S.37

File With

SECTION 131 FORM

Appeal No

ABP— 320354-24

Defer Re O/H

Having considered the contents of the submission dated/received 28/8/24

from Rural Residents Wind Aware + Environmental Group I recommend that section 131 of the Planning and Development Act, 2000 be/not be invoked at this stage for the following reason(s): No new material planning issues.

Section 131 not to be invoked at this stage. ✓

Section 131 to be invoked — allow 2/4 weeks for reply.

Signed	Date
Daniel O Connor (EO)	10/9/24

Signed	Date
(SEO/SAO)	

M

Please prepare BP — Section 131 notice enclosing a copy of the attached submission.

To	Task No	Allow 2/3/4 weeks
		BP

Signed	Date
(EO)	

Signed	Date
(AA)	

An Bord Pleanála

Planning Appeal Online Observation

Online Reference
NPA-OBS-003723

Online Observation Details

Contact Name
Adrian O'Neill

Lodgement Date
28/08/2024 15:30:49

Case Number / Description
320354

Payment Details

Payment Method
Online Payment

Cardholder Name
Adrian O'Neill

Payment Amount
€50.00

Processing Section

S.131 Consideration Required

☑ Yes — See attached 131 Form

☐ N/A — Invalid

S igne d
Daniel O Connor
EO

Date
30/8/24

BP40 - no receipt needed

Fee Refund Requisition

Please Arrange a Refund of Fee of
€

Lodgement No
LDG— 074378-24

Reason for Refund

Documents Returned to Observer
☐ Yes ☐ No

Request Emailed to Senior Executive Officer for Approval
☐ Yes ☐ No

Signed
EO

Date

Finance Section

Payment Reference
ch_3PsmtZB1CW0EN5FC0VSqd2vt

Checked Against Fee Income Online
EO/AA (Accounts Section)

Amount
€

Refund Date

Authorised By (1)
SEO (Finance)

Authorised By (2)
Chief Officer/Director of Corporate Affairs/SAO/Board Member

Date

Date

Rural Residents Wind Aware and Environmental Group
C/o Fiona Donnelly,
Baunreagh,
Old Leighlin
Co. Carlow
R93 EP65
Phone: 087 7706856
Email rrwaeg@gmail.com

An Bord Pleanala
64 Marlborough Street
Rotunda
Dublin 1
D01 V902

28.08.2024

Application Reference:	Bord Pleanála Case reference: PL01.320354 Planning Application **Ref: 2460122**
Re:	Planning Application to Carlow County Council for a Wind Farm Development and all associated works in the townlands of Ridge, Agharue, Coolnakisha, and Seskinrea, Co. Carlow
Proposal Detail:	7 no. Wind Turbines, 38KV onsite Substation, Battery energy storage system and associated works and infrastructure in the townlands of Seskinrea and adjacent townlands, in Co. Carlow

The concerns related in the following submission are our community issues that need to be considered by An Bord Pleanála, all members of the Rural Residents Wind Aware and Environmental Group, are in agreement with concerns raised in these observations, as all of the issues are very relevant due to shared locations of the community. We now feel, that our community observations and submissions have to be extensively reviewed.

Yours sincerely

Adrian O'Neill Fiona Donnelly Delaney

Background to Community Consultation

We the residents of the surrounding area of this proposed windfarm are disappointed with the conduct of EDF & Coillte in relation to the lack of community consultation. We are aware that ALL the consultation was done ONLY with landowners and Coillte until the plan for turbine location, substation and access roads were drawn up and confirmed. It is only at this time that their "public consultation" started. Their leaflet drop, house calls, newspaper notices and public meeting calls are nothing more than a box-ticking exercise telling the residents what they were going to do.

No concerns or fears of the local residents had any effect on the already agreed plans.
Both EDF and Coillte state that community consultation is important to them. Another facilitator Galetech submitted plans in 2014 to Carlow County Council for a wind farm consisting of 21 Turbines. On that occasion, Carlow County Council received more objections to their proposed development than objections to any other planning application received by Carlow County Council. So EDF and Coillte were very aware of our opposition to Industrial-sized turbines before they submitted proposals for the area. We as a community were in complete opposition to 21 No. smaller turbines in 2014. The proliferation now of wind farm applications now brings the area up to 19 no. turbines in a small and confined area of Carlow.

EDF and Coillte have shown us as a community that they are not willing to consult with the community now on two occasions. In their submission they gave details of Telephone numbers set up, email contacts available and Clinics held. Residents of the community refused to engage because they knew that their voices would not be heard, and no changes would be made to the planning application as was the case previously in 2014.

In EDF planning application details the "Impact of Community Consultation on Project", they go through details of how it was impacted.
The ONLY change between the initial plans that were put forward and the final plans that were sent to Carlow County Council was the slightly change in turbine size from 7.2 to a 6.6Mw Turbine per turbine

In the **Code of Practice for Wind Energy Development in Ireland 2016** emphasis is put on community Engagement and its importance in the success of wind energy projects. The Code states that in relation to engagement: " *The project promoter should engage with the local community throughout each stage of the project, e.g., feasibility, design, EIA and planning, tender, construction, and operation. These elements should all form part of a Community Liaison Strategy (CLS) which must set out an engagement timeline at key project milestones (following the sample template at Appendix 1) and include at a minimum a dedicated website, the distribution of regular newsletters, education and outreach programs. The actual approach in each project/stage will vary, but there must be open and transparent sharing of information and outreach, e.g. site and project information, advising individuals and communities of lodgment of consent applications, updating on progress. As well as providing information, promoters should work to understand the views of local communities at an early stage to enable these to be considered in the final design of the project to the greatest extent possible."*
We, as a community were not consulted on the feasibility, design or EIA stages of the project. We were basically told what happened when the plans were completed. We feel that EDF and Coillte

have failed us as a community by not involving us in these stages. This led to mistrust of EDF as a result and resulted in increased opposition from the community as a whole.

If there was genuine community engagement from EDF, they would know about our residents. They would know the concerns of a community mother who has worries about her 11 year old son with epilepsy or our community members with special needs, or the worries about residents who believe that if this project goes ahead their houses will be devalued which will result in higher interest rates when their loan to value ratio is affected as a direct result of the proposition of a windfarm.
EDF don't know these stories, they don't know our community because they didn't **engage.** Our community set up a Facebook page. It is called "no to turbines in the old Leighlin and Coolcullen areas". Through this website we set up a petition for people who have a connection with Old Leighlin to sign. To date there are in excess of 700 signatures on our files

Coillte Community Consultation

We as a community are also disappointed with Coillte's involvement in this project and their lack of consultation.

As per Coillte's website

OURENGAGEMENTPROCESS

Coillte has a long history of working with communities and our experience around the country has generated an inherent understanding that each community and receiving environment with which we interact is unique.

When developing our projects, we aspire to work with the communities surrounding our projects and wish to be good neighbours and to build a healthy relationship based on trust and respect. Community engagement should be undertaken in an appropriate manner with the communities in the environs of the development, at all stages of the project lifecycle from; Development, Construction through to Operations.

The intention of our engagement process is to;

- *ensure that all persons living and working in the environs of our developments are kept informed of ongoing and proposed works throughout the project lifecycle.*
- *maintain a proactive flow of accurate messaging from Coillte, in order to avoid misinformation circulating.*
- *be transparent in order to contribute towards building respect and trust as a good neighbour in the long term.*

- *develop an understanding of the communities surrounding our projects and determine if there are community needs and/or requirements that will be addressed by a future Community Benefit Scheme.*
- *be visible and accessible to the community and stakeholders to find out about project updates and the Community Benefit Scheme.*
- *ensure communications and public/stakeholder engagement at all stages of the project lifecycle from; Development, Construction through to Operations are;*

CONSULTATION WITH THE COMMUNITY

By engaging early and often, Coillte can better understand the local community and local issues. This can create value for stakeholders as well as use the engagement process to better inform the design of a project or the necessity to remodel a project.

Consultation with stakeholders and the public is vital to the project design and where possible the project is revised to address concerns and constraints identified. The final project proposal involves a careful balance between the development of a project and the technical, environmental, economic and social issues.

As per today not one member of our community has been approached by a representative from Coillte.

Do to the enormity of the developments and community impacts We believe that EDF, Gaeltech and Statkraft have failed to consult with the community on a proper and meaningful way.

Our community supports Carlow County Councils decision to refuse planning permission for this development and appeal to An Bord Pleanala to support this decision on the grounds as stated within refusal form Carlow County Council both in 2024 & 2014.

In consideration EDF are given planning permission without fulfilling their obligations for community consultation in a meaningful way at all stages of the development process as per the **"Code of Practice for Wind Energy Development in Ireland 2016"** then it has encouraged other windfarm developers to follow the same path. If wind energy is going to form part of our obligations towards our renewable energy targets, then Community Consultation is the most important step.

Aarhus

PUBLIC PARTICIPATION

The Aarhus Convention protects every person's right to live in a healthy environment. It guarantees the public three key rights on environmental issues.

Access to Information
Public Participation
Public Health & Safety

The second fundamental of the Aarhus convention is that of public participation. This is the second right where members of the public can take part in making decisions where there may be an environmental impact. There have now been three developers come into the community. There has been no active engagement in any public consultation with any of the developers. The public meetings were poorly attended as they only gave out pre-printed information about what they have decided to develop in the area, land lease agreements were "supposedly" in place with landowners and it was said this is where the turbines are going, this is the development. At no point have any of the initial schemes changed due to public consultation, some have got bigger and widened their development. Some have sought planning permission on lands with no landowner consent, which confirms blatant disregard for this community.

An Bord Pleanála needs to query the actual engagement from EDF (and the other developers) and show where proper cumulative consultative dialogue has happened about this development and the cumulative effects on the other planned developments. As a community, we will challenge a breach of the Aarhus Convention to the European Courts of Justice where blatant overdevelopment in a rural but populated area has been allowed.

- Public Participation is required from the 'concerned public' when activities affecting specific groups or individuals are being carried out, such as plans for construction (Article 6 of the Aarhus Convention).

- Public participation is required from 'the public' for the development of plans, programmes and policies relating to the environment. This includes issues such as climate policy (Article 7 of the Aarhus Convention).

- Public participation is required for the development of legal acts relating to the environment (Article 8 of the Aarhus Convention).

Introduction

RURAL RESIDENTS WIND AWARE & ENVIRONMENTAL GROUP

We are representatives and members of our communities, we are the members of the local clubs, and organizations, our children are the members of the schools, participants and proud to be part of our community in every way.

Our homes, of approximately 130 homes within 1500m of and surrounding areas to Seskin Wind Farm development. This development will have a direct influence on all homes especially due to higher altitude and in low sun conditions. The impending Boolyvannanan (Bilboa) wind farm with planning permission consent and a subsequent ABP decision to grant the Whitehill Wind Farm (currently in Judicial Review) will have a detrimental effect to the area on human population and habitats directives.

The **Seskin wind farm** again will have an increased influence on the northeast area surrounding the Ridge with turbines that are to be built even higher and wider than Boolyvannanan and Gortahile, which are a similar scale to Whitehill. It is unacceptable to our community and within the wider community of the Ridge that these developments are considered in any way suitable for this area.

With the planning permission refused by Carlow County Council, it should have been felt that Carlow has allowed more than enough wind turbines in such a small area.

Below is a list of our members and have listed their objection on Seskin Wind Farm-

Anna Dunphy
Michael Boyd
Jonathan & Florence Elliott
Justin & Susan Hayden
J. Burroughs
Margaret Meaney
Mark Galvin
Shelley Coe & David Brogan
Louie Coe
Stephen Keogh
Martin Walsh
Bergin Family
Mary Farrell
Nicola O'Leary & Justin Rattigan
Alice O'Leary & Seamus Hayden- Old Leighlin Hall Committee
Alice O'Leary & Stella Grant- Old Leighlin Tidy Towns
Louise Delaney
Rose Arnolds
Westley Delaney
Thomas Kavanagh
John Kavanagh
John & Ellen Shore
Catriona & Pat Nolan
David O'Leary
Philip Daly
Maura & Jane Kavanagh
Alice & Denis O' Leary

Patrick Kavanagh
Michael Delaney
Francis Kavanagh
Grainne Kavanagh
Kay Delaney
Raymond Quirke
John & Terri O' Neill
John Shore
Denis O'Leary
Lorraine Kavanagh
Anne Honeyball
Old Leighlin Sustainable Energy Community
Michael Gahan
Willie Lakes
Kevin & Ann Sheerin
Emma Riordan
Alan Tallon
Rory & Mary Sheerin
Jaakko Ranta
Ellie and James Kinsella
Michael Lakes
Agnes Kavanagh
James Kavanagh
Eilish & James Kavanagh
Janet Daly Jamie Morrissey & Adam Morrissey
Mary & Liam Forde
Eoghan Carpenter
Eamon Colman
Tadhg Carpenter
G. & D. Gahan Tom
Quirke
Tommy Quirke
F. Farrell
M. Murphy
Rural Residents Wind Aware & Environmental Group
Martin & Yvonne Moseley
B. Lennon
Chloe Carpenter
Elizabeth Nolan
T. & E. Carpenter
Kevin Carpenter
Pauline O'Connell
John Walsh
C. McCabe
D. & D. Comerford

A. Quirke
R. Farrell
R. Kidd & N. Daly
G. & R. Quirke
Mark O' Brien
Save Our Hills
S. Lennon
J. Lennon
Adrian O'Neill & Sinead O'Neill
M. Lennon
Sinead O' Neill
Fiona Donnelly
Laura Carpenter
Gemma Carpenter
Jenny Kane
Willie Delaney
Rhona & Gerry Mulhall
Raheen Lane Residents c/o Jenny Kane & Caroline Taylor
John & Joan Carpenter

These are all members living within proximity of the SESKIN WIND FARM, but also a lot are affected and reside between two proposed wind farms.

We would also like to point out that Old Leighlin Area is a highly motivated group which created its own SEC Group as highlighted in the attached appendix A of this document.

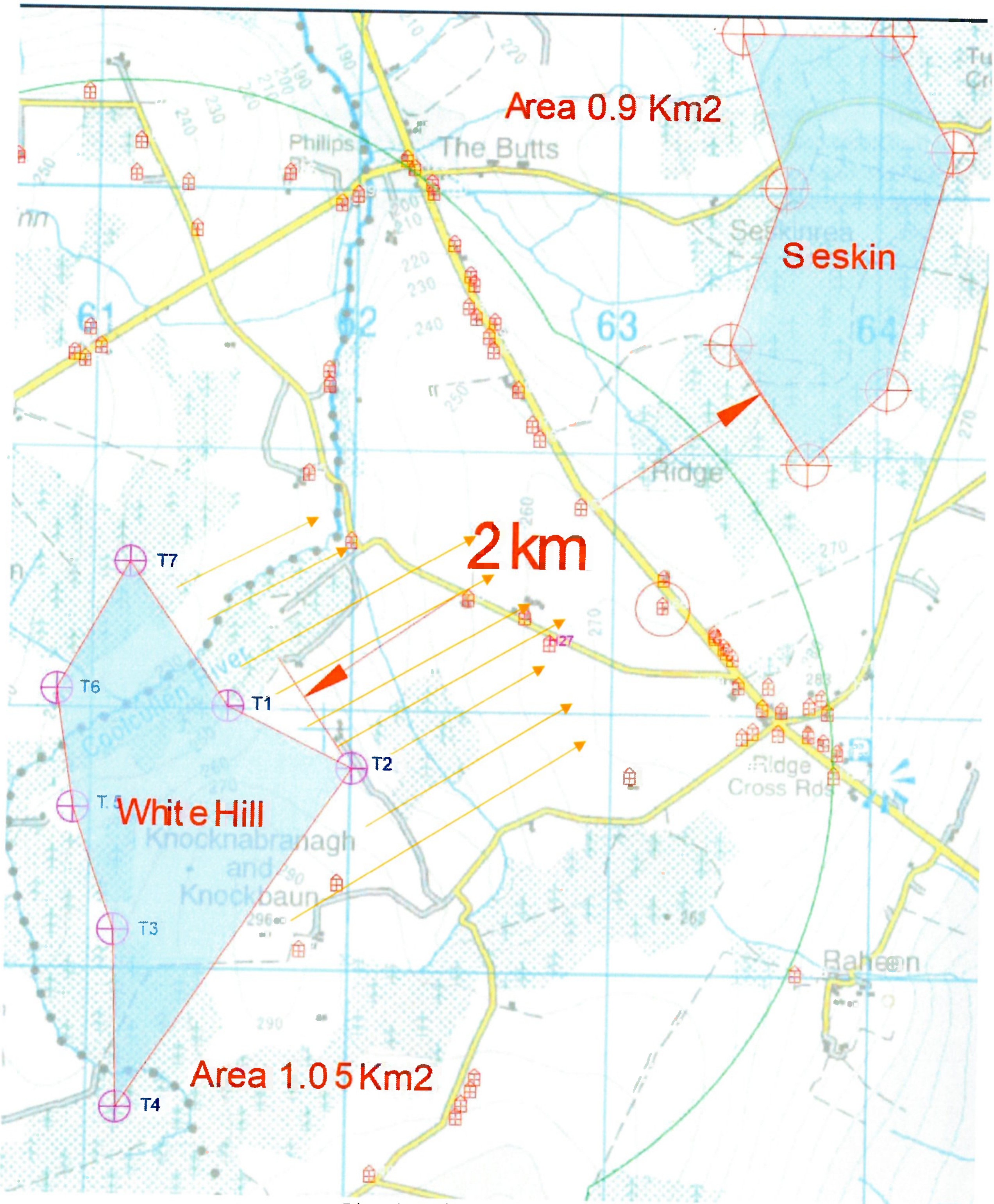
The SEC group has many members within our own group that have already submitted their objections to Carlow County Council for this application.

Ch 7 : Climate Action and Energy

Wind Energy Policies

WE.P4 Wind farm development will not normally be permissible in the Uplands Landscape Type as shown in Figure 6 of the Carlow County Landscape Character Assessment included as Appendix VII to this Plan. This provision shall not apply to micro energy generation and community energy projects as provided for in Section 7.10.3.5, where deemed appropriate and subject to compliance with proper planning and environmental considerations.

LOCATION



Direction of prevailing wind.

1500M BOOLYVANNANAN – SESKIN- WHITEHILLS PROPOSALS

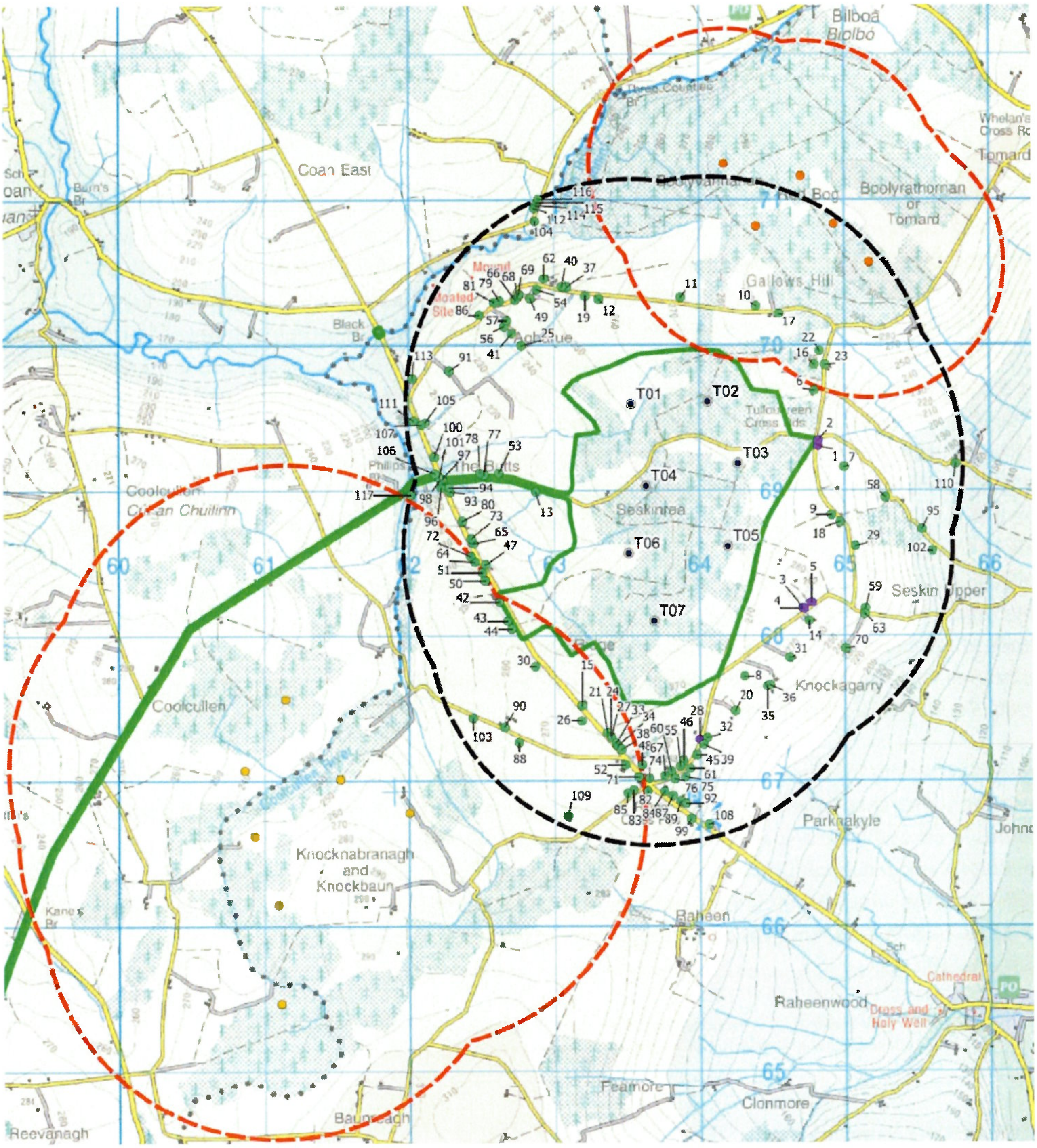


Image shows the number of homes that live within the 1.5km. The overlapping of homes on the Whithills development and Boolyvannanan (Bilboa) increases the effects of large scale turbine developments on homes overlapped in this area. It is totally unfair to ask residents to live within the effects of three wind farms in such a populated area.

Design & Layout

DENSITY

Density of the development

Due to the size and scale of the proposed turbines within a very small area of approx. 0.79Km^2, it is suggested the layout of the turbines will have a detrimental effect on the aspect and ratio within the landscape character of the area. The nature of the layout is that which will increase the risk of greater air turbulence in the wake of each turbine decreasing the actual performance of each turbine which is situated too close either downwind or crosswind of another turbines. The spatial density proves again that there is little to no regard shown for the landscape to absorb the amount and scale of wind turbines of this density. This is hugely negative and will have a profound and effect of "over development" to out-of-date regulations.
Further to other developments such as Whitehills and Boolyvannan (Bilboa) Wind farm the densities are lowing this scale and density of development will set a very negative precedence both for this area but also for other parts of the country. Carlow County Council need to consider the size and scale of this development to be
Boolyvannan Wind Energy (Bilboa Wind Farm) already with planning permission is again within the same region has 5 no. turbines with a capacity of 22.5Mw. The overall scale of the turbines being proposed for Knockbaun & knocknabranagh, Seskin, Bilboa will have severe impacts on the landscape character and visual impact of the areas, and contrary to the relevant provisions of Carlow County Council Plan 2022-2028.

The spatial density for the proposed SESKIN development equates to a density of **31.5Mw/0.79km^2.** This is far higher than anything permitted in any region even in mainland Europe. Onshore wind turbines in Europe have a spacing density of **14.1Mw/km^2**. Refer to the extract in 2019, appendix A Enevoldsen and Jacobson [25] which conducted a specific spacing density exercise for more than 1,200 operating wind turbines. The result for <u>onshore</u> wind turbines in Europe was a spacing density of **14.1 (6.2-28.9) MW/km2** which is in the range of what was suggested by Enevoldsen and Valentine [10].

(25) P. Enevoldsen and M. Z. Jacobson, "Data Investigation of Installed and Output Power Densities of Onshore and Offshore Wind Turbines Worldwide," Renewable Energy, 2018.

SPATIAL DENSITY Summary

Seskin Wind Farm **39.8Mw/km^2. (cluster)** In summary these figures Whitehills **50.4Mw/km^2. (cluster)** show how out of date Irish Boolyvannanan **75.0MW/ km^2. (Slightly linear)** guidelines are.

