape aesthetics, and real-estate value. Today, allegations regarding WTN's potentially harmful repercussions for humans are examined, becoming another reason for communities, governments, and other organizations to object to erecting windfarms in certain areas. In many cases, this has led to establishing specific planning and zoning regulations regarding the siting of wind turbines near residential areas [7]. The effects of WTN on animals are considered in several studies pertaining to WTN effects on farm animals (e.g. pigs and geese) [8,9], and some attention has also been given to regulatory attitudes towards potential WTN effects on

Abbreviations: WT, Wind Turbine; WTN, Wind Turbine Noise.

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<https://doi.org/10.1016/j.rser.2022.112801>

Received 14 January 2022; Received in revised form 21 June 2022; Accepted 18 July 2022

Available online 27 August 2022

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farms and farm animals (e.g., Hansen and Hansen 2020 [10]), but not wildlife (except for Rabin, 2006 [36]).

The effect of WTN on people has been studied increasingly in recent years, with a wide range of findings and conflicting conclusions regarding its impact on human health and wellbeing. Some studies consider WTN an annoyance similar to or even greater than other forms of industrial noise or traffic noise [11]. Other studies differ greatly in their findings and suggest that some alleged physiological effects of WTN on humans, especially in locations more than 500 m from WT farms, are minimal, partial, or highly affected by psychological factors, with literature reviews finding that direct correlation existed only with general annoyance and sleep disturbance (e.g., Refs. [11–14]). Low Frequency Noise (LFN) (<20 Hz) has been addressed in these general WTN studies, but has also received specific attention by some researchers, who found direct correlation only between LFN emitted from WTs and sleep disturbance in residential areas in proximity to WT farm [15–17]. Nevertheless, recent work on WTN effects on humans in relation to planning has suggested that WTN disturbance for humans should be considered in planning and legislation, and asserts the need to set a noise limit for WTN, similar to other noises [18].

In terms of WTN effects on wildlife, the focus of this study, there is evidence that WTN could have negative impacts on habitat quality and wildlife [2]; Dooling et al., 2002; Dai et al., 2015). As onshore wind farms are often located in rural or other non-urban areas [19], the impact of WTN on the natural acoustic environment is particularly important. However, as shown below, while the potentially adverse effects of WTN on humans are being studied and regulated by planning and building laws, the same scrutiny has not been applied to examining or reducing potentially adverse effects of WTN on wildlife. The impact of noise pollution on wildlife is still largely ignored in environmental impact assessments (EIAs) during planning processes, and there is insufficient mapping of wildlife species and their noise sensitivity, even in areas considered biodiversity hotspots [2].

In this paper, we first review the current literature on the potential effects of WTN on wildlife, and the various factors that could contribute to these effects. We then examine and analyze the current planning solutions and regulations put in place to reduce harmful WTN effects, using three case studies of places where environmental planning regulations address WTN with respect to humans: US (California), Germany, and Israel. Lastly, we discuss whether these adequately address the short and long-term negative effects of WTN on natural ecosystems and wildlife species, or if additional measures should be taken.

## 2. Wind turbine noise

### 2.1. Potential effects of noise pollution and wind turbine noise on wildlife

Noise pollution influences the acoustic environment even far from anthropogenic centers, in remote areas that include critical habitats for endangered species [20]. Noise pollution negatively impacts wildlife by disrupting mechanisms that are crucial for their survival [5,21,22]. In particular, noise can: 1) cause physiological damage such as chronic, high levels of stress hormones [23], or actual hearing loss [24]; 2) be directly perceived by animals as a threat, causing them to increase costly anti-predatory behaviors at the expense of foraging, or flee the affected area altogether, leading to functional habitat loss [25]; 3) distract foragers, reducing their efficiency of finding and handling food (Dominy et al., 2021); 4) hinder animal communication by reducing the distance at which a signal can be detected [26], limiting the ability of the signal to reach its intended recipient, and decreasing the amount of information that can be extracted from a signal, such as the sound of an approaching predator or potential prey [27,28]. These mechanisms are not mutually exclusive, and the role that each plays in determining the impact of noise pollution varies by species. Not all species react to noise in the same way, due to differing sensitivities to noise, context, and life-history [1,5]. Overall, noise pollution alters animals' communities,

reduces their overall survival and fitness, and contributes to the decline of global biodiversity [22].

While the number of studies on the impact of noise pollution on wildlife is increasing [29], very few focus on WTN [30]. Nonetheless, dedicated studies on WTN are important given that properties of sound, location of its source, and spatial propagation have all been found to vary greatly between land uses, and be crucially significant for determining the type and extent of anthropogenic noise effects on wildlife [1, 31]. Traffic is the most widely studied source of anthropogenic noise [29]. [32] compared the spectral properties of WTN and traffic noise, and suggested that a combination of highway noise and WTN might create a greater, more complex disturbance, rather than one masking the other. Specifically, WTN alters the natural acoustic environment by inducing airborne loud broadband sound [33] which is within the hearing range of many animals [34], including most bird species [35]. A few other studies have also looked at the effects of WTN on other wildlife with mixed results. For example [36], found that WTN affects the California ground squirrel's antipredator behavior, causing a higher level of alertness attributed to loss of auditory capacities.