Figure 10 below shows the average number of turbines and power rating installed on mainland Europe. As you can see the power ratings are an enormous factor when sighting and planning locations of turbines. The power ratios should set the size and noise figures for distance and spacing of large scale wind turbines.

Extract from Wind Europe 2020:

EDF have stated to use between 6-6.6Mw turbines. These power ratios have only ever been considered for off-shore turbines, they are new to the onshore market in Europe.

Based on the available data from 16 countries, the weighted average power rating of onshore turbines was 3.3 MW. Data in appendix A.

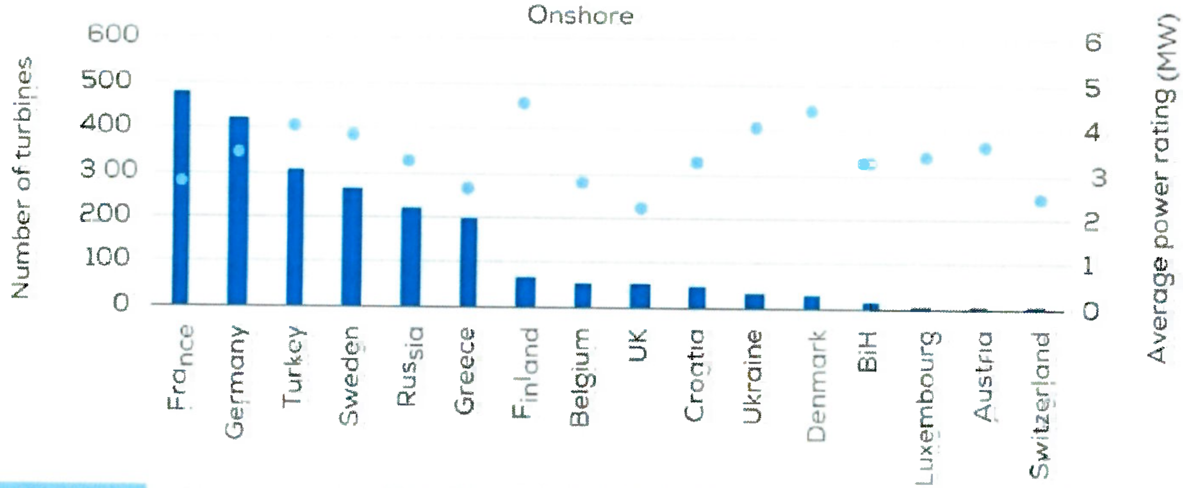
The scoping exercise should have noted that while performance is listed as 6.6Mw/ turbine the actual performance of turbines is only approx 38% efficiency.

As you will note in figure 10 in the above chart there are no turbines shown in excess of 4.5Mw onshore in any European country. Failure to implement proper regulations (not just guidelines) should have been in place since 2006. It has to be noted on why now this scale of turbine is been pushed into a small area of Carlow, when new regulations are imminent. It is perceived that setback distances will be linked to power ratios. Carlow County council should suspend all wind energy applications until the regulations are implemented. Failure to do so will find high courts full with judicial reviews and noise nuisance claims.

The average power rating of new on shore turbines was 3.3Mw
It is against all planning principles to allow such structures to be built in such close proximity of homes.
This reason alone should refer this application as non-compliant to industry and planning guidelines.

FIGURE 10

Number of turbines installed in 2020 and their average power rating

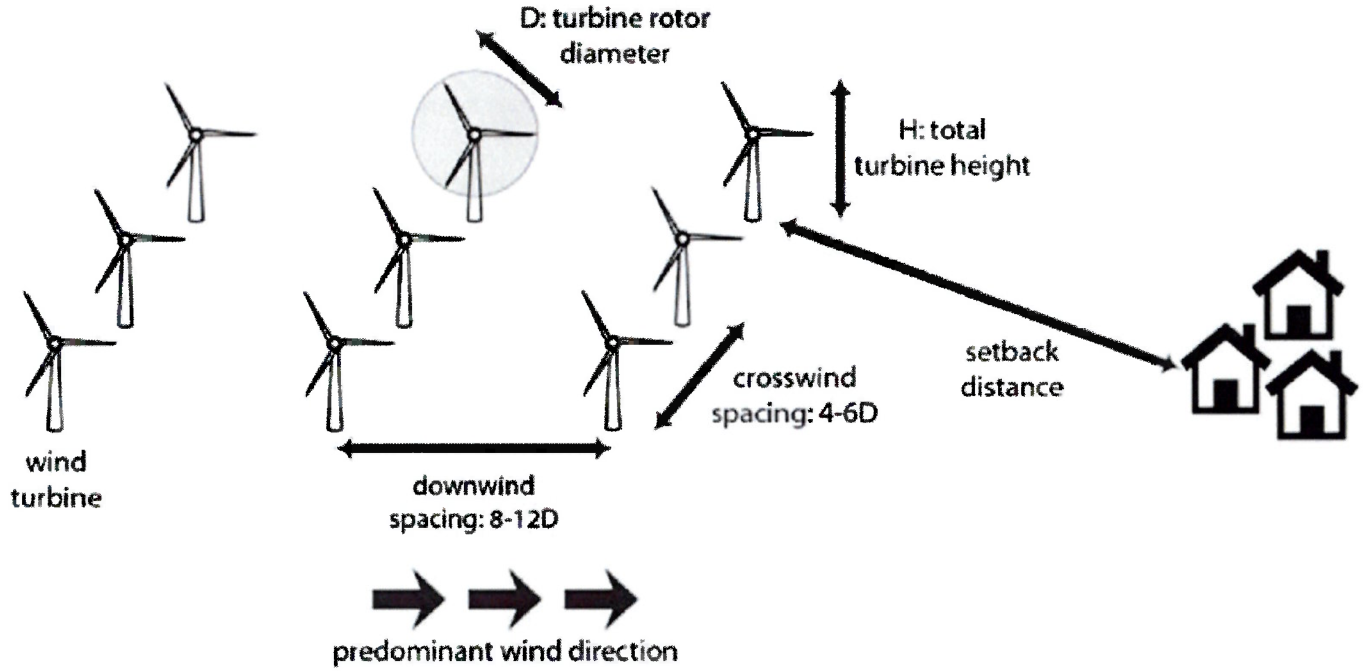


	France	Germany	Turkey	Sweden	Russia	Greece	Finland	Belgium	UK	Croatia	Ukraine	Denmark	BiH	Luxembourg	Austria	Switzerland
Number of turbines	477	420	306	264	223	200	67	55	52	47	36	31	15	9	7	5
Average power rating	2.8	3.4	4.0	3.8	3.2	2.6	4.5	2.8	2.2	2.0	4.0	4.4	3.2	3.3	3.6	2.4

SPACING

The spacing layouts recommended for the optimal performance and less impacts on the surrounding environment, homes and habitats. As you will see the recommended rotor diameter for wind turbines downwind (or the prevailing wind direction) and crosswind.

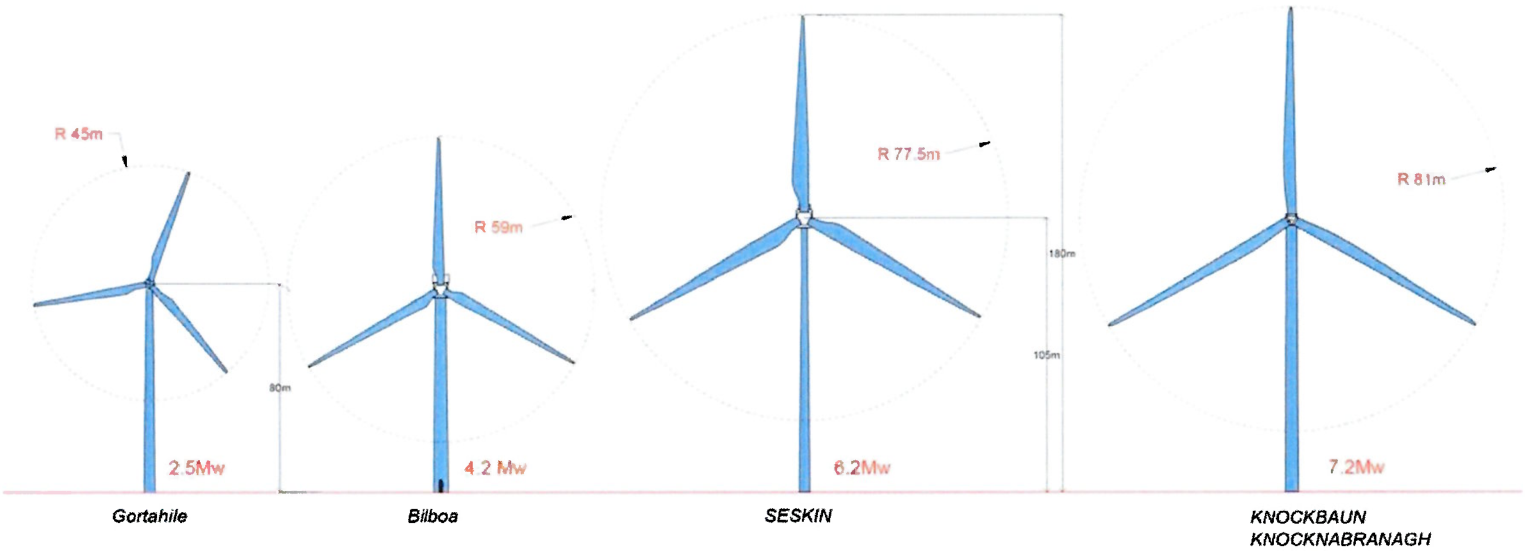
EDF are ignoring industry advice and even current guidelines.



The spacing between of three wind farms is not in keeping with proper planning guidelines. The cumulative effects of the developments have overlapping homes and in some cases homes will have dual aspects of wind farms in front and behind their homes. This is unprecedented and in principle should not be allowed.

SCALE

The following notes are prepared in sections and the relevant aspects of the documentation submitted with this application for Whitehill Wind Farm, Seskin Wind Farm, and Bilboa and Gortahile wind farms.



The four sizes and types of turbines and scale are represented in the above drawings. Seskin Wind Farm scale of turbine & power rotor diameter is un-precedented for onshore developments and especially in confined locations surrounded by homes. Please note there are approximately

The close proximity of the sweep area to ground level of each turbine for Whitehill and Seskin will mean huge impacts on bats and birds that generally fly and hunt at these levels. The EIA impact statements do not take into account the low trajectory of the blade sweep areas. Carlow County Council cannot ignore such information in relation to the peregrine falcons, hen harriers that are within both the EIA statements submitted by EDF and previous developers, copies and reference in appendix A.

The identified wind turbine submitted by EDF states a hub height of 105m, higher ground clearance is generally a requirement to avoid bird and bats, but also to ensure less air turbulence for the turbine wake. As with previous wind farm developments, if planning is granted, developers have a history of applying for an increase in height, size and ratios, as per Boolyvannanan Bog and Red Bog (Bilboa) planning applications attached for reference in Appendix A.

The information issued by EDF in the initial consultation periods was for different sizes turbine power ratios and rotor blade diameter. Both developers of the wind farms deliberately changed the size ratios without increasing distances.

The below data used by EDF shows the actual technical information from Vestas. The sound power of this particular make is 104.9db, measured at a hub height of 155m and wind speed of 8.0m/s These sound power ratios are never considered and generally removed from any assessments, and concentrating only on tonal noise from blade sweep etc.

Technical specifications

Power regulation operational data	Pitch regulated with variable speed
Rated power	6,000kW
Cutout windspeed	3 m/s
Cut-out wind speed	25m/s
Wind class	IEC S
Standard operating temperature range	from -20°C* to +45°C

SOUND POWER	
Maximum	104.9dB(A)**

ROTOR	
Rotor diameter	150m
Swept area	17,672m2
Aerodynamic brake	full blade feathering with 3 pitch cylinders

ELECTRICAL	
Frequency	50/60 Hz
Converter	full scale

GEARBOX	
Type	two planetary stages

TOWER	
Hub heights	105 m (IEC S), 125 m (IEC S/DIBt S), 148 m (DIBt S), 155 m (IEC S) and 166 m (DIBt S)

SUSTAINABILITY METRICS	
Carbon Footprint	5.6g CO2e/kWh
Return on energy break-even	5.9 months
Lifetime return on energy	41 times
Recyclability rate	85%

Configuration: 155m hub height, Vavg=8.0m/s, k2, **Depending on site-specific conditions. Metrics are based on an externally reviewed Life Cycle Assessment available on vestas.com

LAYOUT

Site Layout & Impacts

The layout of the Seskin wind farm is in direct comparison to the density of the Whitehill Wind Farm as mentioned previously. The proposed location of the windfarm will mean that if all wind farms are allowed, that 30 homes will be directly affected by two wind farms and these homes will find themselves living within a wind farm development.

The developers obviously share a lot of information and yet do not share the magnitude of these developments directly with the residents of the area. It should be noted that while wind farm companies have years to plan a wind farm, residents have only a short 6-week timeframe to review and raise queries and seek expertise and advice. Residents have to research and find the magnitude and consequences of these developments generally when it's too late and rely on the sole information supplied by the developer.

The location of the turbines which transcend the SAC areas of the Barrow and Dinin River, Coolcullen river, the natural county boundaries between Kilkenny and Carlow, are shown in the attached, is bordered to the North of the site by the Nore SAC and to the south and wets the Barrow SAC. Please refer to the chapter below.

Site Layout & Setback Distances

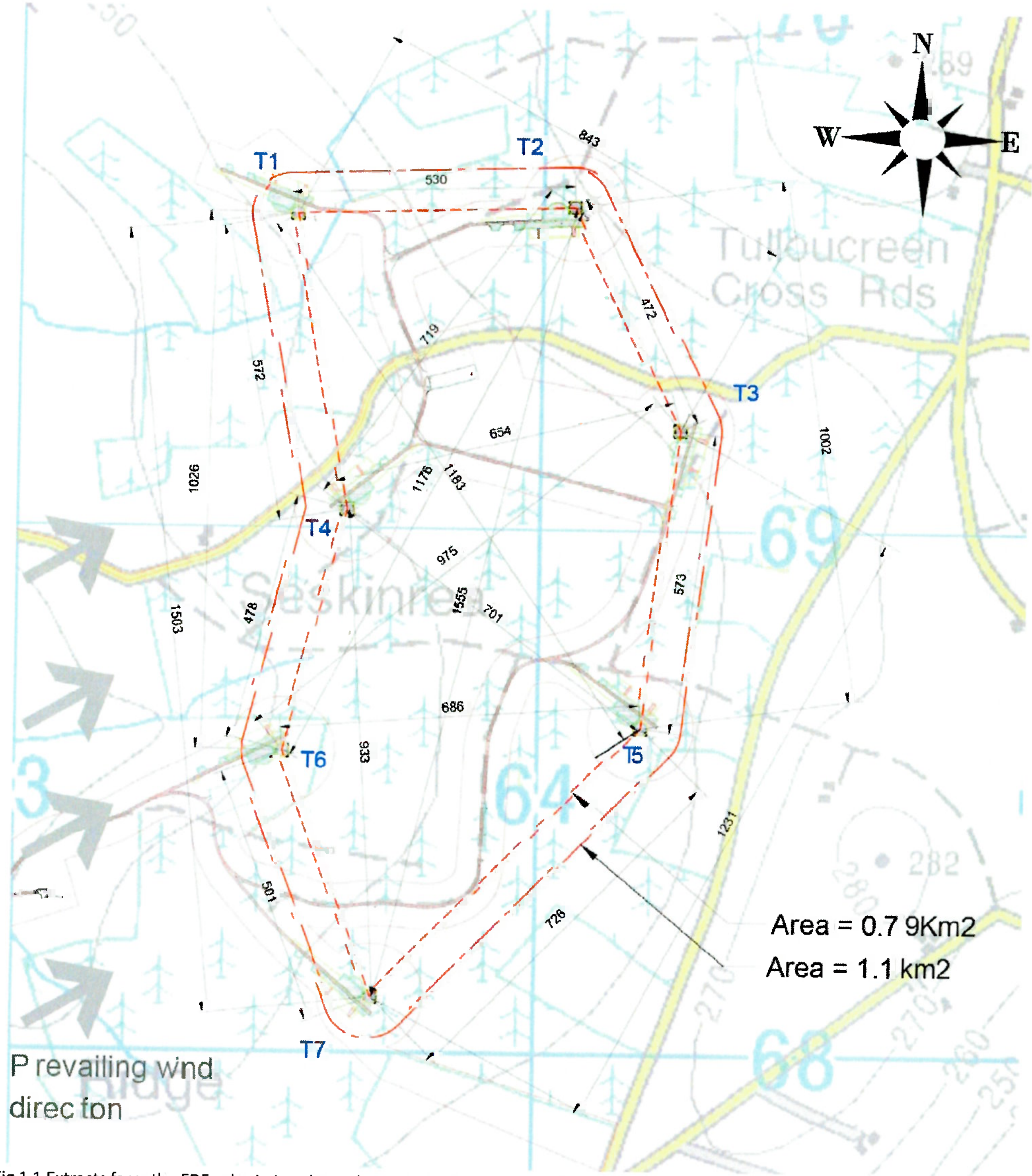


Fig 1.1 Extracts form the EDF submission showed very little dimensions and non from turbines. Dimensions are taken from a scaled reproduction to try ascertain compliance to 2006 Planning Guidelines.

Area of wind sweep (outside blade tip) = 1.1km^2
Area between turbines (base to base) = 0.79Km^2

Setback Distances for turbine layout.

Turbine	T1	T2	T3	T4	T5	T6	T7
T1	0	530	843	571	1183	1025	1502
T2		0	472	719	1002	1176	1554
T3			0	654	572	975	1217
T4				0	701	478	700
T5					0	686	726
T6						0	501
T7							0
Downwind Setback distance (7 x RD) set back distance from turbine to turbine i.e. 1085m (2006 guideline ;)							
Crosswind Setback Distance (3 x RD) set back distances form turbine to turbine i.e. 465m (2006 Guideline ;)							

The above chart shows the inadequate spacing between turbines following 2006 guidelines section 5.13 the minimum setback between turbine to turbine is 3 x tip height (155 x 3 = 465m). Various issues arise from the inadequate spacing of wind turbines including, wake turbulence, attenuated noise issues, shadow flicker, and excessive visual amenity pollution.

The above chart shows inadequate setback distances from each turbine as the industry recommends the following i.e. downwind (8 x RD) and crosswind (4xRD). The size and scale of the proposed turbines completely dominate the landscape in this location and do not respect the scale of the surroundings nor the guidelines as mentioned in the below extract.

5.13 Windtake
In general, to ensure optimal performance and to account for turbulence and wake effects, the minimum distances between wind turbines will generally be three times the rotor diameter (=3d) in the crosswind direction and seven times the rotor diameter (=7d) in the prevailing downwind direction.

The turbines create visual confusion and conflict in this landscape, which is contrary to the guidance provided either in 2006 or 2019 drafts. Placing a wind farm with cumulative effects in direct view to each other across the same vista is not advised in 2006 Guidelines. Whitehills, Seskin, Bilboa are all in direct view on the same vista, and should be considered in excess to visual guidelines.

The layout as shown and stated by EDF may need micro siting of 20m. The adjoining properties and boundaries in certain areas cannot accommodate micro siting and should be verified with adjoining property land agreements in place prior to any form of micro-siting that can be accommodated. EDF has not issued any details of land agreements, consent letters of adjoining properties, proximity housing agreements along the grid route.

Noise

GROSVENOR CONSULTING – FULL REPORT IN APPENDIX C

Rural Residents Wind aware & Environmental Group have sought the assistance of Grosvenor Consulting for analysis of the information submitted within EDF submittals. Grosvenor report is outlined in chapter 2 of this submittal, and we endorse the findings to Carlow County Council as an independent review. The information within this submittal is further evidence that information submitted by EDF may need a lot of independent analysis and the cumulative effects have to be considered in detail.

Grosvenor Consultancy Ref 2460122 Seskin WPP - WT Noise Submission on behalf of "Rural Residents wind aware and environmental group" 14 June-24. FINAL 16.04.

Annex List.
Response to Applicant's Operational Wind Turbine Noise Report.

Attached Annex 1 Finnish Study *Pilot study shows no significant reduction in damage caused by infrasound until more than 15 kilometers from wind farms*

Attached Annex 2 & 2a JUDGMENT of Ms. Justice Emily Egan delivered on the 8th day of March 2024, found in favour of the Plaintiffs, but extracts from this Judgement show (Annex 2 & Annex 2a)

Annex 3. **INWG responds to WSP Report 15 April 2023, "A review of noise guidance for onshore wind turbines"**

Annex 4 . Clinical Protocol for Evaluating Pathology Induced by Low Frequency Noise Exposure .

Annex 5. IARO Review *The Health Effects of 72 Hours of Simulated Wind Turbine Infrasound: A DoubleBlind Randomized Crossover Study in Noise-Sensitive, Healthy Adults - PMC (nih.gov).*

Annex 6. *Hunterston National Offshore Wind Turbine Test Facility. Hearing Statement Rita Holmes. Chair of Fairlie Community Council'.*

Annex 7. INWG WP1 Work Package: '*The Fundamentals of Amplitude Modulation of Wind Turbine Noise'.*

Annex 8. IARO '*Commentary on "Wind turbine noise and human health impacts in Fairlie, North Ayrshire" produced by Health Protection Scotland, July 2017'*

Annex 9 Chapter Infrasound Exposure: High-Resolution Measurements Near Wind Power Plants

Annex 10. *'A third of Groningen villages visit the doctor because of complaints about wind turbines'*

HUSON & ASSOCIATES – FULL REPORT IN APPENDIX D

Huson & Associates has been commissioned by Rural Residents Wind Aware & Environmental Group (RRWAEG) and Save Our Hills Group to review Appendix 12.2 'Wind Turbine Operational Noise Report' (Report), prepared by TNEI, of an EIAR accompanying the planning application for the Seskin Wind Farm (Application).

After refusal of the Application by Carlow County Council (case number ABP-320354-24, planning reference no. 2460122) the proponent (EDF Renewables Ireland Limited) has lodged an Appeal of the decision. This review also considers the Appeal response to Reason 3 of the refusal that was prepared by MKO on behalf of EDF Renewables Ireland Limited.

This review has been prepared by W Les Huson BSc(Hons) MSc CPhys MInstP MIOA MAAS (brief CV in Appendix D).
Referenced papers can be made available on request if required.

Huson & Associates are international consultants and professionals in Acoustics to ascertain the effects of Acoustics within the environment.

The reason for the commissioning of a review of desktop studies submitted by developers, needs to be reviewed by Acousticians and experts in their field. Previous developments have seen underdeclared values to be found in more than one wind farm development in Ireland. Huson & Associates & Grosvenor Consulting have been further commissioned to carry out a full site study of the Seskin and Ridge areas to further verify their findings.

Impacts & Residents Awareness

Due to local knowledge and awareness of the environment that we live in every day, we are very aware the affect of the prevailing winds and natural sounds that are created in the area surrounding all homes. We are very conscious that this development will have 6.2Mw turbines near homes & workplaces. Seskin proposal will be one of three wind farms that have dual aspects to homes and workplaces in this specific region. The arrangement of turbines both in Seskin and Whitehill & Bilboa cumulatively contravenes the 2006 guidelines.

In this proposal of 7 turbines on top of 7 from Whitehill and 5 for Boolyvannan (Bilboa) brings a total of 19 of the largest rotating structures built on land concentrated along each horizon (east and west) to the front and rear of properties running between the Seskin & Whitehill development. The risk of cumulative sounds from all 19 turbines will be channeled (due to the prevailing winds) into homes and work place. The risks associated with the scale of this development have never been appraised before especially in such close proximity to homes in essence there is listed 130 homes within 1500m of the Seskin Development.

Repercussions are generally only brought to attention after the wind farms are constructed to find out the declared noise values were underdeclared form desktop studies.

Previous Noise Assumptions:

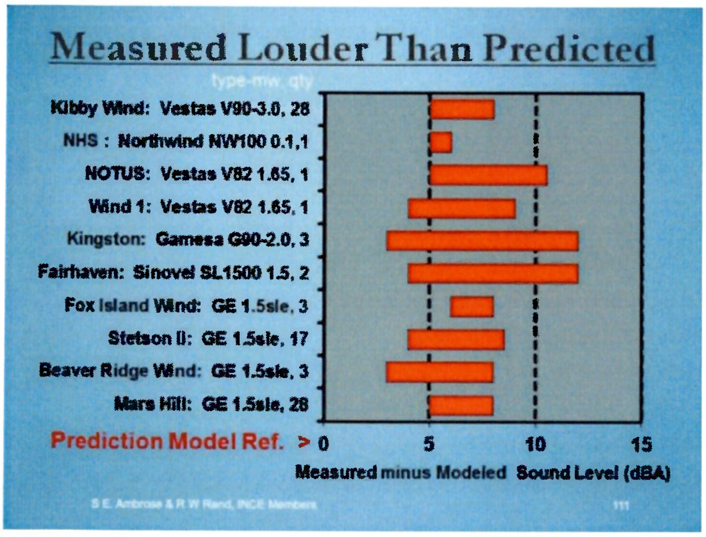
In Offaly, there have been several noise complaints associated with the operation of the Meenwaun wind farm since it began operating. An operational noise assessment submitted within the initial EIA by Fehily, Timoney and Company between February and May 2018 (reported in the Operational Noise Survey Report for Meenwaun Wind Farm, dated July 2018) as part of the planning consent requirements. The assessment concluded that the Meenwaun Wind Farm complied with the consented noise limits, however there are serious concerns regarding the conclusions due to some aspects of the assumptions and methodology used in this assessment.

The attached report (see appendix A) from ARUP (consulting Engineers) Assessment of compliance noise conditions for post construction of industrial wind turbines at Meenwaun found that the declared values within the EIA acoustic report issued by Fehily Timoney & Company were well below the actual values recorded on site, thus there were serious complaints from close proximity homes.

The analysis of the data has shown that ambient noise levels are above the consented noise limits at wind speeds of 5 and 6 m/s. There is further evidence of low frequency noise levels far exceeding the assessed levels from other wind farms with much smaller sized generator see chart below. Meenwaun turbines are 2.7Mw, the proposed turbines for Seskin wind farm are 6.6Mw with a sound power in excess of 105dB, which further exemplifies the risk associated with such a development that again has not been built onshore in Ireland.

Because no proper on-site assessments can be assimilated prior to construction of this scale, the desktop studies prepared by the consultants cannot be replied upon to make decisions for this scale of turbine and the close proximity to surrounding homes.

Poorly prepared and biased information issued within EIA assessments will not only put the risk of individuals close to turbines but also costly independent surveys, remediation works and court cases to assure noise level breaches cannot and will not happen.
Further to this the following chart shows that predicted noise level are underdeclared by the manufacturers. Noticeably the "prediction levels" are predominantly between 5 – 12dB louder than predicted in provisional desktop studies. As a homeowners, we cannot accept the risk put upon us by desk top studies.



Failures to predict noise levels are a frequent issue with wind farms. Consequences are generally "paid to go away" and/or extensive and costly court cases.

Due to the un precedented sizes and close proximity to the ground the desktop studies produced by EDF were independent analyzed by Grosvenor Consultancy and commissioned by RRWAEG.

Further to the above reports, recent current studies have shown wind turbines situated within close proximity to each other and down wind of each turbine (wake) creates greater wind noise turbulence.

Acoustic studies (attached paper) have shown the effects of turbulence conditions in the inflow of a wind turbine and the measured acoustic emission of the turbine. Variations in turbulence can affect overall, unweighted sound pressure levels by as much as **7 dB.,** the range of turbulence intensities observed at the National Wind Technology Centre. Note: a range of 10db can constitute and doubling of sound affects. When turbine manufacturers declare lower acoustic power combined with turbulent wake conditions the results can far surpass the 43db requirements.

Wind turbine noise fluctuates at a rate depending on the speed of rotation. Technically this is known as **amplitude modulation**, which means variation in noise level, although it is sometimes referred to as **aerodynamic modulation** or **blade swish**. This feature of amplitude modulation can readily be observed close to a single wind turbine such that on the downward stroke a different level and timbre of noise may be heard to that as it passes the tower, or as occurs on its upward stroke. As distance from the turbine increases this effect reduces, although for some configurations of turbine sites the effect has been noted to be audible at residential locations some distance away (12RD). In the Guidance Note for Noise Assessment of Wind Turbine Operations at EPA Licensed Sites (NG3) it sates that features which enhance this effect are:

- ***close spacing of turbines in linear rows***

This development as shown below is greatly below the advised rotor diameter (RD) x height to spacing ratios. Please refer to previous chapter on density layout.

➢ ***tower height to rotor diameter ratio***

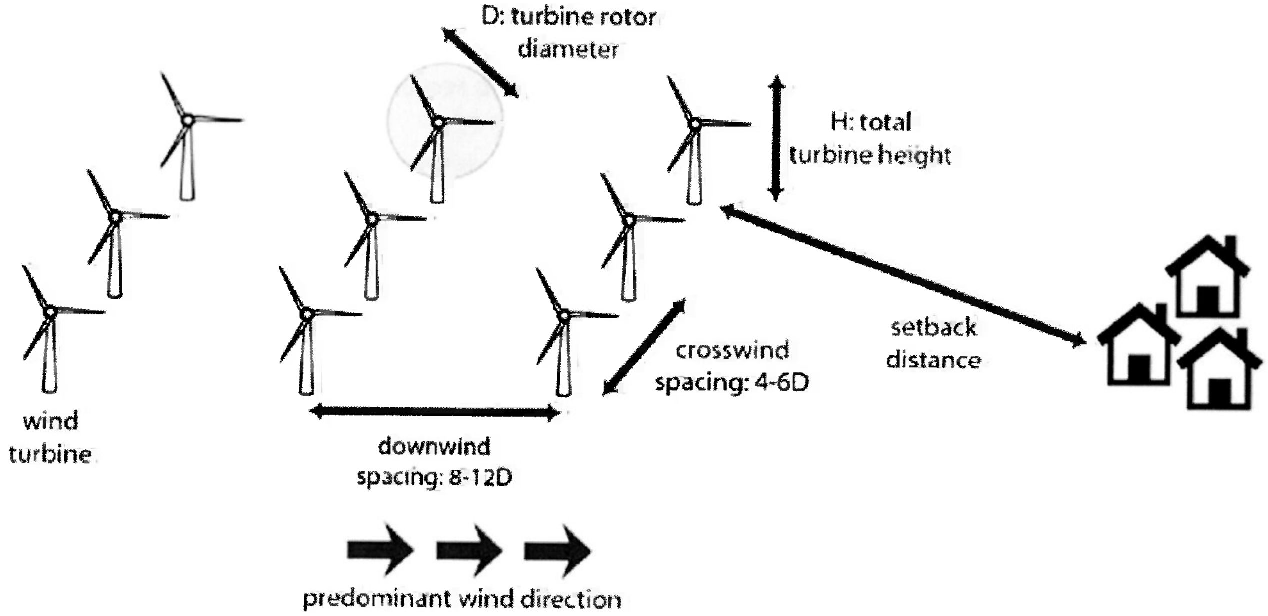
Where the tower height and rotor diameter ratio is less than 0.75, its amplitude modulation is increased due to size of blades and closer proximity to the ground. The tower height to rotor diameter for this development is **0.67.** The Tip of the blades are only 27m from ground level.

➢ ***stable atmospheric conditions*** This can be more audible in lower wind speeds.

➢ ***topography*** leading to different wind directions being seen by the blades at different points in their rotation, turbines at close proximity both to each other and to ground as per different levels as per this development.

Excessive amplitude modulation

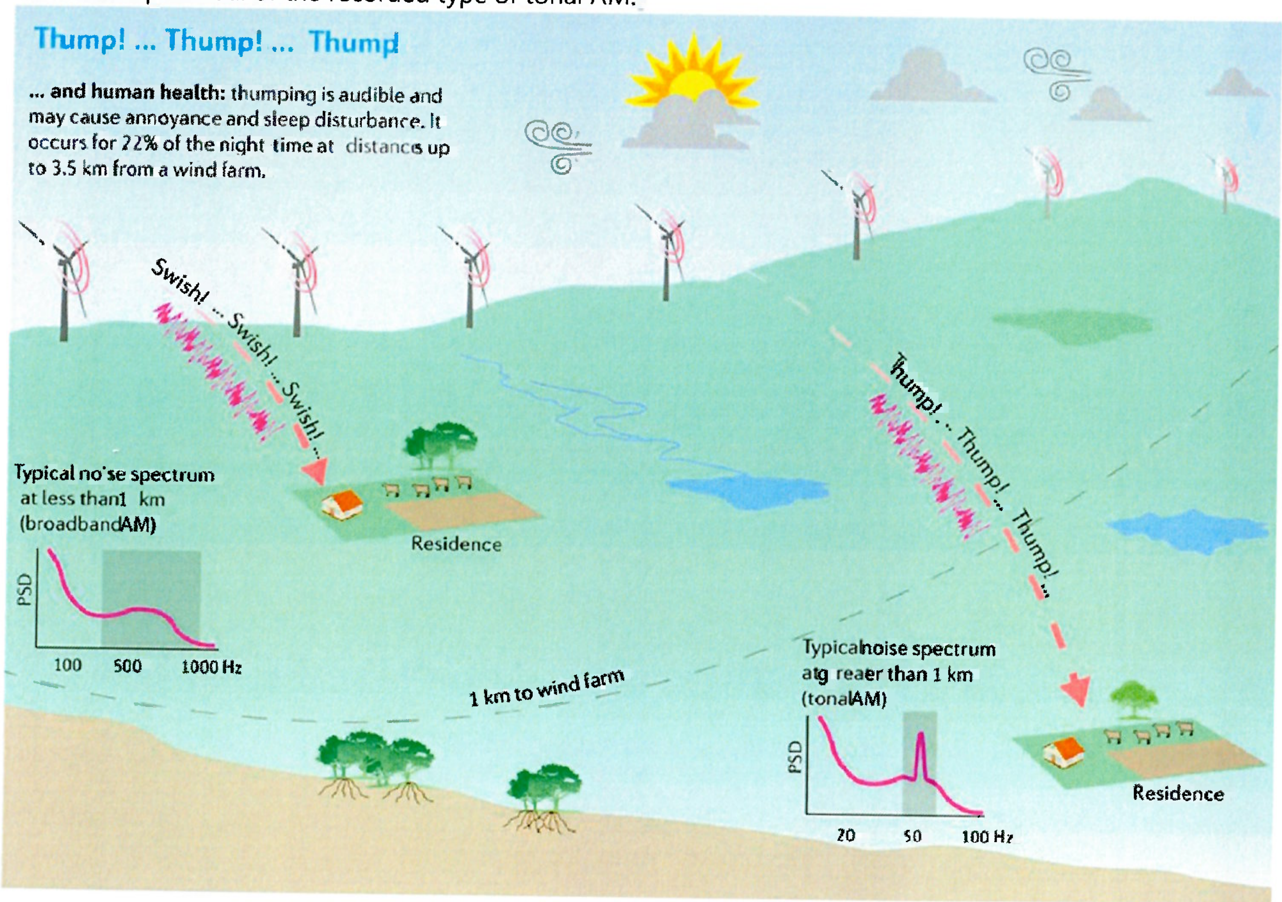
Can be heard whilst trying to get to sleep will generate stress as it extends the time required to fall asleep. This is likely to be exacerbated by excessive audible amplitude modulation, the level of which itself may vary with time & exposure. Audible noise at in variations and above 45db for people that need to sleep during the day (such as night shift workers and drivers) will be far excessive for people to rest.
There-fore it should be noted the acceptable noise levels shown on the desk top studies within the submission do not show variations due to underdeclared values, wind turbulence or differential wind pressures & wind speeds. Both EDF and Gaeltech notes in tables provided that values in their tables do not include the uncertainty allowance, which instead is taken into the calculation process, so the declared values are meaningless?
A proper CFD analysis where the affect of turbulence is factored into sound attenuation studies should have been carried out and presented. Analysis shown are very basic sound studies with no in depth analysis given for verification.
As mentioned, the size and spatial layout as proposed will give greater issues with air turbulence within the wake of each turbine. Industry standard recommended that each turbine down hill of a prevailing wind is approximately 8-12 times rotor diameter from each other, thus would require each turbine in the Seskin development to be a minimum distance of 1240m (minimum) from each, see attached extract on industry study for spatial strategy for wind turbines.



Cross wind recommended to be 4-6D = 620m (minimum)
Wind Energy Development Guidelines for Planning Authorities 2006 states that *"An appropriate balance must be achieved between power generation and noise impact."*

Audible Thumping

In summary, a study investigated the prevalence and characteristics of wind farm AM at 9 different residences located near a South Australian wind farm. Their work showed that, despite the number of AM events being recorded to reduce with distance, audible indoor AM still occurred for 16% of the time at a distance of 3.5 km. At night-time, audible AM occurred indoors at residences located as far as 3.5 km from the wind farm for up to 22% of the time. In a statement to *Advances in Engineering*, Dr. Kristy Hansen pointed out that the adopted approach was successful, although more research was needed to quantify the annoyance and sleep disturbance potential of the recorded type of tonal AM.

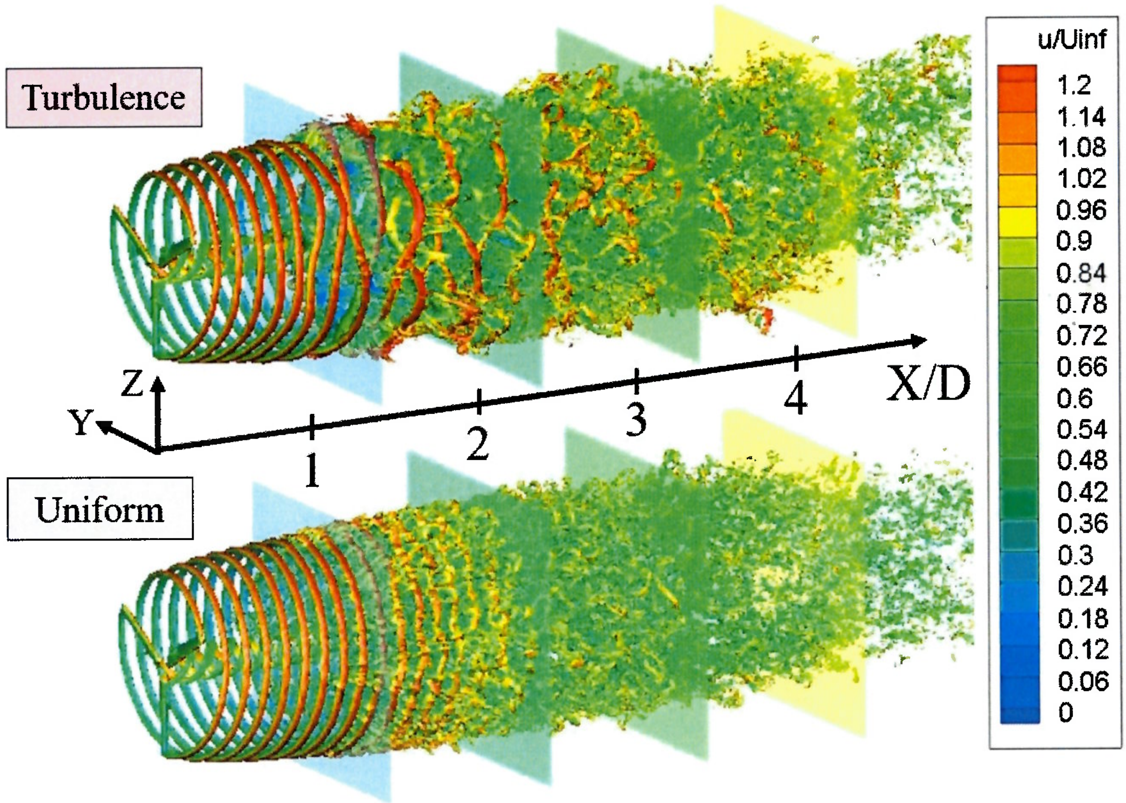


ETSU-R-97 – "The Assessment and Rating of Noise from Wind Farms" was published in 1996 and is the UK government's preferred method of assessing wind farm noise for planning purposes. In the attached assessment by By Dick Bowdler, Published in IOA Acoustics Bulletin, Vol 37, No3

The ETSU-R-97 compares the turbine noise with a level 5dB above background noise but, when background noise levels are low, it sets a lower limit. The day time lower limit can be anywhere between 35 and 40dB and the night time lower limit is 43dB. All these noise levels are quoted as LA90 and so are about 2dBA less than the LAeq. The most bizarre result is that night time noise can be up to 8dBA more than the day time noise.

A review of desktop studies needs to be reviewed against the 2006 guidelines to rule of misinterpretation of results, and complaints for noise issues on wind farms. Article attached in Appendix A. See Grosvenor reports and appendices within chapter 2 of this document.

Wake Turbulence



Developers are pursuing the proposed layouts based on either smaller turbines or out-of-date guidelines. Far reaching studies show that wind turbines placed too close together exemplifies greater risk within the aerodynamic wake affects such as limiting down wind energy reduced by 30% but also increases noise, shadow flicker and air turbulence issues. Within the EDF sound studies there is no reference to the effect of wind turbulence due to inadequately spaced turbines. A proper CFD analysis should have been used to predict the sound and atmospheric disturbance to ascertain the proper affects of noise attenuation from the turbines especially downwind of prevailing conditions.

Note wake affects from turbines can be up to 20 x rotor diameter.

No theory on wake affect from Turbines in any Gaeltech Submission.

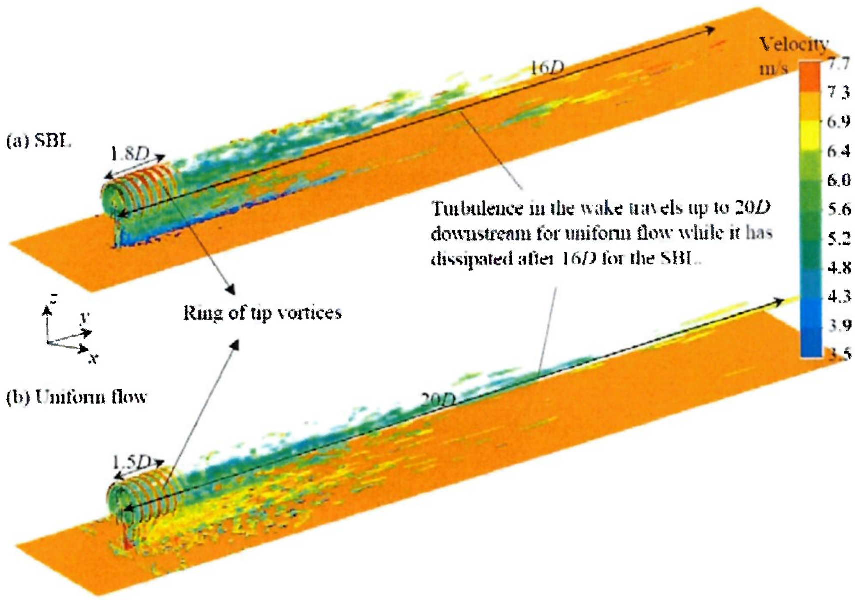
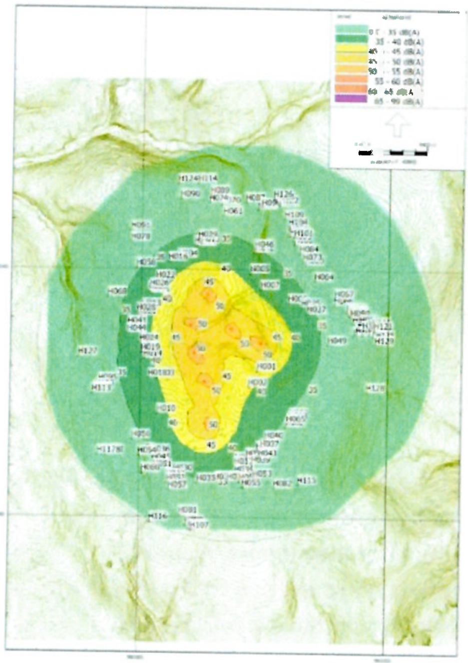


Figure 6.17 Iso-surface of instantaneous normalized Q-criterion, coloured by axial velocity magnitude, showing the vortical structures in the wake region.

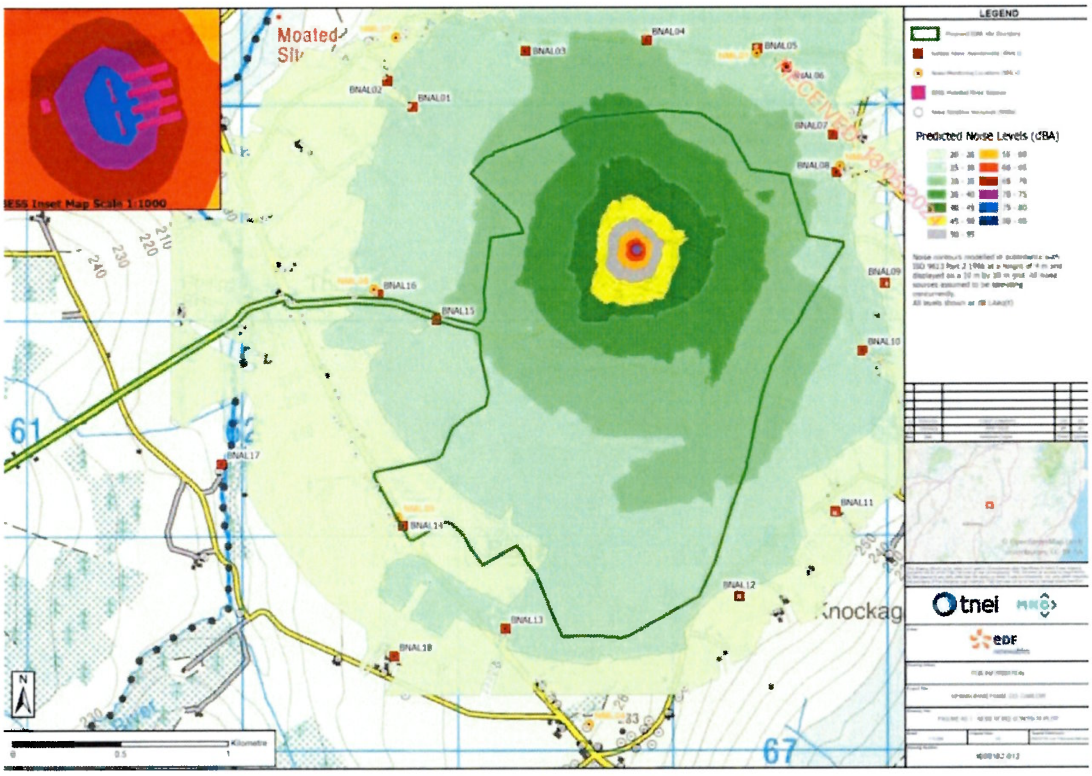
Noise Contour Map

EDF have not submitted any noise contour maps for the effects of turbine noise, and bury information in figures where lay people cannot follow. This is a deliberate attempt to mislead



Similar maps submitted by Gaeltech submission for Whitehill wind farm.