Despite the dearth of studies concerning the effects of WTN on wildlife, they have generated some insights that could contribute to understanding the ecological impact of WTN. In general, it has been shown that noise pollution affects species demography (i.e., community composition, population density) and promotes habitat avoidance (e.g. Refs. [1,29]), because noise alters animals' habitat selection. Several studies have demonstrated the impact of WT on demography and habitat avoidance, mostly in birds (e.g. Refs. [37,38], but also in other taxa such as mammals [39]. Very few studies have been able to isolate and connect habitat avoidance specifically to WTN (e.g. Ref. [40]), but Lehnardt et al. (in review) recently teased apart the effects of WTN on songbirds experimentally, by broadcasting the sound of a wind turbine in the field and showing that this significantly reduced the number of birds present. Furthermore, the existing literature implies that WTN alters birds' vocal communication, with possible implications for reproductive success [30, 41,42].

Buxton and colleagues [20] argue that protected areas experiencing high levels of noise pollution must be identified and managed appropriately, and that noise pollution merits consideration as a serious threat to biodiversity. Moreover, Francis and Barber [5] suggest that noise pollution must be addressed using a combination of tools, technologies, and techniques, many of which are already available. They also advocate to include considerations pertaining to noise pollution in the planning and management of protected areas, adding that different types of noise can affect wildlife in various ways. Despite the current dearth of studies examining the direct effects of WTN on wildlife, there is already sufficient knowledge accumulated on the impacts of noise pollution, and the effects of WT on avoidance behavior in birds and mammals in response to the spectral properties of WTN. Therefore, WTN should concern planners and policy makers who seek effective guidelines for the sustainable planning of wind farms.

### 2.2. Factors influencing the acoustic effect of WTN

WTN can be divided into two types, according to the origin: *mechanical and aerodynamic*. Mechanical WTN is produced by the turbine's moving components (gear box, generator and bearings). The normal deterioration of these parts over time, the use of substandard parts and inadequate maintenance contribute to increased noise production. Mechanical noise can be decreased by appropriate design (e.g., adding insulation), proper and regular maintenance, and using high-quality parts [7,43]. Aerodynamic WTN is the noise produced when the wind passes the turbine blades. It increases in correlation with the speed of the rotor, and can be influenced by several other factors, such as atmospheric turbulence that can create a "whooshing" sound [44], wind direction and wind speed [45]. Aerodynamic WTN can be somewhat reduced by changing the design of the turbine blades prior to

manufacture [7].

The direction in which WTN is emitted has also been found to be an important variable for its effect on the acoustic landscape. The pattern of sound radiation or “directivity of sound” can vary, and the angle of the acoustic range around the noise source can be more or less acute or obtuse [46] although the average noise angle for WTN is approximately 120° (calculation based on Friman, 2011). Several variables can influence the directivity of the “whooshing” aerodynamic sound of WTs, which is the dominant source of WTN. They include the angle of attack (i.e., the angle in which the wind meets the blade), wind velocity, blade shape, blade tip velocity, and turbulence in the air. Additional variables, including weather conditions such as temperature or cloudiness, as well as background noise, might also influence sound directivity and mapping measurements [46]. Furthermore, WTN levels depend on environmental conditions and can greatly differ between nighttime and daytime. Increased levels of WTN at night may be attributed to the stable night-time atmosphere that causes high wind shear [11,47].

Sound can be considered as either *sound power* or *sound pressure*. Sound power is the total acoustic power emitted by a source and can be used to predict how far the sound will travel and what the sound levels could be at various distances from the source. It is measured at the source, making it independent of the dB level where it is received. Conversely, sound pressure reflects the sound level received and perceived by the listener. For observers distant from the source, the sound pressure decreases, as the sound moves farther from the source. This distinction is important, because WTN measurement and solutions could focus on either reducing the noise at the source (i.e., lowering the level of noise emitted by the turbine), which would require the development and implementation of new technologies; or on reducing the level of noise experienced by the receiving side, which might be achieved using acoustic barriers, zoning, or micro-siting.

The amplitude, frequency, and sequence (i.e., temporal pattern) of WTN can differ widely, and dramatically change the type and level of WTN impact on humans and wildlife. Most studies of the effects of WTN on people pertain to low-frequency noise, between 20 and 200 Hz. Outdoor WTN levels upwards of around 40 Hz normally exceed the hearing thresholds of indoor areas, although this might vary depending on noise insulation standards [48]. Sound frequency is also important when addressing WTN effects on wildlife, since WTN is usually characterized by a broad band range, with changes in the WTN spectrum observed in the frequency range of 200–5000 Hz [49], which overlaps with the hearing ranges of many wildlife species [34], particularly birds [35]. Wind turbines also emit a low frequency noise that is out of most people’s hearing range, including very low frequency noise (<20 Hz) that some refer to as “infrasound” or “infrasonic and low frequency noise” (IFLN). It is still unclear whether IFLN has any influence on human health or wellbeing in situations where turbines are too distant for audible noise to be detected. However, a few states have decided to take the precautionary approach and address resident claims in some cases [14,15]. While the perception of IFLN has been documented in several mammal and bird species [16], the extent to which the infrasound component in WTN impacts wildlife is yet to be thoroughly examined.