Battery Energy Storage Faciality

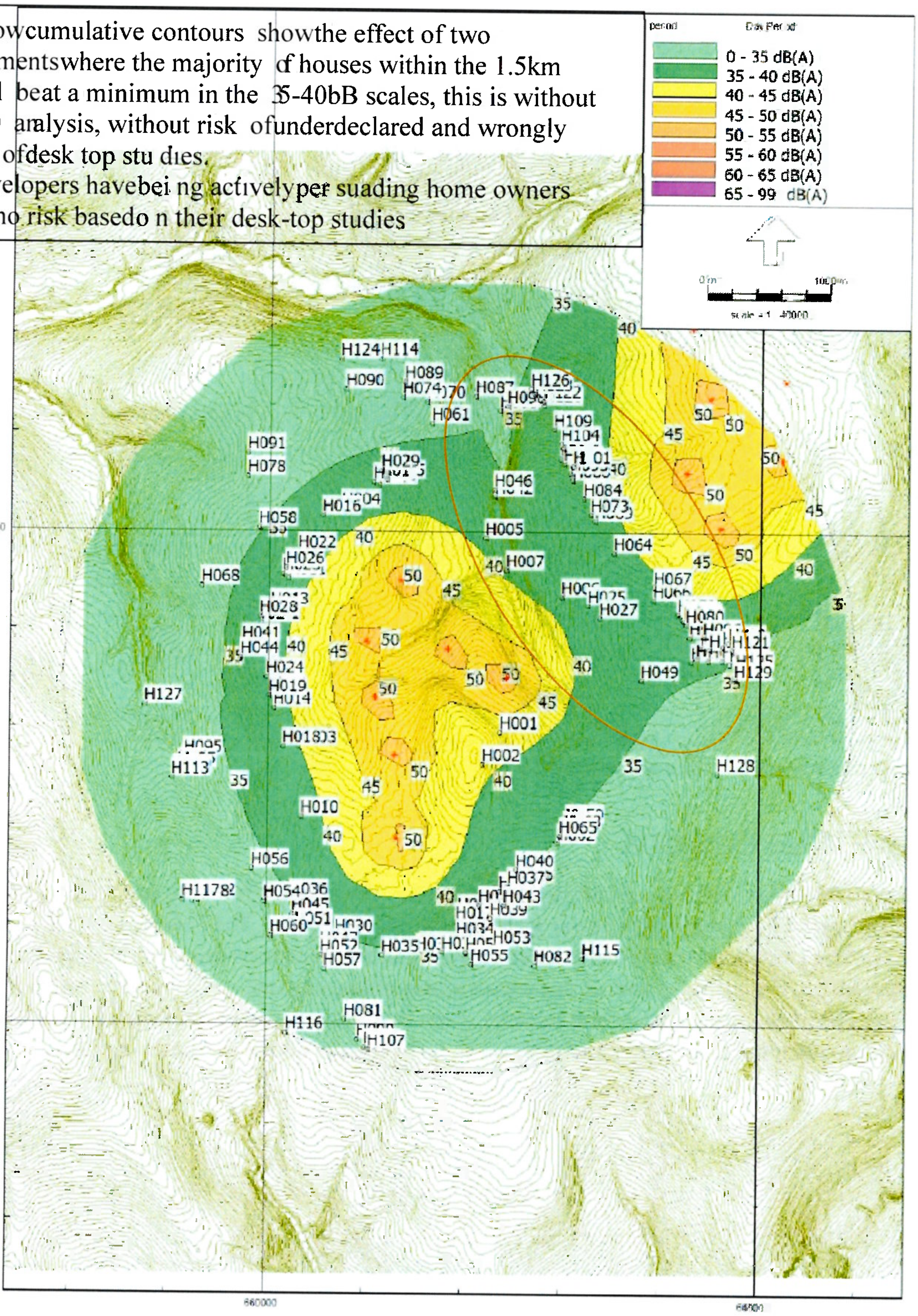


This is the only noise contour maps submitted by EDF

Cumulative Noise Contour

The cumulative sound affect study as submitted by Galetech for whithill wind farm has used the wrong size wind turbine, EDF plan to use the similar power scale turbine i.e., 6-6.6/Mw . The developers have submitted data for 6Mw turbine (with deliberately lower noise octave band frequencies) in their calculations and diagram, shown below. The worrying part of this is the volume of housing that are constantly within the 3540db category (with the wrong power ratio turbine), given that these figures don't take into consideration any deviation from under declared values and issues with turbine wake effects. *See appendix A for details.*

The bel owcumulative contours showthe effect of two develop mentswhere the majority df houses within the 1.5km zone will beat a minimum in the 35-40bB scales, this is without any CFD analysis, without risk ofunderdeclared and wrongly analysis ofdesk top stu dies.
The D evelopers havebei ng actıvelyper suading home owners there is no risk basedo n their desk-top studies



WIND TURBINE NOISE AND HEALTH EFFECTS

Wind turbine noise — BMJ editorial
Author: Hanning, Christopher; and Evans, Alun
Wind turbine noise seems to affect health adversely; an independent review of evidence is needed. The evidence for adequate sleep as a prerequisite for human health, particularly child health, is overwhelming. Governments have recently paid much attention to the effects of environmental noise on sleep duration and quality, and to how to reduce such noise.[1] However, governments have also imposed noise from industrial wind turbines on large swathes of peaceful countryside.

The impact of road, rail, and aircraft noise on sleep and daytime functioning (sleepiness and cognitive function) is well established.[1] Shortly after wind turbines began to be erected close to housing, complaints emerged of adverse effects on health. Sleep disturbance was the main complaint.[2] Such reports have been dismissed as being subjective and anecdotal, but experts contend that the quantity, consistency, and ubiquity of the complaints constitute epidemiological evidence of a strong link between wind turbine noise, ill health, and disruption of sleep.[3]

The noise emitted by a typical onshore 2.5 MW wind turbine has two main components. A dynamo mounted on an 80 m tower is driven through a gear train by blades as long as 45 m, and this generates both gear train noise and aerodynamic noise as the blades pass through the air, causing vortices to be shed from the edges. Wind constantly changes its velocity and direction, which means that the inflowing airstream is rarely stable. In addition, wind velocity increases with height (wind shear), especially at night, and there may be inflow turbulence from nearby structures—in particular, other turbines. This results in an impulsive noise, which is variously described as "swishing" and "thumping," and which is much more annoying than other sources of environmental noise and is poorly masked by ambient noise.[4,5]

Permitted external noise levels and setback distances vary between countries. UK guidance, ETSU-R-97, published in 1997 and not reviewed since, permits a night time noise level of 42 dBA, or 5 dBA above ambient noise level, whichever is the greater.

The aerodynamic noise generated by wind turbines has a large low frequency and infrasound component that is attenuated less with distance than higher frequency noise. Current noise measurement techniques and metrics tend to obscure the contribution of impulsive low frequency noise and infrasound.[6] A laboratory study has shown that low frequency noise is considerably more annoying than higher frequency noise and is harmful to health—it can cause nausea, headaches, disturbed sleep, and cognitive and psychological impairment.[7] A cochlear mechanism has been proposed that outlines how infrasound, previously disregarded because it is below the auditory threshold, could affect humans and contribute to adverse effects.[8]

Sixteen per cent of surveyed respondents who lived where calculated outdoor turbine noise exposures exceeded 35 dB LAeq (LAeq, the constant sound level that, in a given time period, would convey the same sound energy as the actual time varying sound level, weighted to approximate the response of the human ear) reported disturbed sleep.[4] A questionnaire survey concluded that turbine noise was more annoying at night, and that interrupted sleep and difficulty in returning to sleep increased with calculated noise level.[9] Even at the lowest noise levels, 20% of respondents reported disturbed sleep at least one night a month. In a meta-analysis of three European datasets (n = 1764),[10] sleep disturbance clearly increased with higher calculated noise levels in two of the three studies. In a survey of people residing in the vicinity of two U.S. wind farms, those living within 375-1400 m reported worse sleep and more daytime sleepiness, in addition to having lower summary scores on the mental component of the short form 36 health survey than those who lived 3-6.6 km from a turbine. Modeled dose-response curves of both sleep and health scores against distance from nearest turbine were significantly related after controlling for sex, age, and household clustering, with a sharp increase in effects between 1 km and 2 km.[11] A New Zealand survey showed lower health-related quality of life, especially sleep disturbance, in people who lived less than 2 km from turbines.[12]

A large body of evidence now exists to suggest that wind turbines disturb sleep and impair health at distances and external noise levels that are permitted in most jurisdictions, including the United Kingdom. Sleep disturbance may be a particular problem in children,[1] and it may have important implications for public health. When seeking to generate renewable energy through wind, governments must ensure that the public will not suffer harm from additional ambient noise. Robust independent research into the health effects of existing wind farms is long overdue, as is an independent review of existing evidence and guidance on acceptable noise levels.

BMJ 2012;344:e1527 (Published 8 March 2012)

Christopher D. Hanning, honorary consultant in sleep medicine

Sleep Disorders Service, University Hospitals of Leicester, Leicester General Hospital, Leicester, U.K.

Alun Evans, professor emeritus

Centre for Public Health, Queen's University of Belfast, Institute of Clinical Science B, Belfast, U.K.

Provenance and peer review: Not commissioned; externally peer reviewed.

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Work Life

Safety in the workplace

Being a rural but populated area, there is now a lot of people that work from home. Home and work hours will be both affected by the dominant structures of wind turbines, the visual and noise that will occur will be unacceptable, making it hard to live, work and relax within the same vicinity, we cannot accept any risk of stress, noise & communications interference, lack of sleep etc., that can be caused by this development.

With reference to quality of life, Rural Residents of the area have commissioned an independent analysis of the information contained in the Seskin application. This report from Grosvenor Consultants gives a proper and independent review and the results of which speak for themselves.

Work-Life Balance and Miscellaneous Provisions Act 2023
Under this act it states that a home workplace must be suitable for the work. This includes the work environment and communications, up to and including rest periods. Within this undertaking a lot of home workers who run rather successful business and offer a better work life balance have invested heavily to create a work environment from their homes and work life has ensured a quality lifestyle. Within the government charter of the National Remote Work Strategy, there is a direct conflict to the *Pillar 1. Create a Conductive Environment*.

1. **Make a significant investment in remote work hubs and infrastructure in underserved areas to underpin the development of the national hubs network. (DRCD - National Hub Network Working Group, DETE, Q4 2021)**

The over development of this area into a large wind farm, with dual aspect and practically surrounded by noise and visual impediments. Within the Grosvenor report it shows if you work from home there is no escape allowed for, you simply cannot go home to switch off.
I refer you then to the following act repeated so often in this submission.

SCHEDULE 2, Article 1, Protection of Property of the European convention on Human Rights Act 2003.
"Every natural or legal person is entitled to the peaceful enjoyment of his possessions. No one shall be deprived of his possessions except in the public interest and subject to conditions provided for by law and by the general principles of International law."

Communications:

A lot of our community need clear and good communications both from Vodafone and 3, which provide h mobile & mobile broadband specifically for my home working and are dependent on a clear and uninterrupted signals. If Whitehill wind farm is allowed to progress livelihoods and ability to work from home can be stopped.

The layout of the signal homes to the telecommunications mast near Anagar is close to the Whitehill wind farm. The correspondence from the communications companies do not list the tower and list the exact location for signal transfer specific to the Ridge areas as the communication towers generally service the

larger populated areas along the M9 corridor. At no point in the correspondence has it been clearly identified
I would require a more definitive statement form all companies, with signal maps fully identified etc.
there is no risk to signal loss due to high frequency interference and/or physical blockages to my home office.

CUMULATIVE AFFECT

White Hill Wind farm
White Hill wind farm is within the confines of a previously rejected planning application – refer to Appendix A for copies of decisions. This new application of 7.2Mw turbines vastly oversized and enormous in comparison will have the same if not worse impact on the landscape characteristics. The decisions in 2014 should be the same criteria for this application.
The Landscape characteristics have not changed in recent years to influence a change in these decisions, in fact, the areas of population have increased in the past 10 years up 17% in the general area. The location of Seskin, Whitehill, Boolyvannanan is contrary to Carlow County Development Plan 2022-2028. Extract in Appendix A.

Seskin Wind Farm
Is a new wind farm application that is currently being pursued by EDF Renewables. This development again is seeking turbines in similar size and aspect of White Hill wind farm.

Bilboa Boolyvannanan
This wind farm has current approval and is seeking to increase heights and rotor diameter, the three wind farms as a cumulative negative affect enormous to the area. The size and nature and scope of three wind farms trying to be operational by 2030 makes the current planning process a farce without proper regulations and up to date guidelines it leaves the area suspectable to sporadic speculative developments. Current application within Appendix A.

Spatial Extent
The three developments taken into context will contravene proper planning as the irregular spatial extent of the layouts in clusters long a ridge line & raise plateau over looking Carlow and Kilkenny lowlands will prove to be unacceptable where sweeping and continuously even areas of upland plateaus would be more desirable. The areas and land availability cannot give the required spatial extent and spacing to achieve a favorable layout.

Environmental and Habitats are dealt with in another chapter, but all developments will have a serious effect on a range of biodiversity and wildlife habitats.

Water

Hydro-G Report – Appendix B

Rural Residents Wind aware & Environmental Group have sought the assistance of Hydro-G for analysis of the information submitted within EDF submittals. Hydro-G report is outlined in Appendix B in this submittal, and we endorse the findings to Carlow County Council as an independent review. The information within this submittal is further evidence that information submitted by EDF may need a lot of independent analysis and the cumulative effects must be considered in detail.

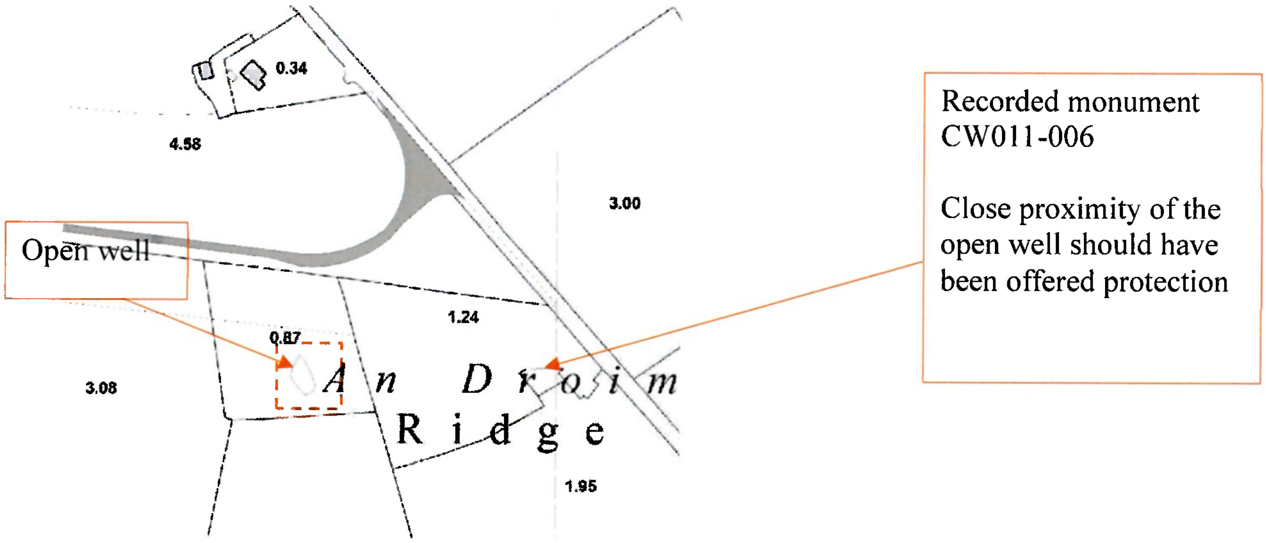
Bored wells are extremely sensitive to any works and even new wells bored in the vicinity. The water run off and risk to water course in the vicinity of possibly been contaminated by construction work, spoiled deposition areas and mineral deposits from broken and unclean stone fill to roads etc. The specification of stone and "imported fill" is not shown on any documentation, there is no mitigation measures for the quality control of such mineral wash out when fill is deposited.

Water Framework Directive

Under national and European law, water is a protected under the barrow and Nore catchment areas. There has been no validation within the EIAR that these directives have been followed and considered. The Seskin Areas is directly connected to Dinin River and is a Nore River tributary. Which are listed within the EPA as having water dependent habitats species.

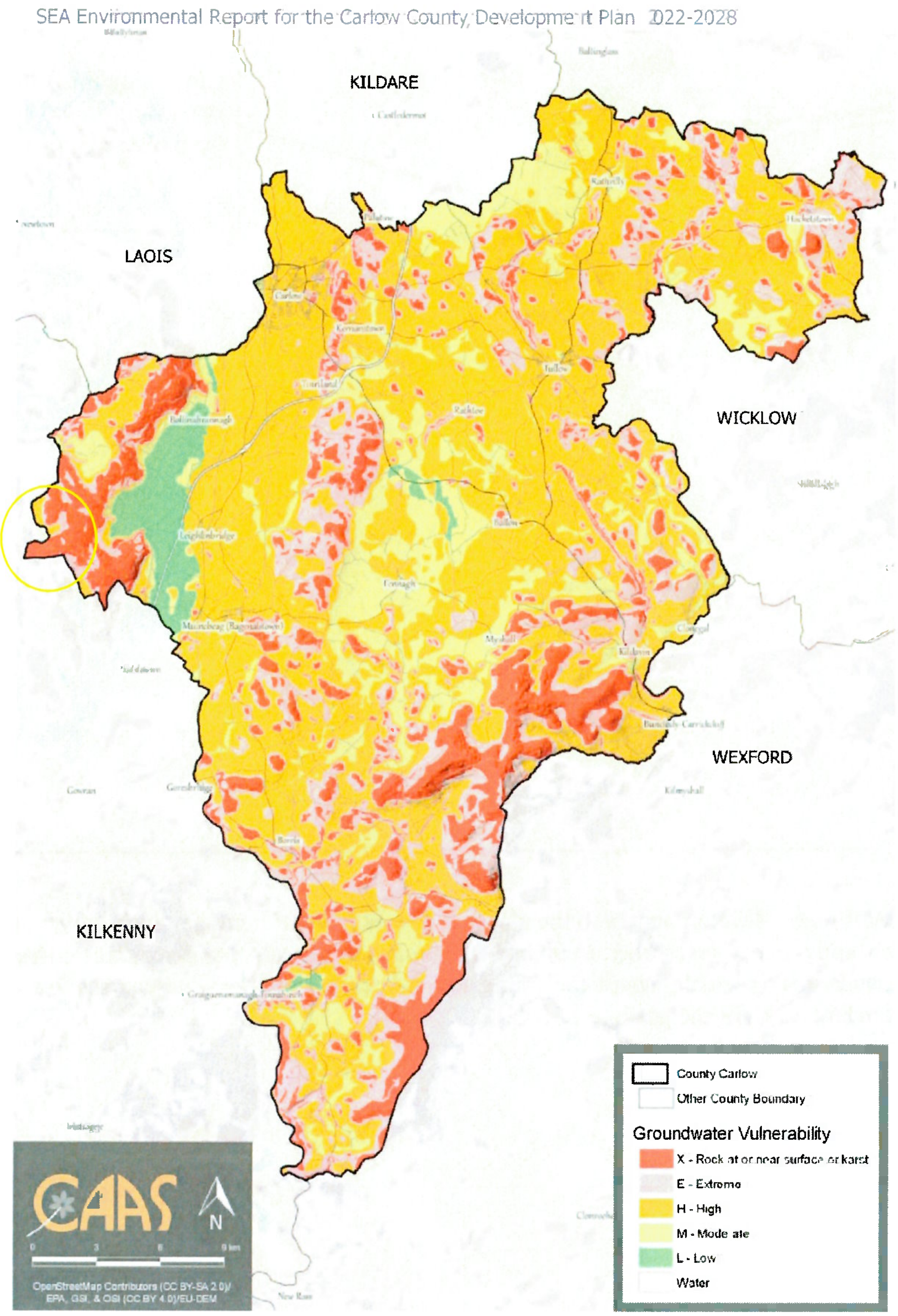
Open Wells

Near the entrance of the site, there is an open well. This well is very unique to the area and should be offered protection, the well has influence to all existing wells to houses along the Ridge. EDF have failed to identify this well in any of their submissions. The well is directly beside the Carlow Heritage



Within Carlow County development plan the aim is to Protect natural heritage, the biodiversity of rivers, streams and other watercourses, to maintain them in an open state, to discourage culverting or realignment, and where possible, uncover existing culverts and restore the watercourses to acceptable ecological standards and for the passage of fish.

GROUND WATER VULNERABILITY



The majority of the area is classified with a rating of (X) above Extreme vulnerability indicating that bedrock is at or close to the surface and therefore there are wholly reasonable grounds for the concerns about the lack of empirical evidence available in the EIS and the potential impacts on groundwater flow. The applicant's view that this issues can be dealt with post planning is simply not acceptable for a development of this size and scale given the potential environmental impact.

WATER SUPPLY SCHEMES

Part of the proposed development area lies within the Outer Protection Zone (SO) of the Paulstown Water Supply Scheme and Castlewarren Group water scheme, which are noted as a spring source ... This means that rainfall percolates to groundwater at Baunreagh Hill close to Turbine location T4 i.e. Knockbaun, Knocknabranagh areas and has the potential to move down gradient towards Paulstown/ Castlewarren Water Supply.

There is a serious concern that during development works, fissures within the bedrock could be fractures which may lead to a change of course of groundwater which may in turn affect the level of water in private bored wells of any residential dwellings in the area. **There has been no definitive conclusion drawn stating that any works on site would not fracture fissures in the bedrock, in turn altering courses of groundwater flows. The applicant should be requested to submit mitigation proposals in this regard**

For a member of our community identified various underlying issues of sink holes created from realigned underground fissures in the bedrock. This could be a general fault surrounding the development and direct implications for Castlearren Water scheme and Paulstown Aquifier.

SOIL EROSION

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 due on this compact area will contribute to the erosion potential of the soil, local terrain, vegetation covers. The Coolcullen river and an abundance of natural streams and surface water drains are running through the site leaves great risk to surface water bodies. The activities that could contribute to soil erosion include:

- Ground surface disturbance on site, at borrow sites, and along access roads would occur during the construction or installation of access roads, wind tower pads, staging areas, lay-down areas, substations, transformer pads, underground cables, and other on-site structures. The extraction of geologic materials from borrow areas or quarries would also result in ground surface disturbance and contamination. The areas identified on the maps for soil deposition areas have already been fused by the landowners for "fill" due to their own farm work excavations for slurry tanks, new building etc. A ground analysis for stability to these areas have not been carried out, and some are on the inclines leading to the Dinin and Coolcullen river which will make the areas close to the banks very unstable which could lead to subsidence.
- Heavy equipment traffic. Heavy vehicles can disturb or destroy originally stable soil conditions and enhance soil erosion by both wind and surface runoff. The access roads are crossing and meandering over Dinin rivers, streams and natural drainage paths. Disturbance and/or re direction of

routes may create a complete unbalance of the environment and could result in existing bored wells becoming contaminated and/or dry.

- Surface runoff pattern disturbance from construction activities (e.g., grading and excavation) and the implementation of on-site storm water controls (e.g., culverts and drainage ditches along roads) could alter surface runoff patterns by diverting natural drainage into new areas and locally increasing runoff volume, but it cannot give complete risk-free conditions.
- Surface water run off from the deforestation of 24 Hectares in the general vicinity will also add to the risk to surface water contamination and possible changes to infiltration and surface runoff patterns, thereby influencing groundwater flow and distribution.

Site Investigations

Our second observation in relation to the trial pits is their location. Because the pictures taken are specifically of the pits and don't show us any landscape references in the pictures, what checks will be done to ensure that these trial pits are indeed done in the locations they suggest. Are they still open for inspection? Will trial pits be done independently on the development site before a decision is reached by An Bord Pleanala. We as the community have extensive experience on the lands in question and the general consensus is that all of this land is marshy and peatlands. This is the reason that the majority of the land in and around this development site is under forestry. There is a large river and several streams also running through it. It is crucially important that these pits are independently tested for confirmation.

We have walked the site of the proposed sub-station and battery storage and can confirm there is no access for a excavator and there is no evidence of trial pits excavations. Gaeltech need to indeptndently verify that these trial pits actually happened with exact co-ordinates and scoped grounds.

SAC & SEA

SAC & SEA Habitats Directive

The proposed development is in the direct vicinity to **The River Barrow** and **River Nore** Special Area of Conservation (site code 002162), which is designated for a range of riverine species and habitats such as Freshwater Pearl Mussel for which suitable water quality is required. This development **(Seskin)** has the potential to have a significant effects to riverine species and habitats.

Seskin is formed in a depression on a raised plateaux approx. 270m above sea level. The form is similar shape to a large saucer with higher surrounding ground surrounding the perimeter. Naturally falling away to North West into the SAC Nore SPA. Water form this area, not only finds its way to the Nore but also to the Barrow. Natural fissures in stone rocks show a lot of smaller streams running easterly into the Barrow SAC . On such a raised plateaux the Seskin and Ridge areas all have a major influence of water ground water corridors to surrounding towns and villages.

EDF have given little information on the habitats that surround this area, from Perigerine Falcons to Hen Harriers, immediately in the SAC are otters & fish species.

Site Name	Site Code	Minimum Distance from Project Site (km)	Minimum Distance from nearest Turbine (km)
Natura 2000 Sites			
River Barrow & River Nore SAC	002162	0.0	1.7
River Nore SPA	004233	11.5	13.0
Lisbigney Bog SAC	000869	12.4	19.6

In combination with other plans and projects in this direct area such as **Bilboa Wind farm** (already granted PP) to be built on the Boolyvannanan Bog and Red Bog wetlands, **Seskin Wind Farm** adjacent to this development also within a wetland and forestry zone.

This general area, known as a raised plateau, will constitute significant importance on this and other European sites of conservation.
Cumulative assessments produced by the developer are limited in scope and it should be considered by Carlow County Council as inadequate, and not fit for purpose due to the risk to the SAC areas mentioned and is in contravention to the European Communities (Birds and Natural Habitats) Regulations 2011 and Article 6(3) of the Habitats Directive.

Direct correlation studies identifies rare and protected species in both the Seskin and White Hill wind farm also the recent Bilboa Wind Farm, both reports identified the following birds that are local to the areas.

Biodiversity

BIRDS

The biodiversity in the area is generally protected by the lesser use of pesticides and chemical sprays that are more abundant in the lower lands where extensive farming generally diminishes and minimizes natural habitats. The lands at Seskin are generally raised wetlands as seen in the pictures, local farming and forestry have continually and failed to excessively drain the areas.

Local people to the Ridge & Seskin report that there were historically Red Grouse (red-listed) found up here along with the ever-diminishing Curlew (red-listed) and Hen Harrier & Peregrine falcons, with an abundance of Plovers. While Merlin may have bred adjacent to area in the recent past. The red-listed Snipe still uses the area as a roosting habitat and the red-listed Woodcock are found around the margins of the area in winter as well as breeding in the forestry nearby. Meadow Pipits (also red-listed) breed on the to the edges of the area. Kestrel hunt over the site and swifts feed overhead (both red-listed). It is one of the last places to see/hear Cuckoos in Carlow away from the Blackstairs. This cultural and natural heritage story should be told and the bog protected for future generations.

There are areas within the forestry plantations on site and bordering the development which contain Devil's Bit Scabious, the foodplant of the protected Marsh Fritillary butterfly (Annex II protected species). Adult Marsh Fritillary butterflies have been found here as well as larval food webs proving breeding on site.

Cranberries (*Vaccinium oxycoccos*) and Bog-rosemary (*Andromeda polifolia*) are raised bog indicators and are present on the bog adjacent to the site, with the Blackstairs being the only other place in the county where Cranberry is noted to be recorded (NBDC, 2021 b). Other species present

on this Red Bog include Bilberry, Bog Asphodel, Bog Cotton, Cross-leaved Heath, Purple Moor Grass, *Calluna vulgaris*, *Cladonia* sp., *Sphagnum* sp. In 'A Flora of County Carlow', the hills about Old Leighlin are referenced as an area in which the Bog Orchid (*Hammarbya paludosa*) historically resided (Booth, 1981). Therefore it is possible that this site once contained this species and restoration may provide the catalyst for a return of this threatened species to its former historical range within Ireland and Carlow. Orchids (*Dactylorhiza* sp.) are present around the peripheries of the Red Bog and extending into the banks of the Coolcullen river.
The site is threatened by extensive deforestation and windfarm developments in all directions. The area in such a small curtilage will be overwhelmed with construction and operations of a wind farm and will force the destruction and removal of natural fauna and wildlife species form the area.

A management plan detailing the rewetting and restoration of the Red Bog is needed for the site. Trees encroaching on the Red Bog from the surrounding forestry should be removed. Drains in the surrounding forestry leading to and or adjacent to the bog should be removed/blocked to maintain water levels on the bog. The drains on the bog itself should be blocked. Tree planting immediately adjacent to the bog should consist of native bog woodland species but set back from the bog. This is not an exhaustive list.

There are also old remnant patches of traditionally managed wet grassland on the Ridge which contain Devil's Bit Scabious and have the possibility of Marsh Fritillary, as confirmed at Seskinrea/The Ridge (52.767541, -7.043855).

As confirmed by local farmers the kingfisher has been viewed many times and recorded on the Nore and Coolcullen ad Dinin territories. A total of 16-22 territories have been recorded by National Parks and wildlife servise by Birdwatch Ireland on June 2010.

Bird Species Surveyed on the areas in recent times:-

Species	Knocbaun & Knocknabranagh Area	Seskin Bilboa Areas

Buzzard	Winter Season & Breeding season 2021 155 flight lines	Buzzard were observed regularly in the study area during the 2019/2020 season, with a total of 26 individual records
Hen Harrier	1 flight line 2020 winter	A total of five observations of hen harrier were made during VP surveys within this period. All birds observed were lone 'ringtails' (either juveniles or females; not distinguished due to similar colouring). One observation (20th December 2019) was of a ringtail hunting
Kestrel	21Flight lines 45 flight lines 2020 winter	This species was recorded on only three occasions during winter 2019/2020. A total of seventeen observations for kestrel were noted over the summer season 2021,
Peregrine Falcons	1 Flight line 2 flight line breeding season 2020	This falcon species was recorded on four occasions during winter 2019/2020. Observations were all lone peregrines and included both male and female birds.
Sparrowhawk	14 flight lines 23 flight lines 2020 winter	Sparrowhawk were recorded frequently during the 2019/2020 season, Amber-listed sparrowhawk was observed six times during the winter season 2020/21 with all observations being of individual birds.
Golden Plover	4 flight lines 53 flight line winter 2020	This migratory wader species was recorded on three occasions during the 2019/2020 season. On 16th February 2020, a flock of 120 golden plover was observed flying. On 17th March 2020, a flock of approximately 100 golden plover was observed flying

Snipe	7 flight lines	Snipe were recorded incidentally on four occasions during winter 2019-20 VP surveys. Red-listed snipe were observed once in the winter season 2020/21 on the 23rd of December 2020. Four snipe were flushed from a field to the north east and outside of the buffer zone by horses. They flew off quickly and climbed gradually in a northeasterly direction. Their flight path was entirely outside of the flight activity area.
Grey Herron	4 flight lines	This secondary species was recorded on two occasions during the winter season. On one occasion (23rd January 2020) a grey heron was observed flying within the flight activity area. On the second occasion a grey heron flight line which extended both inside and outside the flight activity area was recorded.
Lesser Black Backed Gull	1 flight line 1 flight line	Lesser black-backed gull was observed four times in the summer season 2021. Flights of this species were observed in June and July 2021 only and across all VP's. On three occasions three birds were seen flying together, two observations were of gulls flying outside of the flight activity area and one was of gulls flying both inside and outside the flight activity area. A flock of 14 was sighted crossing the flight activity area on the 9th of June 2021, flying at heights between 100 - 185 m

Barn Owl	There were 2 no. sightings of Barn Owl, *Tyto alba* in the vicinity of the site. The first was recorded on 15 January 2020 at ITM E660280 N664299 c. 0.5km southsouthwest of the wind farm site	
Curlew	2 flight lines 2020	

The above lists the species that breed and migrate to the areas, these are limited time studies and should be appraised to find what species are in the general area.

BATS

As per the planning application *"Bat Surveys were carried out using a combination of daytime building and habitat suitability assessments and both active and passive bat detector surveys"*. We believe that the bat surveys carried out for this development were incomplete. *"Eurobats Publication Series No.6, Guidelines for consideration of bats in wind farm Projects"* sets out Survey methods for Land based Turbines.

3.2.2.1 states that for land-based turbines *"Surveys of proposed wind turbine sites should employ the best methods and equipment for the relevant habitat. This generally includes the use of manual bat detectors and automated bat detector systems. Investigation of potential roost sites should also be conducted. In Particular, in areas with large coverage of limestone karst, previously unknown roosts are frequently discovered. When wind farms or infrastructure associated with wind farms are planned in forests, more intensive methods are required, such as bat detector surveys above the canopy, trapping to verify species and status (using mist nets for bats and /or harp traps) and, exceptionally, radio tracking to find tree roosts.*
Due to the range of heights of new wind turbines, existing structures (towers or masts) at the study site should be used to deploy automatic detection systems at the relevant heights (preferably at the proposed blade swept zone) whenever possible. Weather conditions should always be monitored and recorded whilst conducting surveys (temperature, precipitation, wind).

It is our finding no comprehensive surveys were done above the canopy , nor were any bats trapped to verify species. Further information on types of surveys required and timings of surveys are available in the Eurobats publication. We believe that further guidelines in relation to the timing of surveys was not adhered to. This publication also states that *"Wind turbines should, as a rule, not be installed within all types of woodland or within 200m due to the risk that this type of siting implies for all bats. German studies have shown that fatalieies have been recorded up to 95m from a wind turbine (NIERMANN et al.2007) and that N.noctula was most often killed at wind turbines that were at a mean distance of 200m from wooded areas(DURR 2007)"*

We believe that the siting of these turbines are contradictory to these guidelines. None of the 7 turbines are in green field sites further than 200m from wooded areas.

Population & Human Health

Description of Likely Effects

10 Year Planning Permission

EDF request for a 10 year planning permission should be rejected by Carlow County Council. EDF are trying to avoid new planning regulations that are scheduled to be relaeased by the gorvernment in a statement from the Taoiseach on the 21st of May this year. This is planning permission is primarily been sought to comply with out of date 2006 Planning Guidelines which were introduced when wind turbines and generators were 50m high with 2.5Mw turbines generally been the norm.
The onslaught of wind farm applications at the moment is so to avoid new planning regulations to the wind industry, which are now pursuing out of scale turbines, and up to 7.2Mw generators, which have no prescednence in Irish Planning for onshore developments.
As with high court challenges and decisions have been made due to the audible polution to nearby homes both in Offfaly and Wexford where underdeclared noise values were presented from desktop studies that county councils and An Bord Pleanla have accepted in good faith were all found to be misinformation. The outcome is that people have been forced to either live with the pollution or move away form their homes. Carlow County Council should suspend the acceptance of any new wind farm developments in Carlow until the Planning Regulations are updated, failure to do so will find all planning applications ending up in the high courts for Judical review. Currently the two wind farms Whitehill and Boolyvanannan are being appealed to the high courts.

Carlow County Development Plan

Ch 14 Rural Develpment

I wish to bring to your attention to extracts form your own rural development plan Map 14.1 which shows a growing population 7-21%. The chart shows a vibrant rural community along the Ridge, Seskin & Bilboa areas these are clearly identified and recognised by Carlow County Coucil. In the chart below you will notice this is the only area in the region that has growth and therefore there is a necessaity to protect the area from over development of industrial wind farms which will stifle growth, and create a depopulation of the area.

The growth in the area could be attributed to the equine industry and rural residents that have availed of the work from home options to minimise commuting and carbon pollution.

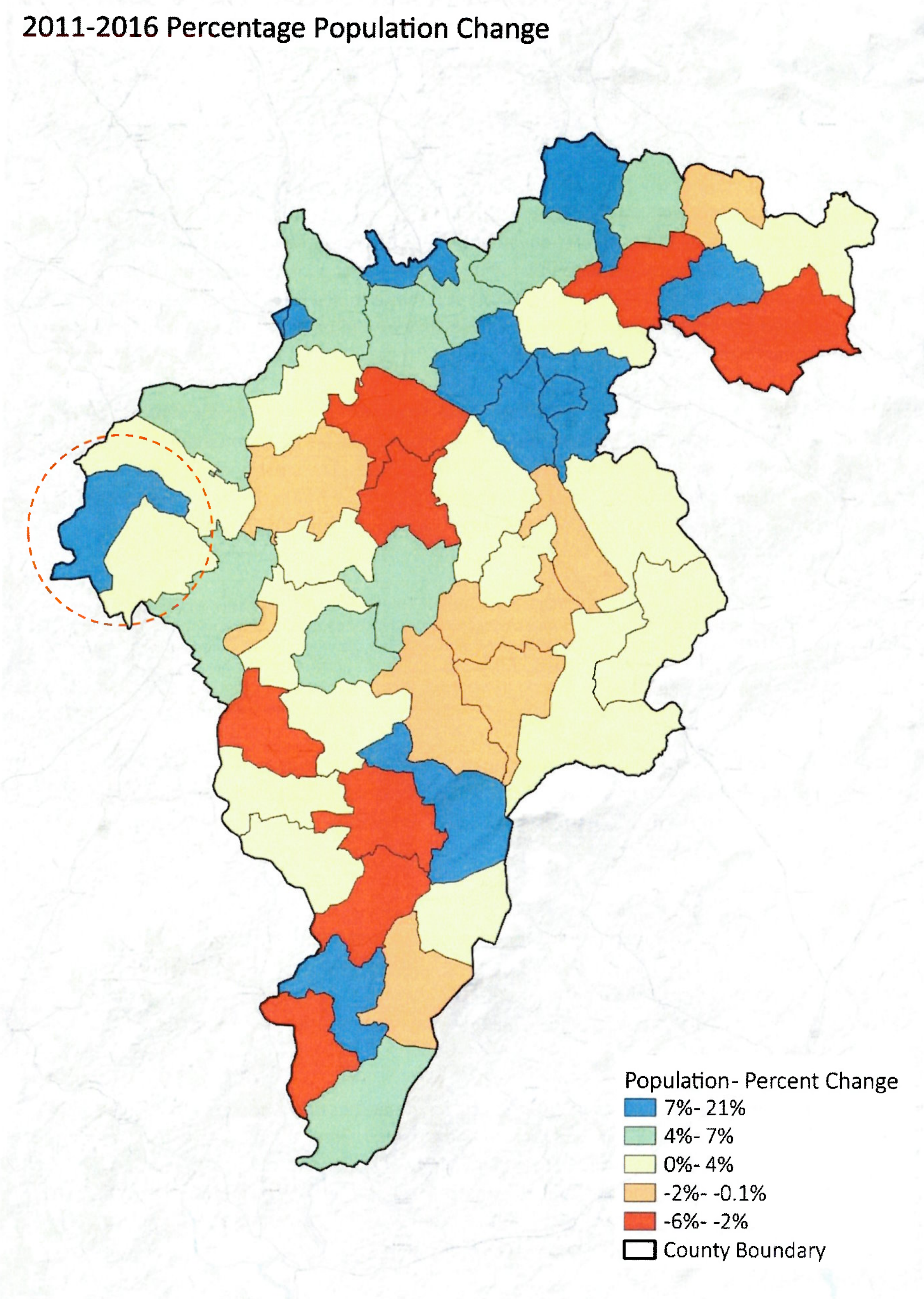
Ch 7 : Climate Action and Energy

Wind Energy Policies of Carlow County Council states below:

WE.P4 *Wind farm development will not normally be permissible in the Uplands Landscape Type as shown in Figure 6 of the Carlow County Landscape Character Assessment included as Appendix VII to this Plan. This provision shall not apply to micro energy generation and community energy projects as provided for in Section 7.10.3.5, where deemed appropriate and subject to compliance with proper planning and environmental considerations.*

Child welfare report

See appendix A



Map 14.1 Population Change by ED between 2011-2016

PROPERTY DEVALUATION

There was no mention in this section of the planning application about the loss of value in the properties within 2km of this proposed development. As a group of residents Independent valuations taken in the area are giving estimations of a minimun of 15% property devaluation to properties loving in close proximity of a development. For those properties situated between two wind farms there is a loss of between 30% to 50% in value depending on location and some valuers are stating that it may actually be impossible to sell a house where a wind farm is situated in front and behind. As you will noptice on the below maps a lot of homes are between three propsed wind farms.

As mentioned in the governemnet charter **National Remote Work Strategy** – *Making Remote Work.* It clearly states that a lot of homes with a home office have increased the property values due primarily to the investement of people in their homes to provide a better work life balance, of less commuting etc. If a persons right to work from home, or indeed has an established work life from home that is impeeded then there is a significant right to compenstation from the developer. Valuations such as below stated values should be the minimum criteria.

Remote work also provides the opportunity to relieve accommodation pressures in cities where demand has caused rent and house prices to increase significantly above the national average. Remote work can facilitate workers to move to less congested urban and rural locations, supporting balanced regional development. Already the rapid onset of remote working has resulted in an increase in interest for rural properties. According to analysis from MyHome.ie, searches for properties under €100,000 have increased by six times in counties Cork and Leitrim and by five times in Galway, Wexford and Mayo. On top of this, searches for properties valued at under €300,000 in Cork and Wexford increased by eight times and these patterns can be seen across the country.[12]

SCHEDULE 2, Article 1, Protection of Property of the European convention on Human Rights Act 2003.
"Every natural or legal person is entitled to the peaceful enjoyment of his possessions. No one shall be deprived of his possessions except in the public interest and subject to conditions provided for by law and by the general principles of International law."

Example case- Howard v United Kingdom (1987)
In this case a public authority wanted to use a compulsory purchase order to acquire a property for development. The European Court of Human Rights held that the question was whether the authority had struck a fair balance between the rights of the individual property owners and the rights of the community. One of the main factors in any such balance will be the availability of compensation reflecting the value of the property acquired by the authority.

Also as per Article 1. In certain situations a refusal to grant special indemnities can amount to to a violation of Article 1 of Protocol No. 1 (Azas v. Greece, 52-53: Athanasiou and Others v. Greece,. For example, in cases of partial expropriation, where a motorway was built in the near vicinity of the applicants house, such interference might warrant the granting of additional compensation on account of the limitation on the use of the house. The nature of the construction had evidently contributed more directly to the substantial depreciation of the value of the remaining property (Bistrovic v. Croatia)

It is our case that if this development is allowed to go ahead we are subjected to the compulsory purchase of a share in our houses equal to the amount of loss to the value of the house. We will all then seek compensation from the relevant authorities. We will also seek additional compensation on account of the limitation on the use of our houses.
Rural Residents Wind aware & Environmental Group have sought the assistance of Grosvenor Consulting for analysis of the information submitted within EDF submittals. Grosvenor report is outlined in chapter 2 of this submittal, and we endorse the findings to Carlow County Council as an independent review. The information within this submittal is further evidence that information submitted by EDF may need a lot of independent analysis and the cumulative effects have to be considered in detail.

In relation to property devaluation, Carlow County Council will be aware that under the Fourth Schedule of the PDA, 2000, Reasons for the refusal of permission which exclude compensation, no.10 (c) states:

10. *In the case of development including any structure or any addition to or extension of a structure, the structure, addition or extension would—*
(c) *seriously injure the amenities, or depreciate the value, of property in the vicinity,*

Therefore a development which results in the depreciation of the value of a property is a standalone grounds for refusal of an application. The depreciation of homes within the curtailment of two if not three wind farm developments will seriously affect homes within the direct vicinity.

In relation to the Oxford Study quoted by the applicants this study found that there was "significant impacts" on properties located within a mile of a wind farm. This is particularly relevant in this instance where many of the dwellings are within a mile and in between some of the largest turbines not actually built in (onshore) in Ireland. In fact it found that terraced houses within 1.6 km of a wind farm dropped by 54%, with semi-detached houses dropping by 35%.
A large body of studies have found that wind farms reduce the value of property significantly and this has been acknowledged by the British Government (Davis 20083) who have reduced property related taxes on some homes because of reduced valuations caused by wind farm proximity.

Michael McCann (20134) carried out study for a wind farm in Tipton County in Indiana included a literature review of 11 previous US studies. He concluded that properties within 2 kilometres of a wind farm experienced a drop of between 25% and 40%.
Particular reference is made to the recent study by London School of Economics (LSE). 'Gone with the Wind: Valuing the visual impacts of wind turbines through house prices', was published by Stephen Gibbons on April 11, 2014. The analysis in this paper provided estimates of the effects of wind farm visibility on housing prices in England and Wales. The analysis used a microaggregated postcode-by-quarter panel of housing transactions spanning 12 years, and estimated difference-indifference effects using a quasi-experimental, postcode fixed effects methodology. All the results point in the same direction. Wind farms reduce house prices in postcodes where the turbines are visible, and reduce prices relative to postcodes close to wind farms where the wind farms are not visible. Averaging over wind farms of all sizes, this price reduction is around 5-6% within 2km, falling to less than 2% between 2 and 4km, and less than 1% by 14km which is at the limit of likely visibility. As might be expected, small wind farms have no impact beyond 4km, whereas the largest wind farms

(20+ turbines) reduce prices by 12% within 2km, and reduce prices by small amounts right out to 14k (by around 1.5%)5.
It is important to note that the average turbine in their extensive sample area was 2.5Mw x 90 metres high to tip, whereas under the current proposal the turbines are 6.2Mw x 185m tip height rotor diameter of 155m. Therefore, it is reasonable to assume that the impact on property values will be even worse with the Seskin Development.

CERIS – Centre for Economic Research on inclusivity and sustrainabilty

In a more recent analysis based on homes in the west of Ireland the results of this analysis indicate a loss in house value of approximately 14.7% - 34% within 1km of a turbine, with greater impact from taller turbines, that are more recently connected. Furthermore, effects are dependent on the number of proximal turbines, with greater effects associated with a higher density of turbines.

Height effects
Turbine height is influential on house price within 1km, with turbines taller than 125m incurring a greater discount (-22.9% - 34%) compared to medium sized turbines (-14.4%).

As you can see there is a significant devaluation of properties, power density & height have a critical impact. Ireland is at high risk of over development and depending on a relatively single source of energy.

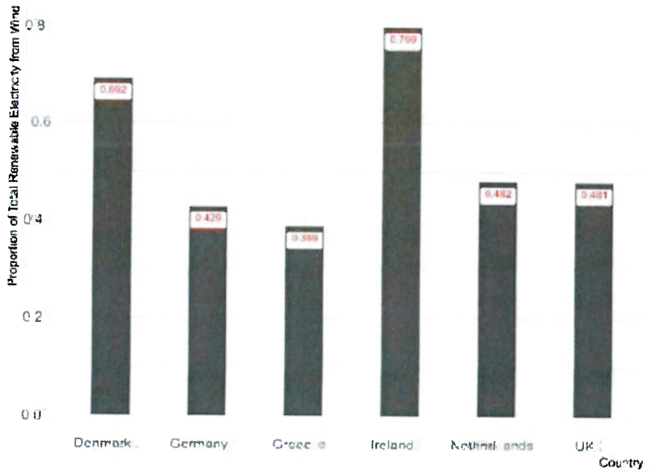


Figure 1: Mean proportion of wind produced electricity out oftotal renewable el ectricityin comparison countries.2021- 2023. Source: IEA (2023), own illı ıstratıon.

Forestry

General

The deforestation and replanting to areas outside the county does not ensure proper and sustainable forestation policy as per Carlow County Council development plan 2022-2028.

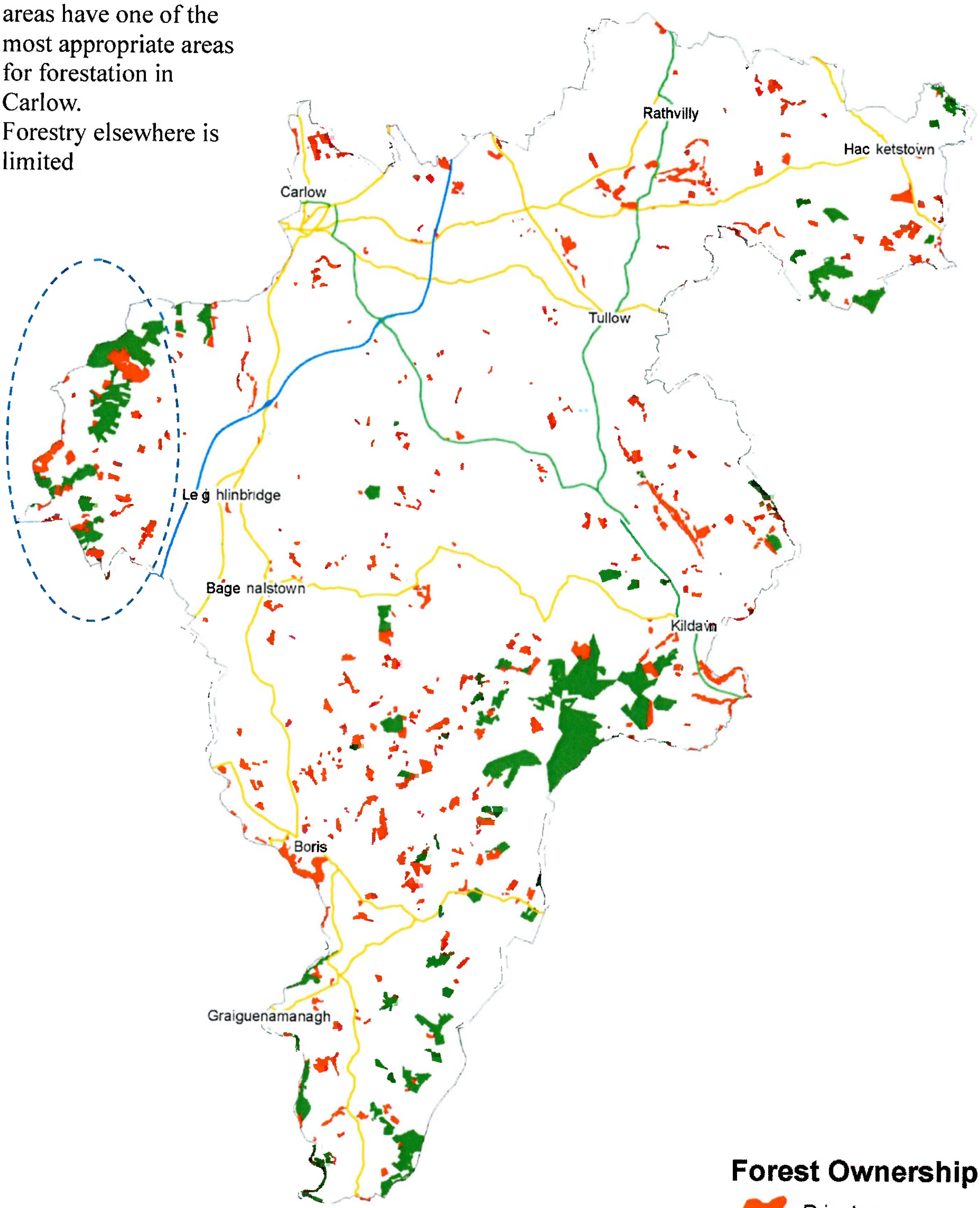
Especially when there is not enough land within the curtilage of the development to replant within the land boundaries. The complusory sowing of foestration within landholdings connectted to the development should be at a minmum compulsory to keep forestation within the confines of the development.