Size, particularly diameter, is key to turbines’ capacity to produce energy. Turbine technology has developed exponentially in the past few decades, with capacity now reaching up to several megawatts (MW) per turbine [50]. A growing trend is using larger turbines, with larger blades, which produce more electricity, because they can harness higher winds, even in areas where there is little wind close to the ground. For instance, US Department of Energy data show that the average height of wind turbines (from ground to blade tip at 12:00 position) increased from 95 m in 2000 to 140 m in 2016, with 50% of the turbines having blades longer than 110 m [51]. However, turbine size does not correlate with noise level, as smaller turbines are actually noisier for their size, because the rotational speed of the blade tips is faster, and because more research and resources have been invested in reducing noise from large

turbines [52].

Available technology and best practices offer solutions for decreasing the damage caused by WTN, either by lowering noise levels at the source, so WTs emit less noise or by creating noise buffers between WTs and residential areas or other areas of interest. The first category includes solutions such as blade design [7] and turbine insulation [48], as well as using high-quality parts and ensuring good maintenance [7,43]. The second category includes physical barriers such as noise attenuation walls [53].

In addition to factors inherent to WTN, the traits of various animal species are also central to determining the impact of WTN on wildlife. Different species respond differently to noise pollution, and this variability is dependent on the species ecology, life-history, and physiology e.g., frequency hearing sensitivity, including ability to hear low-frequencies. Future development of WT, which is predicted to include increases in height, rotor diameter and speed, might further complicate our ability to predict the impacts of WTN. These changes may lead to an additional or altogether different set of species being impacted by turbines [53]. As wind energy is further applied and developed in coming years, unknown long-term effects could change WTN impact. Assessing its cumulative effects will become even more crucial and pose yet another challenge for impact assessment. While long-term WT operation could result in increased habituation to noise in some species, it could also create large-scale habitat fragmentation, while also interacting with other anthropogenic disturbances (e.g., light pollution) and lead to reduced population viability for reasons that are difficult to understand or measure [5,53].

### 3. Findings from three case studies: planning regulations for mitigating WTN impacts and protecting wildlife

The current study includes an in-depth analysis of WTN-related policies and planning documents of three case studies: California, Germany, and Israel. Like many others, these three states are attempting to slow global climate change by reducing GHG emissions and increasing the amount of energy produced using renewable sources, mainly wind and solar. These installations require developing new and better regulatory procedures to mitigate their impacts on the landscape, environment and humanity [54]. Other than Germany, most OECD states regulate the effects of WTN only with respect to residential areas, and do not relate to wildlife in protected or sensitive areas. Koppen and Fowler’s [55] overview of WTN regulations in Belgium, Denmark, Finland, France, Germany, Sweden, Australia, Canada, and various US states, shows that Germany is the only country where permitted noise levels for certain rural areas are lower than those of residential areas, indicating that only Germany has enacted additional WTN safeguards for protected natural areas (which are almost exclusively situated in rural areas).

After a preliminary review of various WTN-related documents from OECD countries, we chose these case studies because they offer variety in terms of geographic location, size, the number and size of current and proposed WT farms, and planning guidelines and regulations that pertain to WTs, noise, wildlife, and zoning (see Table 1). However, there are some similarities between the cases: they are all in OECD member states that have access to advanced scientific data and technologies, are currently promoting policies that support the development of renewable energy and its related infrastructure; they generally have advanced guidelines for WT planning that include multiple environmental aspects; and have some regulatory guidelines and recommendations already in place that address both the general effects of WTN (focusing mostly on humans), and specific guidelines to protect wildlife and habitat. A preliminary review of OECD states’ planning guidelines was used to select the case studies, and revealed that in these three states there is some response related to the issue of WTN effects on wildlife, albeit limited. Preliminary interviews with environmental planners in these countries have indicated that there is a limited but growing

Table 1  
Background data.

Locale	Population (millions)	Size (km <sup>2</sup> )	Density (inhabitants/km <sup>2</sup> )	Wind energy production in 2020 (GWh)
California	39.5	423,970	97.9	13,680 <sup>a</sup>
Germany <sup>b</sup>	79.9	357,022	223.8	50,700
Israel	8.8	21,937	401.1	0.027 (27MW) (Goal: 0.5 GWh in 2025)

<sup>a</sup> California Energy Commission, 2019 Total System Electric Generation. <https://www.energy.ca.gov/data-reports/energy-almanac/california-electricity-data-2020-total-system-electric-generation-2019>.

<sup>b</sup> CIA (Central Intelligence Agency), World Factbook: Germany: Introduction, Geography, <https://www.cia.gov/the-world-factbook/countries/germany/#introduction>.

<sup>c</sup> Fraunhofer Institute for Renewable Energy Systems, <https://www.isc.fraunhofer.de/en/press-media/news/2020-public-net-electricity-generation-in-germany-2020-share-from-renewables-exceeds-50-percent.html> (Retrieved August 17, 2021).

<sup>d</sup> CIA, World Factbook: Israel: Geography July 2021. <https://www.cia.gov/the-world-factbook/countries/israel/#geography>. Numbers including the Golan Heights and East Jerusalem, excluding the Gaza Strip and West Bank.

<sup>e</sup> Israel's Electricity Authority, Report on the Status of the Energy Market: August 2020. <https://www.gov.il/ho/departments/general/dochmeshek>.

awareness of the potentially harmful effects of WTN on wildlife.

In the case studies, we examined the statutory guidelines, regulations, and official requirements regarding wildlife, noise, and zoning applicable to developers who propose new wind energy farms, in order to better understand the current WT planning situation, and whether there might be some regulatory basis for addressing or mitigating WTN effects on wildlife. In each case, we addressed the general guidelines for the locale, including the differences between California counties and German states (*Bundesländern*), if any. For California, the documents examined included federal guidelines (i.e., U.S. Fish and Wildlife Service Land-Based Wind Energy Guidelines, 2012, expiring Nov. 30, 2021), the California Energy Commission and California Department of Fish and Game California Guidelines for Reducing Impacts to Birds and Bats from Wind Energy Development, 2007 [56], and county-level documents from the eight California counties where the largest WT energy producing projects in the state are currently located (CalWEA, 2021).<sup>1</sup> For Germany, the study examined national government documents, focusing mostly on official documents of the German Ministry of Economy and Energy (*Ausschreibungs-spezifische Regelungen für Windenergieanlagen an Land*, FWE 2021a) that address WT planning guidelines for developers and other documents dedicated to the issue of zoning for WT farms (*Zusammenstellung der Bundesländer Initiative Windenergie*, FWE 2013; *Überblick zu den Abstandsempfehlungen zur Ausweisung von Windenergiegebieten in den Bundesländern*, FWE 2021b). These documents also detail the differences between the different states. For Israel, which is still at the preliminary stages of large-scale wind energy production, and has a centralized planning authority with a single set of national environmental regulations for wind energy, we reviewed the current planning guidelines and the requirements from wind energy developers, seeking approval under the Israeli national plans for wind turbines (NOP 10/d/12) and energy infrastructure (NOP 41).

As in many other developed countries, planning tools in California,

<sup>1</sup> There are eight main wind energy installations in California. In size order, they are Tehachapi Pass in Kern County (2925 MW), Solano County (1028 MW), San Geronimo Pass in Riverside County (655 MW), Altamont Pass in Contra Costa, San Joaquin, and Alameda Counties (330 MW), Imperial County (264 MW), San Diego County (181 MW), Shasta County (101 MW), and Pacheco Pass in Santa Clara County (17 MW) (California Wind Energy Association, CalWEA, 2021).

Germany and Israel focus predominantly on zoning and restrictions pertaining to the minimal distance of WTs from residential areas, as well as maximal decibel (dB) noise levels that may relate specifically to WTN or to overall levels of noise pollution from any anthropogenic source. They require an environmental impact assessment (EIA) before approving a WT project, with some attention to WTN, including not just sound pressure levels but also distinction between daytime and nighttime levels, indoor and outdoor levels, and different land uses (e.g., parks and beaches as in Germany). In several cases, rural areas and urban areas are also treated differently in terms of sound pressure levels allowed. In some places higher noise levels are allowed in rural areas and elsewhere the opposite is true, which already hints to the complexity and ambiguity that currently exist around noise pollution from WT. The following review covers the regulations, guidelines, and tools currently applicable in each jurisdiction, as they relate evaluating and mitigating of WTN in general (often only for population centers), and other potentially relevant tools and guidelines that address the impact of anthropogenic noise on wildlife, and which might be employed in the case of WTs.

### 3.1. California (USA)

#### 3.1.1. Zoning

Zoning is heavily dependent on county regulations, with permits for wind projects issued on the county level. Guidelines for WT planning have also been published at the state and federal levels, although these are often outdated and are offered as voluntary steps or general recommendations, as opposed to obligatory regulations [57].<sup>2</sup> A report written by the California Energy Commission (CEC) and California Department of Fish and Game (CDFG) in 2007 [56] offers voluntary guidelines for reducing the impacts to birds and bats from wind energy development, and upholding California Environmental Quality Act (CEQA) recommendations, which are often necessary to procure a permit for wind energy projects. In terms of zoning, these guidelines suggest adhering to county or city ordinances, although they state that "Some county ordinances include language regarding assessment of impacts to birds and bats, but, currently, none provide specific guidance on studies necessary for assessing significance of impacts to bird and bat populations or provide direction for monitoring programs and feasible mitigation options" [56].

On the county level, several California counties require that proposed projects found to have significant potential environmental impact relate to CEQA recommendations and require an Environmental Impact Report (EIR) [58]<sup>3</sup> (see also California Energy Commission, 2019). Developers need to request a permit from the county, in accordance with expectations stipulated by the county for the specific project. The developers then hire private consultants to assist with preparation of the environmental review documents that they must submit to the county. In California, the US Fish and Wildlife Service also must be consulted regarding an "incidental take permit for eagles" [57].