Reference to Carlow County Development Plan section 14.9 Forestry
Forestry is encouraged in appropriate areas, where it will not significantly impact upon designated habitats, archaeology, visually sensitive areas, be obtrusive in the landscape or present a risk to sensitive habitats or water quality. Sustainable Forest Management will be encouraged in accordance with the Forestry Services, suite of guidelines relating to water quality, landscape, archaeology, biodiversity, harvesting, etc.

FR. P 1 & P3 Clearly states the objective of Carlow County council to promote foresrty. As the Seskin site it is poroposed to permanently remove 19 hactares of forestry with no immediate plan or agreement to replace the foestry. This will leave an open agenda to not pursue a proper reforestation on site or elsewhere. Carlow County Council should endorse the lands owners associuated with development are forced to replant within the confines of the land owners to ensure reforestation is secured in Carlow. Th ecummulative affects of White Hills is to remove 18 hectares, Bilboa is to remove 16hectares of forestry will give rise to severe distruciotn to habitats.
Carlow does not have an abundance of forestry sites and will decrease even further of all of these areas are allowed to over develop. As with deforestation comes the severe risk of ground water run off from the high ground areas in a significant volume, this may and will put lower lying lands at sever risk of flash flooding, contamination into the SAC areas defined in this submittal. Removal of forestation will remove any flood aleviations and is contrary to Carlow County Council development plan section 9.10 – Green Infrasturcture.

Carlow Forest Cover 2017

The Ridge & Seskin areas have one of the most appropriate areas for forestation in Carlow.
Forestry elsewhere is limited



Forest Ownership

Private

Public

An Roinn Talmhaíochta,
Bia agus Mara
Department of Agriculture,
Food and the Marine

Access Tracks and Deforestation

We are of the belief that a forestry road that was granted licence No: CN90824 of 435m has been already upgraded as per their commentary above. This is in direct breach of planning laws as the upgrade of this road falls under the planning application before An Bord Pleanala, however, it seems that it has already been upgraded without permission.

We also believe that felling has been completed in relation to Forestry licence CW01-FL0051. The decision for this licence is under appeal. We have no access to information as to why it is under appeal. Please confirm that felling cannot be initiated before all relevant licences are in place.

We have serious concerns in relation to the amount of licences for felling and thinning in relation to this development site. In the description of the project, Chapter 3- Description of the Project, 3.4 Galetech states that they will be felling a total of 15 hectares. We are very concerned about the amount of felling licences that are active within this proposed development site and adjoining it.

The current licences are active with the relevant number of hectares involved with each licence and their status.

We need to establish how much of this is in relation to this proposed development. It looks like the total Hectares could be well in excess of the amount of forestry stated as being felled as part of this development.
In the judgement from the European Court of Justice in relation to the case brought against Ireland in July of 2008 for their failure as *"a member state to fulfil obligations- No assessment of the environmental effects of projects within the scope of directive 85/337/EEC"* (This was in relation to the landslide in Galway in 2003 as a result of the windfarm construction). Ireland were found guilty and are still paying fines of €15000 per day. The total fine is currently in excess of €16m. In the summary judgement the following was stated. *"The commission claims also that the construction of the wind farm required the destruction of large areas of coniferous forest amounting to 263 hectares, a felling licence having been granted on 20 May 2003. However no environmental impact assessment was carried out for that operation, contrary to the very requirements of the Irish legislation."*
We believe that an EIA must be completed in relation to the cumulative effect of all of the proposed development on this site. This **must** include all of the relevant felling or thinning of forestry. Each licence on its own merit may warrant one but the cumulative effect certainly does. All of the felling, whether technically related to the windfarm development or not must also be considered in relation to the windfarm development planning application too because of its proximity to the site.

We also believe that under the planning authorities obligations on a European level they must complete their own independent EIA. Also In the judgement referred to earlier, the commission stated that *"Ireland has not taken the measures necessary in order to ensure that checks are made to*

ascertain, in accordance with Article 2(1) of Directive 85/337 as amended, whether proposed works are likely to have significant effects on the environment".
Significant checks need to be carried out independently by An Carlow County Council in relation to this project to ensure the accuracy of the information included.

Directive 2011/92/EU of the European Parliament and of the Council of 13 December 2011 on the assessment of the effects of certain public and private projects on the environment, article 11 states that:

1. Member states shall ensure that, in accordance with the relevant national legal system, members of the public concerned:
A: having a sufficient interest, or alternatively
B: Maintaining the impairment of a right, where administrative procedural law of a member state requires this as a precondition
Have access to a review procedure before a court of law or another independent and impartial body established by law to challenge the substantive or procedural legality of decisions, acts or omissions subject to the public participation provisions of this directive .

If this development is granted permission, we will seek leave to a judicial review under this directive.

Previous Planning Refusal 2014

CARLOW COUNTY COUNCIL

Carlow County Council refused permission for the proposed development on the basis of 3 no. reasons in 2014, and now again in 2024.

1. Taken in conjunction with existing and permitted wind farm development, yet to be developed in the vicinity, the size of the turbines proposed and their location on the leeward side of this upland area, it is considered that the proposed development would result in an **excessive concentration of wind turbines in this elevated and exposed location**, which would contribute to the spatial extent

and **consolidate the visual confusion and disproportionate arrangement** created by existing/permitted development which would detract from the visual amenities of the area and would be **excessively dominant and constitutes a visually unduly obtrusive feature in the landscape** and which would **adversely impact on the attractive undeveloped rural character**, appearance, integrity and uniformity of this rural area. The proposed wind energy development would, therefore, **seriously injure the visual amenities of the area,** would be contrary to the provisions of The Department of Environment Heritage and Local Government Planning Guidelines for Wind Energy (June 2006), and would be contrary to the proper planning and sustainable development of the area.

2. Having regard to the number, scale and height of the proposed turbines, the proximity of the proposed turbines to a number of residential properties in the vicinity and notwithstanding the proposed mitigation measures contained in the submitted EIS, it is considered that that the proposed wind energy development, if permitted, would **significantly and adversely impact upon the existing residential amenities of a number of houses in the vicinity by reason of visual impact, noise and shadow flicker impacts, as well as depreciating the value of properties in the vicinity**. The development therefore, would seriously injure the existing residential amenities of the area and would be contrary to the proper planning and sustainable development of the area.

3. Having regard to the Environmental Impact Assessment and the Natura Impact Statement submitted with the application, it has **not been demonstrated** to the satisfaction of the Planning Authority **that the proposed development would not adversely affect one or more species listed for protection** in Annex II of the Habitats Directive. Accordingly, the proposed development would contravene materially a development objective indicated on pg 94 of the Carlow County Development Plan 2009-2015 for the conservation and preservation of a European Site and would be thus contrary to the proper planning and sustainable development of the area.
[bold emphasis added]
It is quite clear from the above that the Council has serious issues with:
the visual impact,
the impact on residential amenity
the potential on protected species associated with the nearby Natura 200 site

Appendix A

ADDITIONAL INFORMATION REFERENCED

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1. Carlow County council decision to refuse planning permission 2014
2. An Bord Pleanala decision to refuse planning permission 2014
3. (25) P. Enevoldsen and M. Z. Jacobson, "Data Investigation of Installed and Output Power

Densities of Onshore and Offshore Wind Turbines Worldwide," Renewable Energy, 2018.
4. *Report from Dick Bowdler in relation to amplitude thumping*
5. *Planning permission for Bilboa (Boolyvannanan Bog) Wind Farm*
6. *Arup report on Meenwaun Wind Farm*
7. *EPA Report*
8. *Child Rights*
9. *Old Leighlin SEC Group*

Appendix B

HYDRO- G REPORT

Hydrology analysis and report

Hydro-G

Carlow County Council Ref: 2460122

Applicant: EDF Renewables Ireland Limited Agents:

MKO

Expert Opinion on Applicant's Omitted Details

Public Water Supply Groundwater Sources: Gowran PWS Augmentation Boreholes

Hydrology, Hydrogeology = Lacunae

Supporting Habitats = Inappropriately Assessed

19 ha of Tree Felling, Carbon, Land, Soils & Geology = Reasonable Concerns and Understated Risks

Lacunae in Cumulative Impact Assessment

Omission of Transboundary Impacts Lacunae

Non-Compliant with Climate Action and Low Carbon Development Act 2015

in the context of

Directive 2014/52/EU of the European Parliament and of the Council of 16 April 2014 amending Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment (EIA Directive).

European Union Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy.

European Communities Environmental Objectives (Surface Water) Regulations, S.I. No. 272 of 2009 as amended.
European Communities Environmental Objectives (Groundwater) Regulations, S.I. No. 9 Of 2010 as amended.
European Communities (Birds and Natural Habitats) Regulations, 2011. S.I. No. 477 of 2011.
European Communities (Birds and Natural Habitats) (AMENDMENT) Regulations, 2021. S.I. No. S.I. No. 293 of 2021. European Union (Drinking Water) Regulations 2023 (S.I. No. 99 of 2023).

Prepared by

Dr. Pamela Bartley, Consultant

Hydro-G

For

Save Our Hills &

Rural Residents Wind Aware & Environmental Group

June 2024

Hydro-G

50 Henry St.
Galway
H91 FA4X

pamela@hydro-g.com

087 8072744

Project No.: 2024_WFs_5_Seskinrea

Report Status: **Issue**

Report Title: **Expert Opinion on Applicant's Omitted Details**

Legislation of Particular Note:

- Directive 2014/52/EU of the European Parliament and of the Council of 16 April 2014 amending Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment (EIA Directive).
- European Union Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy.
- European Communities Environmental Objectives (Surface Water) Regulations, S.I. No. 272 of 2009 as amended.
- European Communities Environmental Objectives (Groundwater) Regulations, S.I. No. 9 Of 2010 as amended.
- European Communities (Birds and Natural Habitats) Regulations, 2011. S.I. No. 477 of 2011.
- European Communities (Birds and Natural Habitats) (AMENDMENT) Regulations, 2021. S.I. No. S.I. No. 293 of 2021.
- European Union (Drinking Water) Regulations 2023 (S.I. No. 99 of 2023).

Date: 14th June 2024

Pamela Bartley

Prepared by:

Dr. Pamela Bartley B.Eng, M.SC., Ph.D.

Contents

Statement of Expertise Pamela Bartley B.Eng., MSc., Ph.D

Dr. Pamela Bartley is a water focussed civil engineer and is considered an expert hydrogeological consultant providing service to Consultants, Uisce Eireann, Nationally Important Limestone Quarries and to those involved in Group Water Scheme's sourced from Groundwater. She has over 25 years of field based practice in borehole drilling, groundwater monitoring and abstraction point management. She is considered a specialist in karst hydrogeology and Public Water Supply: her Ph.D was a field based-karst limestone environment study and in the years after she completed CPD training with the GSI at their karst specialist course run in the Burren. Pamela is qualified and IOSH certified to act as PSDP (Project Supervisor Design Phase) & PSCS (Project Supervisor Construction Stage) as defined by the Health and Safety at Work (Construction) Regulations. Pamela's limited company is a registered Uisce Eireann Supplier (no. 1855) and Pamela Bartley is HSQE approved within Uisce Eireann as one of their Hydrogeologist Framework service providers. Upon completion of a Diploma in Water and Wastewater Technology at Sligo RTC, she completed a degree in Civil Engineering at Queens University, Belfast and then completed a Master of Science in Environmental Engineering followed by a hydrogeological focussed Ph.D. on Karst Groundwater Impact: both postgraduate degrees were completed within the school of Civil Engineering at Trinity College, Dublin.

Her key work areas are groundwater impact and groundwater use. She specialises in the engineering of groundwater and large scale water supply boreholes for PWS, GWS, Motorway Service Stations & Hotels. Part of her work requires the assessment of Zones of Contribution to Groundwater and Spring Abstraction Points. Other work areas include evaluation of discharges to groundwater and surface waters for compliance with Irish Regulations and the hydrological and hydrogeological assessments required for EIA of large scale bedrock quarries. She has a skillset in the assessment of groundwater quality for water treatment process parameters and working in collaboration with water treatment plant designers. She is responsible for the successful, legally compliant, attainment of large scale Section 4 Discharge Licences.

Pamela has successfully completed post doctorate formal course training in the areas of:

- PSDP & PSCS (IOSH certified, 2016)
- Karst Hydrogeology (GSI, 2013)
- Planning & Development Act (IE, 2010) & Expert Witness (IE, 2011)
- On Site Wastewater & Water Services Amendment Act 2012 (IE, 2012 & Dublin 2012)
- Zero Discharge Willow Wastewater Systems Design Courses (Denmark 2008 & 2011 & Ireland 2012)

- Surface Water Regulations 2009 (DoE, 2010 & 2011) iv
- Sustainable Drainage (Wallingford/CIRIA, 2005 & 2008)
- Source Protection Zone Delineation (IGI/GSI, 2007)
- Groundwater & Contaminant Microbiology (IGI/GSI, 2006)
- Site Suitability Assessment (FETAC, 2002) & Applied Groundwater Modelling (ESI, UK, 2000)

Pamela's water supply borehole expertise has been gained in the field by her personal supervision of drilling and designing required subsurface completions for large scale abstractions for Gowran RWSS, Co. Kilkenny, East Galway NFGWS Group Water Schemes, many PWS groundwater well sources for Galway County Council, Clare County Council and later for Irish Water in Counties from Donegal to Galway and the Roscommon border. Amongst many other private sites, she has completed successful potable boreholes for Kilronan Castle in Roscommon, Lakeland Dairies in Cavan, The Killeshin Hotel, Co. Laois, The Loughrea Hotel, The Charleville Park Hotel and the Motorway Service Stations at the Obama Plaza, Galway Plaza and the Supermacs Service station in Tipperary. She has developed a competency in camera survey review of boreholes in need of rehabilitation and design of subsequent programmes to improve yield.

As a result of work in evaluating planning appeals, Pamela has become specialist in planning evaluations in the context of enacted Irish Regulation and EU Directives concerning the water environment such as the Groundwater Regulations (S.I. No. 9 of 2010 & Amendment Regulations S.I. No. 366/2016), Surface Water Regulations (S.I. No. 272 of 2009 & Amendment Regulations S.I. No. 386 of 2015), Water Framework and Habitats' Directives. She has been an invited guest speaker at An Bord Pleanála, The Irish Concrete Federation, The Health Service Executive, Environmental Health Officers National Conference, The Irish Planning Institute's National Conference, The International Association of Hydrogeologist's National Conference (Irish Branch) and has delivered hydrogeological lectures to the public during Science Week. In the past, she has held full time lecturing positions in third level institutions (WIT & CIT, 1996 – 1999), delivered practical laboratory instruction in the assessment of subsoils for the FETAC Site Assessor programme and also demonstrated hydraulics laboratory and practical field survey tutorial modules at Trinity College Dublin (1996). Pamela is a qualified and certified 'Site Assessor' and has been an interviewer of examination candidates in respect of eligibility for the Site Suitability FETAC Qualification.

Pamela Bartley's company is Bartley Hydrogeology ltd., registered to trade as Hydro-G. The company holds the industry requisite professional indemnity insurance and employers, public and products liability insurances. Pamela is an expert provider to Uisce Eireann on the Hydrogeologists Framework Panel and Supply Demand Balance Programme. She is now regularly called upon by community groups to provide expert and reasoned independent assessments of renewable energy Environmental Impact Assessments conducted in their habitats.

Reasons Supporting the Save Our Hills Community Objection

1) This report presents information for Carlow County Council's consideration in relation to a Planning Application (Ref: 2460122) for approximately 100 hectares of catchment alteration inside County Kilkenny's borders that area allegedly required to service a proposed Wind Farm in County Carlow that does not have benefit of Planning Permission.

2) The development description provided in the documents uploaded to Carlow County Council's Planning Portal for PL Ref 2460122, includes as follows: *"The development will consist of:*

(i) The construction of 7 no. wind turbines with the following parameters:
a. Total tip height range of 179.5m – 180m,
b. Rotor diameter range of 149m – 155m,
c. Hub height range of 102.5m – 105m,
(ii) Construction of associated foundations, hardstand and assembly areas;
(iii) All associated wind farm underground electrical and communications cabling connecting the turbines and meteorological mast to the proposed onsite electrical substation including road crossing at L30372, Co. Carlow;
(iv) Construction of 1 no. permanent 38kV electrical substation compound including a single-story control building with welfare facilities, all associated electrical plant and equipment, security fencing, entrance on to the access track, all associated underground cabling, wastewater holding tank and all ancillary works in the townland of Seskinrea, Co. Carlow;
(v) A permanent Battery Energy Storage System within the electrical substation compound in the townland of Seskinrea, Co. Carlow;
(vi) All works (within County Carlow) associated with the connection of the proposed wind farm to the national electricity grid, via underground 38kV electrical cabling predominantly within the public road corridor from the proposed onsite electrical substation in the townland of Seskinrea, Co. Carlow to the existing 110kV Kilkenny substation;
(vii) Provision of 2 no. joint bays, communication chambers and earth sheath links along the 1
underground electrical cabling route;

(viii) Reinstatement of the road and track surfaces above the cabling trench along existing roads and tracks;
(ix) 1 no. meteorological mast of c. 36.5m in height, and associated foundation and hard-standing area in the townland of Ridge, Co. Carlow;
(x) The permanent upgrade of 1 no. existing site entrance off L3037 for the provision of construction and operational access;
(xi) The provision of 1 no. new permanent site entrance and the upgrade of 1 no. existing site entrance off the L30372;
(xii) Upgrade of existing tracks/ roads and provision of new site access roads, 2 no. clear span bridge crossings, junctions and hardstand areas;
(xiii) 2 no. temporary construction compounds with temporary offices and staff facilities in the townland of Ridge and Seskinrea, Co Carlow;
(xiv) Carriageway strengthening works at 'Black Bridge' on the L1835 / L3037 (Protected Structure: Kilkenny RPS Ref. D84);
(xv) Peat and Spoil Management;
(xvi) Tree Felling to accommodate the construction and operation of the proposed development; (xvii) Operational stage site signage; and
(xviii) All ancillary apparatus and site development works above and below ground, including soft and hard landscaping and drainage infrastructure.

A 10-year planning permission and 35-year operational life of the wind farm from the date of commissioning of the entire wind farm is sought."

A concurrent planning application for works within County Kilkenny including junction accommodation works, bridge strengthening works and the 38kV underground grid connection to the existing Kilkenny 110kV substation will also be lodged to Kilkenny County Council.

The proposed development includes bridge strengthening works within the curtilage of a Protected Structure (Black Bridge – Kilkenny RPS Ref. D84).

3) The MKO cover letter introducing the development, dated the 13th May 2024, states that "A design flexibility opinion was issued by Carlow County Council on the 14th March 2024 (Ref: DFM001)£ in support of reasons that MKO presented for the applicant.

4) This report has been commissioned by the Save Our Hills Community.

5) The author of this report, Dr. Pamela Bartley, is a surface water and groundwater specialist with expertise in Environmental Impact Assessment and the associated resultant Environmental Impact Assessment Report (EIAR), catchment evaluations, quarrying, public water supply and water dependent supporting species and habitats.

6) Dr. Pamela Bartley's work requires a skillset in completing impact assessment guided by the EU EIA Directive and EPA (2022) Guidelines on EIARs.

7) Dr. Pamela Bartley is especially competent, by virtue of being a principal author of EIAR chapters for a limestone quarry, and evaluation of proposals for groundworks in the Castlecomber Plateau in which the application for development of the proposed Seskinrea Wind Turbine Farm and its proposed associated works in both County Carlow and County Kilkenny.

8) The applicant is EDF Renewables Ireland Limited. The managers of the Environmental Impact Assessment and the associated Environmental Impact Assessment Report are MKO.

9) Dr. Pamela Bartley's 'Project Brief' was to evaluate the application details in the context of whether there is significant Lacunae with respect to the 'Impact Potential' presented for EDF Renewables Ireland Limited by their agents MKO and their consultants.

10) The four elements of the applicant's EIAR that specifically relate to Hydro-G's area of expertise are as follows:

   a. Chapter 8 Lands, Soils & Geology and the associated Appendices. 2 b. Chapter 9 Water and the associated Appendices.
   c. NIS Details for Water Dependent Species and the Biodiversity Chapter 6's presentation of connections to the River Nore SAC and SPA.
   d. Chapter 4 Appendix 4.4 CEMP (Construction and Environmental Management Plan).

11) Prior to Dr. Pamela Bartley's offers on the lacunae of the items listed in a to d, above, there are some general overall issues with the EIAR's context that must be highlighted, as follows:

   a. There seems to be a pattern repeating in proposals presented by MKO for their clients, in this case EDF Renewables Ireland Limited, for Competent Authority's considerations in a Planning Process that is known to be significantly burdened and delayed by overload of indefensible development applications. The proposed development lands are mapped as 'Not Normally Permissible' with respect to wind energy classification. However, MKO propose that the Carlow County Council's investment in their Renewable Energy Strategy failed to consider all aspects that the Environmental Scientists and Planners at MKO have now presented. This is the same argument presented by MKO in the case currently before the Board in the "Strategic Infrastructure Development" Laurclavagh Ltd., Co Galway (An Board Pleanála PA07.319307) in that Galway County Council had zoned the proposed development lands as "Generally to be Encouraged" because the lands are in proximity to a Geoheritage Site with Visual Amenity, and in 'Supporting Habitat' of a Special Area of Protection for Birds and in proximity to a Special Area of Conservation.

b. The Carlow County Development Plan (CDP) 2022 – 2028 was adopted on the 23rd of May 2022, *i.e.*, Two years before EDF Renewables presented their proposal for development. The Introduction of Carlow's CDP 2022- 2028 Renewable Energy Strategy states that *"There is a challenge to not only meet and manage this growing demand, but to do so in a secure, sustainable and efficient manner. It is widely acknowledged that, due to global warming and resource depletion, this cannot be achieved through the use of conventional fossil fuels alone, such as coal, oil and gas. In light of this, emphasis is being placed on energy conservation, energy efficiency and the development of alternative sources of energy, namely renewable energy. & Renewable energy developments can bring economic, social and environmental benefits, such as job creation, decreased import dependency and reduced greenhouse gas emissions. However, there are also challenges associated, such as landscape and visual impacts, the availability of supporting infrastructure and competition for land-use. As a result, it is vital that clear policies and objectives are in place for renewable energy developments* ***to ensure that they are suitably located, economical and sustainable".***

c. However, despite Carlow County Council's engagement of RPS to prepare a detailed assessment and despite its content being adopted by elected representatives of the people of Carlow, EDF Renewables Ireland Ltd., through their agent's cover letter communication with the application, suggest that Carlow, RPS and the elected members "failed" in their assessment and the unelected and unappointed environmental scientists and planners of MKO are correct. This is erroneous.

d. There is significant lacunae in the applicant's agent's presentation of Transboundary Impacts and Cumulative Impact.

e. The EIA Directive 2014-52-EU invokes the Espoo Convention on Environmental Impact Assessment in a Transboundary Context, 1991, and applies its definition of transboundary impacts. The applicant and its agent's proposal fails to assess impacts comprehensively by refusing to acknowledge the REGION or the country of origin of the source materials for the turbine masts, motors and blades, failure to state the method of mineral extraction to support manufacture, fail to state the sea route of the ships bringing the ore to the country of manufacture and in those failures they fail to demonstrate that the proposal is mathematically defensible in carbon generation, rather than its notional *"inter alia"* 'green energy' support for the Climate Action Plan and compliance with the Low Carbon Development Act 2015. There is no information before Carlow County Council that would enable their defence in the context of their obligations to have considered the true mathematical accounting of all impact aspects of the development.

f. Overall information presented by the applicant by their agents with respect to ACTUAL compliance, rather than MKO's (cover letter 13th May 2024) insinuated *"inter alia compliance"*

with the Climate Action Act (2015).

g. With respect to the applicant's proposal and Carlow County Council's "Design Flexibility Option", this is contrary to the legal requirements of EIA as directed by Directive 2014/52/EU of the European Parliament and of the Council of 16 April 2014 amending Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment (EIA Directive).

h. The Machinery Directive 2006/42/EC is a European Union regulation which lays down the requirements for the health and safety of machinery. It applies to nearly all machinery in use or intended to be put into service in an EU member state; no matter where it has been manufactured.

i. The planning application submitted by MKO for EDF Renewables claims that Carlow County Council have issued a "Design Flexibility Opinion" and therefore there is no detail regarding rotor blades, blade pitch control system, yaw system, nacelle, gearbox, or generator, each of which are all critical wind turbine parts that must be carefully designed and manufactured to ensure that the wind turbine operates safely and efficiently. MKO have simply stated that planning is being sought for '7 no. wind turbines with an overall turbine tip height of Total tip height range of 179.5m – 180m, Rotor diameter range of 149m – 155m, Hub height range of 102.5m – 105m and associated foundations, hard-standing and assembly areas'. The Environmental Impact Assessment and EIAR accompanying this planning application is therefore incomplete. Has Carlow County Council decided that they are exempt from the Obligations of the EU EIA Directive? Any claim is false and misguided if it attempts to suggest that that all wind turbines are similar, with only cosmetic differences differentiating them. This claim is over simplified – a quick internet search of the top 15 wind turbine manufactures show 11/15 of these companies are based in China where regulations as strict as European CE certification need not apply. Given that the applicant has not declared what type or turbine they plan to use, there is no way of confirming EU conformity assessment procedures, which the manufacturer must apply to ensure compliance with the essential requirements, has been adhered to.