There are differences in zoning regulations between counties within California when it comes to wind energy projects. For instance, in Imperial County [58], the WT regulations address not only permitted areas, but also a maximum permitted continuous sound level (CNEL 70 dB), "measured at the nearest human receptor site outside the parcel boundary," or 0.5 miles from the sound (whichever is greater) (p.2). In Solano County, the guidelines do not include a WTN distance caveat but do include requirements for spacing between the wind turbines, along roads, dwellings, and property lines California Wind Energy Collaborative, 2006 [59], a topic not addressed in the Imperial County

<sup>2</sup> Shawn Smallwood, counseling ecologist for the Alameda County Scientific Review Committee (SRC), 2006–2011, previously counseling ecologist for the California Energy Commission (2004–2007), personal communication on renewable energy impacts, February 16, 2021.

guidelines (p.10).

Some counties in California also require a safety setback distance from adjacent properties and structures. In these guidelines, the distances differ for buffer zones and required distances between wind projects and other land uses. These distances are stated with varying degrees of clarity and specification, primarily addressing safety concerns such as prevention of damage or injury due to accidental blade-throw. For example, in Alameda County, required distances are 91 m from a property line, and 152 m from dwellings. In Contra Costa and Kern counties, the distances are 152 m from property lines and 305 m from dwellings. In Riverside County, the required distance is 152 m from a residential lot line. In Solano County, distances from both property lines and dwellings are 304 m. Each county also provides a variety of additional requirements and exceptions, such as Alameda County's adjustments for sloping terrains, with safety setback distances also pertaining to roads and highways, which are often adjusted for WT height and other factors. It should be noted that the reason for these safety setbacks is usually not WTN-related; rather they are precautions related to accidental blade throw (i.e., blade failures resulting in projectiles) [56,57].

### 3.1.2. Environment and wildlife

Generally, impact assessments are done in lieu of recommendations from agencies like the US Fish and Wildlife Service (USFWS). USFWS has posted guidelines intended to "encourage scientifically rigorous survey, monitoring, assessment, and research designs proportionate to the risk to species of concern", but these are not official requirements that wind project developers must uphold. As USFWS document itself states, the wind energy guidelines are voluntary recommendations [60]:11).

In California, state and local public agencies must comply with the California Environmental Quality Act (CEQA) before giving a project discretionary approval. A project is compliant if the proposing agency either 1) determines if a project is exempt from CEQA; or 2) if it prepares an environmental analysis which could be one of three types: (a) a negative declaration (ND); (b) a mitigated negative declaration (MND); or (c) an environmental impact report (EIR). Either an MND or an EIR analyzes a project's main environmental effects, address compliance with environmental laws, guidelines, and regulations, and suggest feasible measures to avoid or mitigate those effects. An EIR also offers alternatives to the project [61]. Some California counties include the need to comply with and address CEQA guidelines and submit an EIR for WT in the relevant county regulations and approval process, as for example, Imperial County [62], and Kern County [63].

Nevertheless, CEQA is self-proclaimed to be very broad, and developers are required to use feasible alternatives or mitigation measures to decrease environmental effects only if a site is determined to have a significant environmental impact. If there are no options that are easily applicable or economically viable, developers can usually get around the provisions of this act. They would then fall back on the recommendations made by agencies like the US Bureau of Land Management (BLM) (in the case of land managed by BLM), or the California Department of Fish and Wildlife [57].

Government regulations are similar regarding risks to bats and birds. In California, the CEC & CDFG 2007 government recommendations categorize potential wind sites into four categories based on the bat and bird fatality rates, with one being low risk to four being high risk to bats and birds [56]. However, an EIR is not required for each site. More specific recommendations are outlined, but again, none of them are legally mandated [59]. Nevertheless, developers who choose not to follow CEQA guidelines expose themselves to potential lawsuits, which in turn could slow project development, require additional changes to the project, or even stop the project entirely. Therefore, developers might choose to follow voluntary guidelines to avoid potential losses that could end up costing them much more than earlier compliance would have.

### 3.1.3. Noise

Noise regulations are solely concerned with humans, with standards

for permitted WTN sound levels varying by county. However, the Fish and Wildlife Land Based Energy Guidelines (2012) do briefly address the issue of WTN on wildlife, and mention that there is scientific evidence that WTN can cause damaging effects on wildlife:

Turbine blades at normal operating speeds can generate levels of sound beyond ambient background levels. Construction and maintenance activities can also contribute to sound levels by affecting communication distance, an animal's ability to detect calls or danger, or to forage. Sound associated with developments can also cause behavioral and physiological effects, damage to hearing from acoustic over-exposure, and masking of communication signals and other biologically relevant sounds (Dooling & Popper, 2007). Some birds are able to shift their vocalizations to reduce the masking effects of noise. However, when shifts don't occur or are insignificant, masking may prove detrimental to the health and survival of wildlife (Barber et al., 2010). Data suggest noise increases of 3 dB–10 dB correspond to 30% to 90% reductions in alerting distances for wildlife, respectively (Barber et al., 2010) (page 46).

However, they add that there is still a need for more data to achieve an adequate understanding of WTN impacts:

The National Park Service has been investigating potential impacts to wildlife due to alterations in sound level and type. However, further research is needed to better understand this potential impact. Research may include: how wind facilities affect background sound levels; whether masking, disturbance, and acoustical fragmentation occur; and how turbine, construction, and maintenance sound levels can vary by topographic area." (Fish and Wildlife, 2012, p. 46).

Finally, studies of potential or existing WTN effects on wildlife, as per the USFWS guidelines, belong to a category "Tier 5 studies," which the guidelines state are usually conducted only in cases of substantial current or foreseen fatalities of a proposed project. The USFWS guidelines also clearly state that for most projects Tier 5 studies will not be required or conducted (Fish and Wildlife, 2012, p. 46; Smallwood, 2021).

## 3.2. Germany

### 3.2.1. Zoning

German regulations for wind energy planning differ between states (*Bundesland*), with some also including multiple zoning criteria for wind farms, in order to address distances from land uses related to wildlife or nature-related, protected areas. In 2021, the German Agency for Wind Energy on Land (*Fachagentur Windenergie An Land*) published a report summarizing the zoning guidelines for different size WTs in each state. Despite the great variation between states, it is nonetheless evident that at least some have enacted zoning measures to reduce the effects of WTs on valuable natural habitats, areas of natural landscape and heritage, and nature recreation sites.

The report first describes the suitability of each region for WT farms, and then outlines the regulations in each state for each type of land use. The required distance of WTs from residential areas varies from 400 m to 1100 m, with most requiring a minimum distance of 1000 m. In some states, sparsely populated areas require a smaller distance and some set distances based on WT rotor size, or locally permitted noise levels. In Baden-Württemberg, all distances are determined on a per-case basis. (*Fachagentur Windenergie An Land*, 2021 pp. 5–6).

### 3.2.2. Environment and wildlife

A range of distances, from 300 m to 1000 m or set on a per-case basis, are prescribed for wildlife and habitat-relevant zoning, including open space with special rights for protected/open space networks, priority nature and landscapes, nature reserves, national parks, nature parks, landscape protection areas, protected forests/recreational forests, slopes and knolls that are characteristic of a particular landscape and distinctive landscape horizons (lines of sight) (*Fachagentur Windenergie An Land*, 2021, pp. 5–6). Zoning distances, between 50m and 500 m, but up to 1000 m for officially protected areas, from WT are also set for legally

protected biotopes; bat habitats; bird breeding, nesting, feeding, and resting areas; sensitive or protected areas for local, endangered, and migrating bird species; and any areas protected under federal or EU regulations, including under the EU Bird Habitat Directive (*Fachagentur Windenergie An Land*, 2021, pp. 6–7). Some zoning restrictions (distancing by 50m–1000 m or per-case), apply other potentially relevant areas including protected, sensitive, and large bodies of water on land (rivers and lakes), water sources, and flood plains (*Fachagentur Windenergie An Land*, 2021, pp. 7–8).

### 3.2.3. Noise

Germany has taken one more step than other countries when addressing the effects of noise on wildlife, particularly birds. The Kieler Institute for Landscape Ecology (*Kieler Institut für Landschaftsökologie*) published a special report after conducting an extensive survey of local birds' sensitivity to traffic-related noise (including noise emitted by trains), in cooperation with the German Federal Ministry of Transportation, Construction and Urban Development (*Vorhaben des Bundesministeriums für Verkehr, Bau und Stadtentwicklung*). The report includes a general description of noise thresholds for local species and common migrating species in Germany, suggesting that traffic noise can disturb birds' attentiveness to predators and other dangers, disrupt their communications with each other and have other negative effects. The influence on each species varies according to time of day, the birds' specific reproductive cycle and breeding status (Garniel et al., 2007).

The Kieler Report (2007) observes that the flight patterns of some species, including geese, ducks, cranes, and gulls, tend to have wider radii of spatial avoidance around large WTs than around highways and local roads. Although their data suggest that the visual disturbance caused by WTs is likely the main reason for this finding, they also suggest that some birds, especially geese, are more sensitive to WTN than to noise originating on roads and railroads [64](p. 213). In addition to injuries and deaths from collisions, the report considers it highly probable that WTs have a combined audio-visual effect on birds. In conclusion, the Kieler Institute authors claim that data and knowledge about WTN and its effects on bird populations and habitats remain insufficient, while still contending that birds' sensitivity to noise means that WTN should be minimized, without suggesting specific measures [64]. That said, the report notes that acoustic walls would be insufficient for minimizing the effects of WTN on birds, because they often fly higher than the walls.

### 3.3. Israel

#### 3.3.1. Zoning for WT

Israel's National Outline Plan (NOP) includes [Appendix 3: Guidelines for Promoting WT Plans](#), which states that WTs must be placed at least 500 m from any settlement or planned area that includes a residential area. Moreover, special (increased) attention should be given to the potential impacts of erecting WTs up to 1000 m from residential use, without specifying that the reason for this is noise (NOP 41, [Appendix 3 §A](#)). [Appendix 3 §3.3.D](#) adds that damage to "nature and environmental values" should be minimized, and that WTs should be distanced from heritage and tourism sites, without specifying distances (p. 26). However, the NOP and its appendices do not specifically address ecologically valuable or sensitive areas nor does it include any guidelines regarding the location of WT farms in or near designated protected areas. Some regions, including the Center and Tel Aviv districts, prohibit erecting WTs in undisturbed (natural) areas; although this is allowed in other districts, including the South and Haifa and North districts where most WT projects are planned (NOP 41, [§3.2](#), p. 26).