12) With respect to the applicant's statement that *"A concurrent planning application for works within County Kilkenny including junction accommodation works, bridge strengthening works and the 38kV underground grid connection to the existing Kilkenny 110kV substation will also be lodged to Kilkenny County Council."*, that applications proposes to alter significant stretches of roads in County Kilkenny, in order to enable a prospective development in County Carlow, involving large scale earth movement and rock breaking for the creation of deep and wide trenches for electrical cabling, delivery of said cabling and "other abnormal loads" by Heavy Goods Vehicles and to build a substation, yet no detail has been presented by the applicant or their agents for assessment with respect to Impact on Public Water Supply sources or the characteristics of the hydrogeological environment with respect to how it delivers groundwater to users despite proximity to two Zones of Contribution. There are significant observations, objections and submissions on Kilkenny County Council's PL 2460210 file that apply here in Carlow County Council's consideration for consent.

13) The issue of the applicant's agent's omission of the Risk Assessment obligations of the European Union Drinking Water Regulations 2023 (SI 99 of 2023) is no small matter. A Risk Based catchment assessment is required of the European Union Drinking Water Regulations 2023 (SI 99 of 2023). Without detail presented by the applicant to populate a catchment-based Drinking Water Regulation (2023) Risk Assessment for impact on groundwater as a source of public supply, a legally defensible decision by the local Planning Authority cannot be executed. With respect to the fact that the applicant proposes to build many kilometres of trenches connecting the Carlow Seskinrea Wind Farm to the Kilkenny Substation over the likely distribution water mains network of Castlewarren GWS is a potential for Cumulative Impact that has not been assessed by the applicant's agents. There is neither evidence of consultation with the GWS nor evidence of the Statutory Risk Assessment completed. With respect to Gowran's Regional Water Supply, whilst the local Planning Authority MIGHT review the Geological Survey of Ireland's Groundwater Data and Maps portal and determine that the application area and its enabling works are not within the GSI (2002) mapped Source Protection Zone (SPZ) for Paulstown Spring, as the applicant attempts to convey in their Chapter 9's Figure No: 9-12, the Planning Authority's determination would be founded in error. Kilkenny County Council are advised that the GSI (2002) SPZ is for the abstraction rate of over 20 years ago. Increases in abstraction volumes and increases in groundwater abstraction points have resulted in a real life expansion of that Source Protection Zone, regardless of the 2002 dated mapping on which the applicant [4] relies. The applicant has failed to consider current information that could have been obtained in the _________ duration of their assessments. It is not enough for the agents or applicant to state that Uisce Eireann did not alert them to that fact. The engineers acting for MKO and EDF Renewables Ireland Limited in their assessment of potential impact are well aware of Gowran Regional Water Supply's updating with testing and drilling of new Boreholes and augmentation of Paulstown Spring because they were engaged, by consultants for Uisce Eireann, to complete that groundwater drilling programme and associated field work at the same time as they were writing up the 'Impact Assessment' for Seskin Wind Farm.

14) No detail for Risk Assessment has been presented by the applicant with respect to the European Union Drinking Water Regulations 2023 (SI 99 of 2023) despite the fact that the proposed Carlow Wind Farm development is mapped by the EPA in their publically available ENVISION mapping system

(https://gis.epa.ie/EPAMaps/Water) as a "Mapped Protected Area Drinking Water – Groundwater" Drinking Water – Groundwater [NAME Shanragh, Type GWB, EU_PA_Code IEPA1_SE_G_124, EU_PA_Type Article 7 Abstraction for Drinking Water] AND that the trenches they propose in Kilkenny overlie a Mapped "Mapped Protected Area Drinking Water – Groundwater" [Named Castlecomber and EU_PA_Type Article 7 Abstraction for Drinking Water, EU_PA_Code IEPA1_SE_G_034]. The proposed development's associated works in the neighbouring County Kilkenny is in proximity to Castlewarren GWS's FIVE WATER WELL SOURCES, their ZOC and reservoir and new Uisce Eireann Boreholes at Woodquarter Roads' Depot that are intended to enable Gowran and Paulstown's economic expansion. A current and defensible catchmentbased Risk Assessment would have to repopulate the twenty year old assessments cited as GSI (2002) to incorporate changes in the mapped Zones of Contribution to reflect increases in the amount of water sent to the public and the climate changed recharge patterns. How is this related to Carlow's consideration for consent? It is related to Carlow's consideration because the 'Cumulative Impact' requires defensible population with facts, which are missing from the detail submitted by the agents for the applicant.

15) With respect to the assessment of Lands, Soils and Geology (LSG), as presented in Chapter 8, the information presented to Kilkenny County Council for their evaluation is selective and fails to present as follows:

a. HES (2024) LSG Ch 8 WRT to Site Investigations completed, state as follows:

i. *"Site investigations comprised the completion of 8 no. trial pits, 6 no. dynamic probes and 28 no. hand vane tests.*

ii. *The trial pits extended to a maximum depth of 2.7mbgl.*

iii. *No competent bedrock was encountered at any of the intrusive site investigations. The trial pits completed at T02 and T03 encountered possible weathered bedrock at depths of 1.9 and 1.6mbgl."*

&

"Based on the GSI mapping, there are 2 no. faults mapped to underlie the Proposed Wind Farm site. 1no. fault dissects the Proposed Wind Farm site in a north/northwest to south/southeast orientation and is mapped ~120m east of T06 and ~230m west of T01. A second northwest to southeast orientated fault is mapped in the southwest of the Proposed Wind Farm site. This fault is mapped ~500m southwest of T07".

Hydro-G offers: Despite the GSI mapping of bedrock faults and slips of bedrock between differing formations and despite hub heights of c. 100m supporting blades of 80m length each, the consultants for the applicant's agents appear to deem unnecessary Site Investigation to the depth proposed for their foundation footings. On a pure civil engineering and structural basis, the design of the foundations require an understanding of how the turbine masts are going to be anchored into solid ground. Even though the applicant's agents state that the specific type of turbine cannot yet be stated, it is reasonable to know that a 180m top tip piece of infrastructure will require excavation of foundations of between 10 and 20m into ground. Why then are there no Site Investigation Boreholes to the 25m depth? Why? Is it because the EIAR is speculative and essentially 'phishing' for a Request for Further Information to inform its 'proper planning' scale of Environmental Impact? Can we beg Carlow County Council to revert to precedent for refusal by the Board, as detailed in Appendix A, as follows:

> The Board considered that there is significant uncertainty relating to the effect on soils, water and ecology which precludes assessment of the full environmental effects in accordance with the provisions of EU Directive 2014/52/EU amending Directive 2011/92/EU. The proposed development is, therefore, premature.

b. HES (2024) LSG Ch 8 page 8-11: "No peat was recorded at ~40% of the peat probe locations".

Hydro-G offers that, in the absence of any comment by HES and on the Basis of the extent of Rock Outcrop shown in Figure 8-1, the results of the Ground Investigations using Peat Probes suggests that 40% of the application area is 'Extreme Groundwater Vulnerability and Rock Outcrop'.

Significance 1: the enabling works and substation application area overlie a "Mapped Protected Area Drinking Water – Groundwater". Groundwater Vulnerability is underplayed in the commentary on potential impact.

Significance 1: If "No peat was recorded at ~40% of the peat probe locations" does this mean that Peat was encountered at ~60% of the probe locations? The GSI Data and Mapping information portal maps most of the proposed turbine locations as Blanket Peat.

c. It is stated in the 'Statement of Authority' of both the HES (2024) Seskin Wind Farm Lands, Soils and Geology Chapter and the Hydrology and Hydrogeology Chapter that the authors of the Chapters have *"substantial experience in geological characterisation, peatland morphology, and surface water drainage design and SUDs design and surface water/groundwater interactions"*. Whilst that is true, the sites that they list as some of the 100's of example sites do not include the most high profile Wind Farm case combination of MKO's and HES's assessments named Meenbog Wind Farm in which the EIAR's conclusion of No Potential for Impact was proven incorrect when the land did slide in November 2020 and there was both water impact and habitat destruction requiring Donegal County Council to secure an order prohibiting further works at Meenbog wind farm (Irish Times, April 2024; Donegal Daily, 12th April, 2024). Photographs of the scale of the real risk again presented here for the Seskin Wind Farm Proposal and associated enabling works and Substation are provided here as Plates A and B. The context is that for Seskin's enabling road as there are comparative areas of peat, forestry and Conservation Objective Site's impact potential.

Plate A Proposed Seskin Wind farm (Carlow) and proposed enabling works and substation (Kilkenny) EIAR author's MKO & HES's previous 'Not Potential for Impact' Meenbog Wind Farm site, which failed in in 2020. (Photo credit Donegal Daily 12th April 2024).

Plate B Proposed Seskin Wind farm (Carlow) and proposed enabling substation (Kilkenny) EIAR author's MKO & HES's previous 'Not Potential for Impact' Meenbog Wind Farm site, which failed in in 2020. (photo credit Donegal Live 4th January 2024).

With specific reference to the evidence of peat failure and watercourse impact shown in Plate A and Plate B, the assessments completed and reported for that Meenbog Wind Farm by the same agents for Seskin and the proposed substation, MKO and HES, are available for Kilkenny County Council's review at https://www.pleanala.ie/enie/case/300460 and comparison with the information before them now. In 2018 the Board accepted a conclusion by HES (2017) in the Lands, Soils and Geology Chapter that ***"No significant impacts on the soil and geology of the site of proposed development will occur."*** **and qualifications that** ***"A peat stability assessment undertaken for the site shows that the risk of peat failure is designated trivial and tolerable and that the site has an acceptable margin of safety.".*** Yet, there was a failure. In the Board's 'Reasons and Considerations' supporting a Grant of Permission for Meenbog Windfarm the opening statement is that *"Having regard to: (a) the national targets for renewable energy contribution of 40% gross electricity consumption by 2020….".* However, Mr. Justice Holland is reported by the Irish Times (11th April, 2024) as ruling that *"the integrity of the planning and environmental law systems "weighs heaviest" in this case of all the factors in paly and favour granting the injunction. He did not see that the "undoubted public interest in wind energy" weighs "much at all" in favour of exercising his discretion against making the order.* [Hydro-G provides clarification that Mr. Justice Holland has restrained the developers from finishing their "largely complete" 19-turbine project.] Mr Justice Holland said the developers submitted a report of a civil and environmental engineering expert to the EPA estimating that in the November 2020 incident about 86,240m³ of peat slid, of which about 65,740m³ entered a river and ended up on nearby European-protected sites, "causing significant environmental damage".

Hydro-G offers that the Meenbog Windfarm slide of 86,240m³ of peat equates to destroying a carbon sequestration asset equivalent to 14.8 million kgs of CO2 emissions. [Source: National Trust for Scotland, 2024, provides that 172 kg of CO2eq is contained in each m3 of peat].

Hydro-G offers that with respect to the information presented by HES for the proposed Seskin Windfarm, Table 8-1 presents that it is proposed to deliberately move almost 30,000m3 of peat at least, and that is only for the Turbine bas foundations. There will be other movement of peat for the associated enabling and trench works in County Kilkenny, a described in the description of the development provided for PL 2460210. How can Carlow County Council accept th fact that stripping peat, felling 19 ha of plantation forestry and removing capacity of sequestration of 5 million kgs of CC emissions equivalent is compliant with the most recent Climate Action Plan and Low Carbon Development Act 2015. Ther are other court [7] actions occurring in other parts of Ireland where Environmental NGOs and residents deem that a propos _________for renewable energy must not be exempt from the requirement to address the greenhouse gases they w emit. The order of Mr. Justice Holland should be remembered when he offered that he did not see that the "undoubte public interest in wind energy" weighs "much at all".

d. With respect to the 'Statement of Authority' of both the Lands, Soils and Geology Chapter and the Hydrology and Hydrogeology Chapter that the authors of the Chapters have *"substantial experience in geological characterisation, peatland morphology, and surface water drainage design and SUDs design and surface water/groundwater interactions"*. However, An Bord Pleanála do not currently seem to be convinced by designs by the authors for Seskin Windfarm, MKO and HES. The HES Drainage Designs and Impact Assessment in Case File Reference 309770 resulted in a recent Board Direction (BD-015822-24), dated the 13th March 2024, explicitly stating that there were unacceptable uncertainties in the nature of the windfarm's proposed drainage and uncertainties with the effectiveness of mitigation measures in dealing with the combined issues of construction works. Hydro-G offers that the HES (2023) response to the Board is publically available information, retrievable by google Search, and are provided here as Appendix A for Carlow County Council's convenience. Yet, in 2024 the Board determined in File Reference 309770 that the Drainage design was not enough to rule out risks. Hydro-G offers that the Board is now learning from experience and taking account of previous errors of blindly accepting narratives from EIAR authors. Can Carlow County Council adopt the same principles and acknowledge that the risk is too great and the narratives, in the context of Meenbog Windfarm's 2024 experience, are too weak.

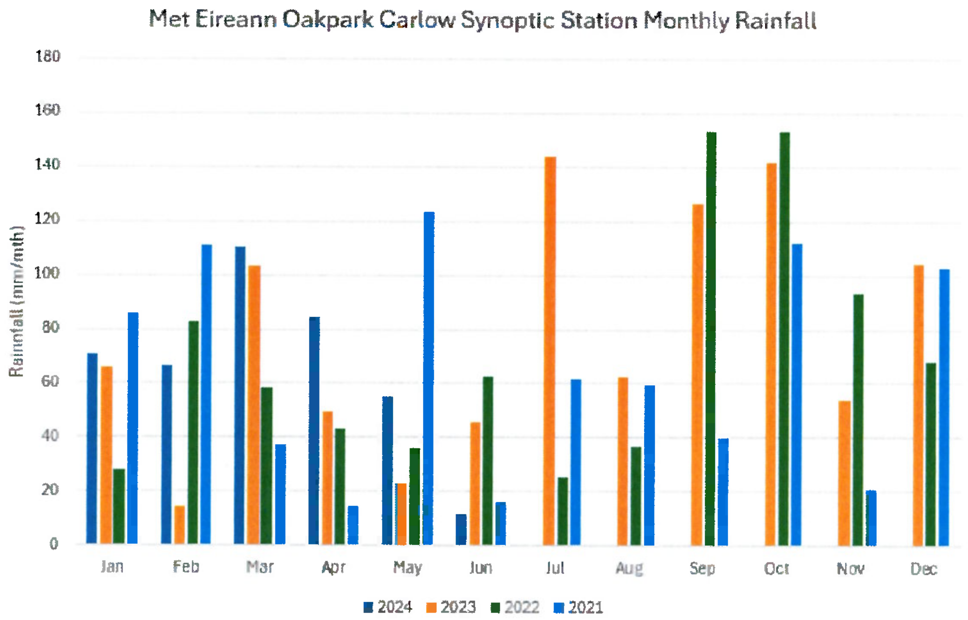
e. With specific reference to indefensible narratives, the MKO EIAR's CEMP Plan (Appendix 4.4) presents some wonderous statements that do not seem to acknowledge the either the facts of construction sites, duration of constructions or Irish weather. Hydro-G offers that no hydrologist, hydrogeologist or civil engineer can credibly accept example direct transcripts from Appendix 4.4's CEMP:

- ***CEMP Text:*** *"The CEMP will also require updating by the selected contractor in order to identify, assess and satisfy the contract performance criteria as set out by the various stakeholders. The CEMP due to its structure and nature will also require constant updating and revision throughout the construction period as set out below. Therefore, this is a working document and will be developed further prior to and during the construction phase of the Proposed Project."*

  Hydro-G offers that the justified cause for concern here is that the Irish Times, April 2024, reporting of the court case heard on Meenbog details the developer's attempt at defence by reason that the changes to the design and management of construction were deemed necessary during construction. Therein lies the precedent for risk and uncertainty that Carlow County Council should not accept in the upland area and at the headwaters of WFD "Good Status 2016 2021 and EPA Mapped 3rd Cycle "Not at Risk" DININ (SOUTH)_020 headwaters of the River Barrow And River Nore SAC (Site Code 002162). Indeed, the headwater streams are in close proximity to the boundaries of the hardcore working area construction pads and temporary roads required to deliver and fit each single blade of the 21 blades proposed and the seven masts, likely delivered in three sections: None of this information is presented or assessed for impact correctly. There is no legal mechanism for Carlow to consider the development. Again, the detail of Appendix A to this report is highlighted.

- ***CEMP Text Page 31:*** *"Traditionally, wind farm construction undertaken during the drier summer months would result in significantly less erosion and siltation."*

  Hydro-G offers that summer is not the season for drier months in Ireland and often August is the wettest month. The basic type of general comments presented in the EIAR and the CEMP convey significant risk potential and a high degree of impracticability and uncertainty to the experienced practitioner. It takes approximately 5 minutes to source Met Eireann's data for the closest synoptic station, which is Teagasc's Oakpark station near Carlow (https://www.met.ie/climate/available-data/monthly-data). A quick copy and paste into excel and plot using 'Recommended Chart' enables a plot of the real life rainfall situation at the closest Met Eireann station, as shown in Graph 1, below.



Graph 1 Met Eireann Oakpark Carlow Synoptic Station Monthly Rainfall

With reference to the Met Eireann data for monthly rainfall, as presented in Graph 1, July was the wettest year last year, in 2023, and March, September and December had similarly high levels of rainfall in excess of 100mm/mth.

- ***CEMP Text Page 31***: *"Construction activities in the hydrological buffer zones shall be avoided during or after prolonged rainfall or an intense rainfall event and work will cease entirely near watercourses when it is evident that water quality is being impacted".*

  Hydro-G offers that it is impracticable and unrealistic to expect that a MEIC Contractor will down tools in the middle of July and on five other months during likely multiple and frequent rainfall events. The project will extend by years in that case.

  Hydro-G offers that neither has the applicant's agents submitted satisfactory detail for the proposed challenges of increased intensity of winter storms arising from changes to rainfall patterns.

- ***CEMP Text Page 31***: *"Given that this site has an established drainage network and 2 no. watercourse crossing points, one existing and one new, there will be minimal impacts on watercourses."*

- **Hydro-G offers** that the beginning and end of the sentence do not agree with each other. As a Project Supervisor, Design Phase, and a Project Supervisor, Construction Phase, and as a person experienced in EIA, it is indefensible to state that **because** there is an established drainage network and 2 watercourse crossing points, *"there will be minimal impacts on watercourses."* There is so much wrong with concluding that the watercourse crossings preclude impact. The scale of construction that will be required and the size of the trucks are out of context with the exiting drainage network and their water crossings. The Competent Authority is referred to Plate A for the scale of what EDF and MKO propose as presenting *"minimal impacts on watercourses"* in the upland setting that Carlow has designated as unsuitable for their development type.

Plate A Scale of turbine base construction pads (7 no. proposed). Note the scale of each of the three rotors relative to the construction workers.

- **CEMP Text Page 30:** *"existing roads are to be used wherever possible".*
- **Hydro-G offers** that the statement "existing roads are to be used wherever possible" has so much lacunae in it that it will not be defensible within the planning system. The upland and plantation forested landscape has no "existing roads" that are wide enough to accommodate the delivery HGVs required for turbine mast and blade delivery. This is why the Planning System is in turmoil: indefensible proposals consuming time and resources unnecessarily.

f. "Afry Ireland Limited" and MKO are reported as having completed the majority of the Peat Probing and Peat Stability Assessments for the Geotechnical Site Investigations. Firstly, it is interesting that MKO Planning Consultants are now conducting Peat Probing when that has historically been the remit of the Geotechnical Consultants. Secondly, one must wonder at the fact that "Afry Ireland Limited" are now Geotechnical Expert Service Providers. "Afry Ireland Limited" present themselves on their own website as *"AFRY Ireland, formerly Ionic Consulting Limited, is one of the leading renewable electricity consultancy firms in Ireland. We are leaders in the onshore wind market and have a growing presence in offshore wind, solar PV and energy storage. Our team is well positioned to help our local and global clients meet their sustainability and climate targets.* https://afry.com/en/offices/ireland/dublin. Is this impartial Geotechnical Assessment of the suitability of a landscape for large scale construction or is this how *AFRY Ireland* is "well positioned"?

Hydro-G offers that the applicant's reliance on point methods for Site Investigation is outdated and has led to many failures and precedent that should preclude evaluation of those methods of Site Investigation. Carlow County Council are advised to refer to the detail presented as Appendix B in which the current Best practice of Site Investigations using methods that are not point (Probes, Trial Pits and soil sampling for Particle Size Distribution based). The Geotechnical Assessment Industry has moved on. However, those 'well placed' for the Renewable Business sector have not.

16) With respect to Water Dependent Habitats and Species, the proposed 7 turbine masts, blades and construction pads are coincident with a headwater stream connected to the River Barrow And River Nore SAC (Site Code 002162). The information presented by the applicant's agents is deficient in the sense that control of sediment release from the proposal to fell 19ha of forestry in the headwaters of a stream that feeds an SAC is a critical issue for protection of the Conservation site.

17) The Kingfisher identified as 'At Risk' due to indirect connection and potential for water pollution. Yet, the applicant's Planning agents and authors of the "Impact Assessment" on the mapped Special Areas of Protection (SPAs) are under the impression that ink on EIAR chapter paper can 'mitigate' the actual risk presented.

18) Chapter's 6 Biodiversity Conclusion is that "Provided that the Proposed Project is constructed and operated in accordance with the design, best practice and mitigation that is described within this application, significant individual or cumulative effects on ecology are not anticipated at the international, national, county, or local scales or on any of the identified KERs"

> **Hydro-G** offers that that Conclusion is at odds with recent experiences in Meenbog and also contrary to the most recent Case Law in Ireland stating that one cannot rely on Best Construction Practices and mitigation to protect Conservation Sites.

19) Carlow County Council is requested to refuse permission to the proposed development on many grounds, some detailed by others, but with specific reference to Water and Lands, Soils & Geology, for reasons as follows

   a. Refusal is warranted on the basis that there is too much understatement of Risk with respect to the Impact Assessment and that previous understatement of Risk by the same agents and authors of EIAR Chapters resulted in real environmental damage: namely at Meenbog Windfarm, Co. Donegal.

   b. Refusal is warranted on the grounds that the applicant has not completed a Risk Assessment as is required by the Drinking Water Regulations (2023). No **<u>CURRENT</u>** information is presented with respect to potential impacts on Public Water Supplies sourced from Groundwater yet the concurrent application with Kilkenny has potential to affect large scale public water supply schemes. Whilst Carlow County Council may perceive that the lacunae is not in their jurisdiction, that is an incorrect interpretation of EIA Law. The applicant's agents specifically reference a "concurrent application" to Kilkenny County Council. Whilst Uisce Eireann provided opinion on whether the proposed routes overlay mains network, they failed to offer opinion on the likely expansion of the Source Protection Areas for Gowran RWSS and Paulstown Spring. The GSI (2002) Source Protection Zone mapping referred to is outdated at 22 years old.

   c. The lacuna with respect to the Drinking Waters Regulations (2023) obligations and the lack of catchment based Risk and Impact assessment is unacceptable when the proposed development is mapped by the EPA's publically available Envision Mapping system as a '"Mapped Protected Area Drinking Water – Groundwater".

   d. There are unacceptable uncertainties with respect to residual risks and land stability, risks of failure and the potential for the proposed turbines and their proposed enabling works to interfere with the headwaters of the River Barrow And River Nore SAC (Site Code 002162) and the numerous downstream water dependent Designated Sites with Conservation Objectives.