#### 3.3.2. Environmental and wildlife impact surveys or assessments

In Israel, an EIA is always required for WTs taller than 40 m, but demands vary for medium (18m–40 m), small (4m–18 m) or micro WTs (up to 4 m), depending on the level of environmental/landscape

sensitivity and the number of WTs in each wind farm. In some cases, developers must also submit a landscape-environmental addendum (LEA), which is reviewed by the Ministry of Environmental Protection (MEP), and the Israel Nature and Parks Authority (INPA) (NOP 41 draft, 2019, [§3.7.1.- §3.7.3](#)). When assessing the effects of WT on wildlife, Israeli regulations focus predominantly on birds and bats, which are the subject of entire sections in the Appendix. The developer must submit a report that examines the primary potential for impact on birds and bats for medium and large WTs, based on existing data, rather than new surveys or active observations. After the report is reviewed by INPA and MEP, the relevant planning authority decides whether there is need for a full bird and bat survey. If so, the survey is done in consultation with the environmental authorities (NOP 41 draft, 2019:28).

[NOP Appendix 3](#) refers to a non-statutory map of areas where birds and bats are vulnerable and developers are asked to consult it, if they wish to promote a WT plan. However, this map does not contain information regarding bird migration, and therefore provides only partial information for assessing potential WT impacts on bird populations. Additionally, if a field survey is done in accordance with the INPA guidelines, it is considered instead of the data on the vulnerability ([Appendix 3, §B](#)). [NOP Appendix 3](#) further states that a year-long survey of local and migratory species must be conducted, and a monitoring plan made before the plan is approved. [NOP Appendix 4](#) includes guidelines for direct (collision) and indirect effects, including "nesting sites and different habitats," but does provide further details. The effects of noise or vibration on bird, bats, and other species are not specifically addressed in this appendix or elsewhere in the new national spatial plan for siting guidelines.

As a rule, the LEA and EIA must include a section examining potential impacts on vulnerable fauna and flora, as well as connectivity (NOP 41: [§2.1](#), p. 51), as in the older NOP 10, which was in effect until early 2021. The fact that the spatial outline plan requires particular information regarding birds and bats suggests that collision risk is the main wildlife-related aspect considered, as it is NOP 10, [Appendix 3](#) (NOP 10 [§3](#) and [§5.2](#)).

#### 3.3.3. Noise

NOP 10 and NOP 41 include adverse environmental effects on humans, including noise and other environmental factors and ecosystem services as subjects that require preliminary surveys for large and medium WTs in ecologically vulnerable areas (NOP 41, [Subsection 4](#); NOP 10, [§3.7](#)). In terms of noise, the minimal distances of WTs from certain areas are determined by adhering to the noise regulations for residential, business, industrial, or rural areas in place since 1990 ([§3.9](#)). NOP 41 [Appendix 3](#) states that WTN shall not increase the existing background noise from other permitted activities by more than 5 dB, and that monitoring of loud noise must be conducted with the WT operators.

The level of infra-sound must be measured before the WTs are operational and monitored after the operation has begun. The noise level should not exceed 75 dB (G-scale), or any other maximum stated by regulations. NOP 10 requires developers specify, in the EIA, the measures to be taken for reducing or limiting the effects of WTN (although permitted noise levels are not specified in the spatial plan). If needed, a detailed account must be provided of the "acoustic shielding types which will be used, their technical characteristics and their effectiveness in reducing the predicted noise" (NOP 10, [§5.7](#)). According to the latest version of the guidelines, developers must submit a predictive WT noise-level map for all WT models (NOP 41 [§6.6.a.2](#)), and this is used to ascertain the minimal distance of WTs from any structure (NOP 41, [§3.9](#)).

#### 3.4. Discussion: knowledge, tools, and potential planning trajectories

While there is growing evidence indicating that wildlife are at risk from anthropogenic noise (e.g. Refs. [[2,33,35](#)]), including WTN, only initial steps have been taken to acknowledge, address or mitigate this

impact through planning guidelines and regulations, as well as other planning-support tools. There are several measures that could be adopted by countries wanting to support renewable energy development by promoting the use of WT, but who are interested in reducing its adverse environmental effects. Wind farms are often placed in open habitats that are otherwise minimally affected by anthropogenic noise pollution, ones that are more likely to be occupied by noise sensitive species that cannot inhabit more disturbed and noisy areas. Therefore, special consideration must be given to WTN at these sites, with emphasis on its impact on wildlife.

The current study of WTN-related planning regulations in California, Germany and Israel did not find any obligatory planning regulations focused on addressing WTN effects on wildlife. Standards and zoning restrictions currently focus on noise disturbance in residential areas or on mitigating other types of potential WT-related environmental threats, e.g., impact injuries to bats and birds, visual disturbances, blade throw. Nevertheless, there are relevant guidelines and official documents addressing zoning, environmental concerns including wildlife, or WTN in general that offer voluntary guidelines and could be a useful starting point for further thinking about how the effects of WTN on wildlife could be mitigated by environmental planning efforts.

When planning processes address the impact of WTN on wildlife, WTN should be kept in context and compared to other anthropogenic activities, especially noise and other types of pollution originating in fossil fuels and alternative energy sources [53]. Currently, however, this might prove unfeasible, due to the lack of scientific or operational data, without there being any governmental targets for obtaining such data. These data would be an important resource when calculating environmental trade-offs and policies for planning scenarios for WT and the development of alternative renewable energy sources. Indeed, the lack of ecological scientific data on the effects of WTN on wildlife constrains many environmental and spatial decisions. A key challenge when assessing the effects of WTN on wildlife is separating it from other potential disturbances, such as blade impact injuries, flickering, or changes to the natural landscape. This might be overcome at the pre-implementation phase by experimentally broadcasting recordings that accurately reproduce the acoustic properties of WTN, and then quantifying the effects of the noise on the surroundings.

The nation-wide Kieler Institute survey [64] of local and migratory birds in Germany attempted to assess the effects of noise on wildlife, including the general and species-specific noise impacts, vulnerabilities, and thresholds. Despite measuring sensitivity to traffic noise rather than WTN, it provides valuable information by identifying the species that are most affected by noise. Similar surveys, which could be based on knowledge and monitoring data already collected by diverse scientists and institutions could provide a much-needed source of information for WT planning, and potentially have significant influence on whether the issue is addressed at all. Translating the findings of these surveys into specific planning guidelines and regulations could then be a next step towards the practical application of the insights gleaned from their data. The time that has passed since first official report in Germany that mentions scientific evidence for the impact noise has on birds suggests that action lags behind scientific findings. This is unsurprising considering the challenge of taking into account all the potential adverse impacts of infrastructure, especially in land-scarce regions. In the case of wind turbines, there are competing values and targets because of the urgent need to advance renewable energy as a key strategy for mitigating climate change.

The negative impacts of WTN can be greatly reduced. One type of solution is technical or mechanical, namely using better technologies, materials, and maintenance to minimize the noise emitted from WTs at the source. A second type of solution is installing acoustic walls to limit the dispersion of WTN to sensitive areas, although these are deemed less useful for protecting birds [64] and could also create habitat fragmentation (see Ref. [65]). This paper focuses on the third type of solution, planning and regulatory tools, such as noise regulations, setback safety

distances, environmental impact assessments (including acoustic assessments), and planning guidelines and zoning of wind turbine farms (see, e.g., Ref. [53]). While these tools were developed and applied for the benefit of humans, or to address non-noise related WT impacts on wildlife, they could potentially be used or adapted to address WTN implications for wildlife. For example, the current requirements for Environmental Impact Assessments, acoustic surveys, zoning regulations, and wildlife monitoring and protection measures already mandated by Israeli and German planning authorities could be expanded to include WTN effects on wildlife. In California, county regulations could also be expanded to follow the state and federal guidelines to include more wildlife-related considerations when considering the impact of WTN.

Zoning that specifies a minimal distance from protected, ecologically-sensitive or valuable habitats and corridors could be an important tool for planners, especially in places like California, where the population density is lower than in Germany, where similar zoning restrictions already apply, due to other conservation concerns such as habitat fragmentation, and bird and bat collisions with WT. However, developers, planners, and their consultants first need access to place-specific data and awareness of effective monitoring methods for the impact of WTN on wildlife needed for developers.

Some scholars have made general recommendations that address EIAs and might also be relevant for assessing and mitigating adverse WTN impacts on wildlife. For example, Conkling and colleagues [66] suggest that rigorous pre-construction risk assessments and post-construction wildlife monitoring could be an important part of the solution to decreasing WT-related ecological damage and improve siting decisions. These should consider a range of potential adverse effects that WT might have on wildlife, including collisions, habitat loss or fragmentation, and altered foraging, breeding, and migratory behaviors. However, studies have also found that the lack of survey standardization, pre-construction baseline determinations and post-construction monitoring efforts are obstacles to reducing the harmful effects of WTs operation on wildlife. Rigorous point counts, behavioral observations, nest searches and acoustic surveys, if done both pre- and post-application, would be useful tools for assessing adverse WT effects on surrounding wildlife and advising planning efforts to minimize them [66,67].

#### 4. Conclusion

Planning regulations are yet to address the issue of WTN impact on wildlife, despite accumulated evidence to suggest that anthropogenic noise generally, and WTN particularly, are responsible for actual and potential harm to animals and consequently to ecosystem function. The current study found that California, Germany, and Israel lack regulations that mandate developers to include the impact of WTN on wildlife in zoning decisions or even in environmental plans and surveys, although planning regulations are already in place to decrease impact injuries to birds and bats, and German zoning regulations protect national parks, protected areas, and ecologically valuable habitats. These, and other tools intended to protect humans from WTN, such as acoustic surveys, could be used as a basis for addressing and minimizing detrimental effects of WTN on wildlife species.

Scientific advances in this field, including technologies that allow for long-term acoustic monitoring in the field, or studies that follow animal movement, behavior, and survival before and after broadcasting simulated WTN, would be another valuable asset for planners and environmental advisors. Surveys of local species' noise sensitivity make valuable contributions to the understanding of the impacts of anthropogenic noise, including WTN, and are already available in Germany, and have the potential to inform, and even change, planning processes for WT. Further research should take into account the local considerations of governments and planners who wish to include wildlife conservation in the planning process, as they transition to renewable means

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# VALLEY SURVEY REPORT 2024

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