Pamela Bartley

Signed: ______________________ Date: 14th June 2024

Dr. Pamela Bartley BEng, MSc, PhD

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Appendix A

Publically Available HES (2023) Drainage Design Response to 3rd party Observations, An Bord Pleanála Further Information Case File ABP- 309770-21. Coole Wind Farm.

& RESULTANT Direction REFUSAL BY An Bord Pleanála (2024) File ABP- 309770-21. Coole Wind Farm.

Appendix B

Current Best Practice Example Paper for the Assessment of Geological Environments

Applied in Ireland for Study of Spatial Areas

Appendix C

GROSVENOR CONSULTING – REPORT

Sound

GROSVENOR CONSULTANCY

Representing Vulnerable Residents & Communities.

Planning & Noise Consultancy Services

Seskin Wind Power Plant Proposal.

Planning application Reference: 2460122 Carlow County Council.

Objection - Operational Wind Turbine Noise & Residential Amenity Impacts.

On behalf of

"Rural Residents wind aware and environmental group".

14 June 2024.

Cover Photomontage VP01 - Coolnakisa.

Photomontage 1

View from a local road in the townland of Coolnakisha. The viewpoint is located on Co. Carlow Designated Scenic Route 8 (CCDP 2022-2028). This viewpoint is located approximately 1.2km north-east of the nearest proposed turbine (T2).

1. Introduction.

1.1. Grosvenor Consultancy has been commissioned by the Community Group, "*Rural Residents wind aware and environmental group*" to review the Environmental Impact Assessments submitted by the Applicant EDF Renewables Ireland Ltd, and submit on their behalf an **objection** to the proposed Seskin Wind Farm, which is considered to be large scale industrial Wind Power Plant.

1.2. This community group comprises of concerned residents living in the vicinity of the proposed Seskin Wind Power Plant (SWPP), and we also understand residents in the vicinity of the operational Gortahile Wind Power Plant (GWPP), the consented Bilboa Wind Power Plant (BWPP) and White Hill Farm Wind Power Plant (WHFWPP).

1.3. This **objection,** is in respect of the significant and material Environmental Impacts to these residents arising from Operational Wind Turbine Noise, Visual Residential and Recreational Amenity.

1.4. Notably, this submission will raise significant material concerns in respect of the Applicant's failure to assess the full spectrum of the Environmental Acoustic

Pollution not only from the proposed Seskin Wind Turbines, but cumulatively in respect of the operational Gortahile wind turbines and the contented Bilboa and White Hill Farm wind turbines.

1.5. We understand that the proposed Seskin Wind Turbine application is due to be determined by Carlow County Council, by the published deadline of 7 July 2024.

1.6. . Grosvenor Consultancy specialist Planning & Noise Consultancy Services, has considerable expertise and experience gained well over a decade, by representing vulnerable Residents & Communities on a non profit basis, in respect of Industrial Scale Planning Applications and when required to do so, at Public Inquiries, as an experienced and competent Lay Advocate. Melvin Grosvenor, (Principal) is a founding member of the Independent Noise Working Group, formed in August 2014.

INWG's Mission Statement is provided below:

'INWG's principle aim is ensuring that the acoustic impacts from wind turbines are properly controlled in order to protect public health and well being'.

1.7. Grosvenor Consultancy, also draws on the expertise and experience of the International Acoustics Research Organisation (IARO). IARO comprises of an International team of highly qualified professionals, expert in the field of acoustics and the assessment of potential acoustical environmental impacts on residents and communities from proposed and operational industrial developments of varying types and sizes.

1.8. Grosvenor Consultancy is also engaged in representing vulnerable rural residents, who are complaining of the debilitating impacts of the full spectrum of Wind Turbine Acoustic Pollution. With the support of IARO and highly qualified and experienced Acousticians we have the experience, expertise and capacity to assess and monitor acoustic immissions propagated by operational Wind Turbines. We also have the capability to monitor the ambient acoustic environment prior to the construction and operation of additional wind turbines within the local area to establish the existing acoustic base line.

2. Grosvenor Consultancy's Residential Amenity & Acoustic Review.

2.1. Grosvenor Consultancy has conducted a review of the Applicant's Operational Noise Impact Assessment and accompanying appendices', undertaken by TNEI Services, which raise significant material concerns.

2.2. The extent of these concerns are such, that we have no alternative to conclude that in the light of the information contained in Appendix 12.2 Table 1.1 *Cumulative Wind Farm Developments* and Figure A1 1A *Cumulative Wind Farm Location*, and the assessed risk of adverse residential amenity impacts that it would be irresponsible for Carlow Community Council to consent the proposed Seskin Wind Turbines, which clearly would occupy the open land between the consented Bilboa Turbines and White Hill Farm Turbines.

2.3. Notably, the operational Gortahile wind turbines, as clearly identified in the Applicant's Figure A1 1A *Cumulative Wind Farm Locations* forms a sequence of wind turbine development over an extended distance with numerous residents homes scattered around and in between these individual wind turbine clusters.

2.4. The applicant's Appendix 12.2 Executive Summary states:

*'There are **158 NSRs within the 2km search area around the Proposed Wind Farm, the NSRs are mainly residential properties with only a few derelict buildings and one church'.***

2.5. However, the combined numbers of impacted residents over this area will undoubtedly increase as indicated in the Applicants Fig A1 1A. It is also of significant concern that an acknowledgement of the prevailing wind is South Westerly, the residents located to the north and north east of White Hill Farm and those north and north east of Seskin will be exposed to increasing cumulative wind turbine acoustic pollution. The cumulative acoustic pollution will also propagate beyond the Bilboa wind turbines. We will discuss this in further detail below at Para 6 and within other sections.

2.6. It is of significant material concern that the separation distances at a number of indentified residents from 6 of the 7 proposed Seskin Wind turbines are unacceptably close as detailed in the Applicant's Table 6.1 Noise Assessment Locations provided below at Table 1 below.

Table 6.1 Noise Assessment Locations

Noise Assessment Location (NAL)	X (ITM) (m)	Y (ITM) (m)	Elevation (m above sea level)	Approximate Distance to Nearest Seskin Turbine (m)	Background Noise Monitoring Location Used
NAL1	662730	670033	242	844 (T1)	NML7
NAL2	662610	670156	240	1,008 (T1)	NML7
NAL3	663257	670292	257	695 (T1)	NML7
NAL4	663822	670342	271	718 (T2)	NML1
NAL5	664335	670312	289	746 (T2)	NML1
NAL6	664468	670252	290	768 (T2)	NML1
NAL7	664688	669900	290	739 (T2)	NML2
NAL8	664705	669725	284	709 (T3)	NML2
NAL9	664928	669208	266	730 (T3)	NML2
NAL10	664824	668894	270	710 (T3)	NML3
NAL11	664698	668149	271	767 (T5)	NML3
NAL12	664248	667759	266	737 (T7)	NML3
NAL13	663144	667630	263	710 (T7)	NML4
NAL14	662682	668090	251	933 (T6)	NML5
NAL15	662840	669042	228	742 (T4)	NML6
NAL16	662555	669161	217	1028 (T4)	NML6
NAL17	661841	668376	210	1632 (T6)	NML5
NAL18	662611	667437	260	1240 (T7)	NML5

Table 1.

The Applicants Appendix 12.1 Table 6.1 Confirms that of the 18 Noise Assessment Locations the separation distance of 13 residential properties vary from a completely unacceptable 695m at NAL3, with at further 11 at under 800m at distances varying between 709m to 763m and NAL 1 at 844m.

Therefore the proposed locations of T1, T2, T3, T4, T5 and T7 are considered to be unacceptably close to these identified receptors.

Even the separation of T6 at 933m from NAL 14 at 933m is too close despite the increase from 695m (NAL3) to 933m.

Grosvenor Consultancy are representing residents who are complaining of deblitating WTN pollution from turbines located at 960m from their homes.

2.7. Grosvenor Consultancy note that the Applicant has appeared to adhere to the criteria referenced in Chapter 14 LVIA and listed with the bullet points at 14.1.4 Mitigation by Design.

'Siting of Proposed turbines adheres to the minimum 500m set-back distance in the DoEHLG 2006 Guidelines and the 4-times-tip-height set-back distance explicitly set out for residential visual amenity prescribed by the Draft DoHPLG 2019 Guidelines'.

2.8. It is clear that in respect of Wind Turbine Noise Pollution propagation from the increased size and power of the turbines proposed, along with those already consented at Bilboa and White Hill Farm, to those in operation back in 2006 and even 2019, continued adherence to this out of date guidance is deeply concerning, especially given that 3 various specifications of the proposed Seskin turbines are referenced in Appendix 12.1. These are provided below:

a) *'Predictions of wind turbine noise for the Proposed Wind Farm were made, based upon the sound power level data for a candidate wind turbine, the Vestas V150 which has a 150m rotor diameter, a maximum rated output capacity of 6.0 MW, serrated trailing edge blades and a hub height of 105m.* ***Blade tip height 180m.***

b) *The specifications for the Siemens-Gamesa SG 6.6-155 with a 155m rotor diameter, a maximum rated output capacity of 6.6 MW and a hub height of 102.5m.* ***Blade tip height of 180m.***

c) *Nordex N149 with a 149m rotor diameter with a maximum rated output capacity of 5.7 MW, serrated trailing edge blades and a hub height of 105m.* ***Blade tip height 179.5M.***

2.9. It appears that the Applicant, has not even closely adhered to the minimal and out of date, '*4-times-tip-height set-back distance,* which at 180m to blade tip height represents a 720m set back distance. Table 1 above advises that NAL 3 is at 695m, NAL 4 at 718m, NAL 8 at 709m, NAL10 at 710m & NAL 13 at 710m all of these receptors are under 720m distance from various proposed turbines. However, the Applicant in their Table 5-8 *Shadow Flicker Results* advise that these properties are in fact derelict, which is misleading.

2.10. Furthermore, It is of note that the Applicant's EIAR Chapter 14 Landscape and (Visual) Amenity Assessment states at 14.1.4 '*Mitigation by Design'.*

'As part of an upland, remote landscape, the Proposed Project site was strategically selected as a landscape highly suitable for accommodating wind energy development.

Yet the as the previous extracts from the Applicant confirms, the Proposed Project site is not particularly remote or, that it is completely uninhabited;

Whilst stating that;

The Proposed Project is strategically sited within a modified, upland working landscape of low landscape value and sensitivity where there is either limited visibility and/or large set-back distance from large population centres.

2.11. It is also of concern that there appears to be conflicting statements between the Applicant's Appendix 12.1, which as previously highlighted states:

*'There are **158 NSRs within the 2km search area around the Proposed Wind Farm'*** and the Applicant's Table 6.1 listing the separation distances from the 18 indentified NAL's

Compared with Chapter 14 LVIA which states:

> *'As reported in the landscape baseline (see Section 14.4.2 Landscape Character of the Proposed Project site), the site is a large uninhabited area characterised by commercial forestry and agricultural fields. The image above illustrates how the Proposed turbines are set back from residential receptors in the surrounding landscape and that the distances are compliant with the guidance in the DoEHLG 2006 Guidelines and Draft DoHPLG 2019 Guidelines. Only landowners involved with the project are located within the 4x tip height (720m) set back distance recommended in the DoEHLG 2006 Guidelines. The map above also illustrates how the uninhabited areas to the west increase set back distances whilst providing a substantial landscape buffer between the Proposed turbines and these receptors'.*

2.12. It is also of note that this Applicant's statement, advises that the 5 NAL receptors listed above, are identified as involved landowners. However, whether occupied or financially involved or not, wind turbine acoustic pollution, cannot be emolliated by any apparent contractual involvement with the Applicant at any level.

2.13. It is of significant concern, that any contractual arrangements between these '*landowners*' and the Applicant, may curtail the enforcement of any potential remedial action, should these 5 properties (or any others) be subjected to significant levels of Wind turbine acoustic pollution.

At this juncture, it is not known whether these NAL's are occupied by persons under any rental agreements or otherwise. This consideration raises further concerns as to the potential lack of statutory protection to these occupiers (or any others) in the case of WTN complaints.

2.14. Furthermore, Table 6.1 lists a further 5 receptors at separation distances of between 730m and 767m, which in terms of WTN and visual impacts is in fact minimal. To effectively propose that an additional 10m to 47m will result in an appreciative separation difference is beyond credulity and that this could be considered to be a '*substantial landscape* (or sound-scape) *buffer*'. It is our expert opinion, that these receptors are considered to be at high risk of being exposed to unacceptable levels of Wind Turbine acoustic pollution.

2.15. In addition, there are further inconsistencies within the numbers of dwellings receptors listed in the Applicant's Table 5-8 *Shadow Flicker Results*.

This table details 117 dwelling houses and their coordinates and distances from turbines, which vary from the Applicant's Table 6.1 *Noise Assessment Locations* (reference Table 1 above). Even if the Applicant has changed names as in House number 1 not necessarily being NAL1, there fails to be corresponding coordinates or distances from turbines. This raises concerns as to whether the NAL's listed are actual dwellings, or representative locations to dwellings.

2.16. A review of the Applicant's Table 5-8 *Shadow Flicker Results* raises further significant material concerns.

This table provides a detailed list of all of the receptors in proximity to the proposed Seskin Wind Turbines, in the apparent absence of an essential Residential Amenity Assessment undertaken by the Applicant.

We have set out below the salient information from the Shadow Flicker Results Table 5-8 as follows:

The table dwelling list No.1 -5 are listed as being derelict with a separation distance of between 563m -696m all of which are marked as being involved.
The table dwelling list No.6 -18 (13) are listed with a separation distance of between 724m - 789m. Of these 3 are marked as Participating Properties.
The table dwelling list No.19 - 34 (15) are listed with a separation distance of between 805m - 899m. Of these 5 are marked as Participating Properties.
The table dwelling list No.35 - 48 (13) are listed with a separation distance of between 905m - 999m. Of these 3 are marked as Participating Properties.
The table dwelling list No.49 - 75 (26) are listed with a separation distance of between 1004m - 1099m. Of these 3 are marked as Participating Properties.
The table dwelling list No.76 - 84 (8) are listed with a separation distance of between 1109m - 1182m. Of these 0 are marked as Participating Properties.
The table dwelling list No.85 - 93 (8) are listed with a separation distance of between 1206m - 1297m. Of these 0 are marked as Participating Properties.
The table dwelling list No.94 - 99 (5) are listed with a separation distance of between 1315m - 1393m. Of these 0 are marked as Participating Properties.
The table dwelling list No.100 - 110 (10) are listed with a separation distance of between 1401m - 1499m. Of these 0 are marked as Participating Properties. The table dwelling list No.111 - 117 (6) are listed with a separation distance of between 1501m - 1550m. Of these 0 are marked as Participating Properties

2.17. It clear from this table that far from being an area with a minimal number of residents, there are in fact 117 dwellings identified within 1550m of the nearest turbines. Of these there are a total of 13 at high risk of adverse Wind turbine acoustic pollution at under 789m, and a further 15 at a distance of under 899m. Notably, the number of potentially occupied dwellings marked as Participating properties at 8 up to a distance 899m, with a further 6 at between 999m - 1099m.

2.18. Our expert position as detailed in Para 2.12 above applies likewise, to those Participating Properties at under 899m and to a lesser extent to those at under 1099m. Notably, Grosvenor Consultancy are representing residents who are complaining of deblitating WTN pollution from turbines located at 960m from their homes. We can also confirm that the 14 operational wind turbines are advised to be Nordex N90 2500 HS 2.5MW and blade tip height of 110m.

2.19. Applicant's LVIA also advises that:

> *'<u>There are two substantial population centres within **5km** of the Proposed Project, Oldleighlin and Ballinabrannagh</u>. The closest District Town to the Proposed Project is Bagenalstown which is 9.6km to the southeast of the Proposed Wind Farm; Castlecomer is another District Town which is located 10.2km to the west of the nearest Proposed turbine (T01). Carlow Town is located 10.8km from the nearest Proposed turbine (T02)'.*

It is our considered expert opinion that whilst separation distances in excess of 9-10km provide greater protection from Wind Turbine acoustic pollution the distances of within 5km are of concern. This concern will be addressed Para 5.10 Mr WL Huson evidence and in further detail **Ref Annex 1** *Pilot study shows no significant reduction in damage caused by infrasound until more than 15 kilometres from wind farms* & Para 6:

2.20. Further comments regarding the Applicant's Visual Residential Amenity Assessment:

Section 14.7.3.2.8 Residential Amenity Discussion of Visual Effects States:

The Proposed Project design process has implemented appropriate set-back distances, with regard to the siting of Proposed turbines in proximity to residential dwellings. The Proposed Project adheres to the recommended 500m set back distance in the DoEHLG 2006 Guidelines and also the 4 times tip height set-back distance set out for residential visual amenity prescribed by the DoEHLG 2006 Guidelines <u>with the closest Proposed turbine (T03) being located 724m from the nearest residential receptor.</u>

This information is contrary to the Applicant's Table 6.1 which advises that the nearest receptor NAL3 which is 695m from T1.

2.21. The Applicant states:

'Photomontages are just one of the tools employed during the LVIA that was conducted in order to inform the assessment of landscape and visual effects. It would be a disproportionate measure to include an individual photomontage from every residential dwelling and this is not required to conduct a thorough and robust assessment of landscape and visual effects'

However, as previously stated it is considered to be good practice to undertake a detailed Residential Amenity Visual Assessment. We note that the Applicant advises in Table 14-17 : *Viewpoint (Photomontage) Assessment Summary* that the selected Residential Receptor is at VP2.

VP2 <u>Residential Receptor</u> approximately 900m from the nearest Proposed turbine (T01) at Agharue.

2.22. The question we raise on behalf of our clients, is why was this View Point selected when there are 28 other receptors listed in Table 5-8 '*Shadow Flicker Results'* at under 899m, with potentially open views towards the 7 proposed 180m to blade tip turbines with a rotor diameter of 150m?

2.23. It is clear from VP2, that the foreground is dominated by foliage, which is unsurprising as the Photomontage was dated 20-06-2023, at the height of the summer season.

2.24. However, the description text on the Photomontage states: '*VP2 View from the L7127 Local Road in the town land of Agharue.'* We repeat the Applicant appears to have not conducted any meaningful Visual Residential Amenity Assessment and there is substantial evidence that this cursory assessment, has sought to minimise the full extent of the direct visual impacts on the amenity of the residents from the curtilage of their homes. This is certainly apparent from our review of the Shadow Flicker Results table at Para 2.15.

2.25. It is of interest to note, that unusually the Applicant references low population density in Chapter 5 Population and Human Health impacts:

'In general, the wider upland area of the Killeshin Hills is a sparsely settled landscape with a relatively low population density. The population of the two No. District Electoral Divisions (DED)s within and surrounding the Proposed Project site is detailed in <u>Chapter 5 of this EIAR– Population and Human Health</u>. As shown in Table 5-2 in Chapter 5, the population density of DEDs recorded during the 2022 Census was 19.70 persons per km2. This figure is

significantly lower than the national population density of 73.27 persons per km2 and the Carlow County population density of 69.08 persons per km2. These findings indicate that the landscape surrounding the Proposed Project site has a low population density relative to other areas in the county and elsewhere in Ireland'.

2.26. Simply, seeking to justify the deployment of ever increasing large scale and powerful wind turbines, unacceptably close to vulnerable rural communities and their homes on the basis of low population density is of significant concern especially, as in majority of proposed and consented schemes, the adverse impacts on the health and wellbeing of residents is not fully considered and usually, is disregarded as being irrelevant. It is also of concern that involved properties appear to be unaware of potential WTN adverse impacts.

Figure 2.

Applicant assessment states: *VP2 View from the L7127 Local Road in the town land of Agharue.*
This viewpoint is located approximately 900m north of the nearest proposed turbine T1.

3. Consideration of the acceptability of the Applicant's adherence to the ETSU - R-97 Guidance and the IOA GPG to supplement the WEDG 2006.

3.1. The Applicant's WTN Appendix 12.2. reference IE 102-008-RO Executive Summary States:

Executive Summary

TNEI Services Ltd was commissioned by MKO on behalf of EDF Renewables Ireland Ltd (the Applicant) to undertake an operational noise assessment for the proposed Seskin Wind Farm (hereinafter referred to as 'the Proposed Project). The noise assessment was undertaken to assess the potential impact of operational noise from the Proposed Project on the nearest noise sensitive receptors, which are primarily scattered residential dwellings. The Irish Government Department of Environment Heritage and Local Government document 'Wind Energy Development Guidelines, 2006' (WEDG 2006, also referred as DoEHLG 2006) are the current guidelines for setting noise limits for wind energy developments. The information relating to noise in the WEDG 2006, is very limited and it is widely agreed that the limits proposed in the WEDG 2006 were drafted to broadly align with the UK guidance ETSU-R-97 'The Assessment and Rating of Noise from Wind Farms'. In 2013, the UK guidance was supplemented by a document produced by the Institute of Acoustics 'A good practice guide to the application of ETSU-R-97 for the assessment and rating of wind turbine noise' (IOA GPG). Reference has been made to guidance contained in ETSU-R-97 and the IOA GPG to supplement the WEDG 2006.

3.2. In our expert opinion, we consider that current Wind Turbine Noise (WTN) Guidance, namely ETSU -R -97 & the IoAGP, and any ensuant WTN Conditions based on this Guidance and Assessment methodology, is systemically not fit for purpose and has not only failed to protect the residential amenity in the recent High Court case in Ireland, between MARGARET WEBSTER AND KEITH ROLLO & ROSS SHORTEN AND JOAN CARTY as Co PLAINTIFFS and MEENACLOGHSPAR (WIND) LIMITED as DEFENDANTS.

3.3. The JUDGMENT of Ms. Justice Emily Egan delivered on the 8th day of March 2024, found in favour of the Plaintiffs, but extracts from this Judgement show (**Annex 2 & Annex 2a** & Para's 5.35) cannot be relied upon to protect the amenity of any neighbouring residents to the proposed Seskin wind turbine development, in the event of any complaints of WT Noise nuisance.

Likewise, in our professional judgement this also applies to the consented Bilboa and White Hill Farm wind turbines.

3.4. It is our experience that complaints in the UK and worldwide, both audible and Infrasound and Low frequency Noise ILFN, largely remain unresolved as wind turbine operators almost always can demonstrate compliance with ETSU -R -7 derived operational noise conditions, as currently is the ongoing WTN nuisance we are involved in Scotland. There is currently no guidance or mechanism to satisfactorily resolve ILFN and audible WTN complaints.

3.5. Living and suffering from impacts from acoustic pollution from wind turbines is '*dose related'* and it is almost impossible for an investigating EHO to '*perceive*' any noise nuisance on an '*occasional*' short visit, when the turbine noise present is not representative of the varying ongoing conditions of debilitating nuisance to the impacted residents, especially during the night time, or out of regular office hours.

3.6. As highlighted at Para 1.6 & 1.7, Grosvenor Consultancy has access to an experienced team which, as an when required, represents vulnerable communities at WTN Public Inquiries and Hearing Examinations.

The team comprises of:

3.6.1. William Leslie Huson BSc (Hons) MSc CPhys MInstP MIoA MAAS. Applied Physics, UK.

Background: MSc Sound and Vibration Studies, Institute of Sound and Vibration Research, Southampton, UK.
Certificate of Competence in Workplace Noise Assessment. Member of the Institute of Physics, UK Affiliations: Chartered Physicist, UK.

Member of the Institute of Acoustics, UK. Member of the Australian Acoustical Society. Member of the AV003 and AV004 acoustics working groups for Standards Australia since 2001 (now combined into AV0001). Australian representative for the International Institute of Noise Control Engineers (I-INCE) Technical Study Group 5 A GLOBAL APPROACH TO NOISE CONTROL POLICY (Now disbanded after completion of the scope of work defining this group – see http://www.iince.org/data/iince061.pdf) #

Mr Huson has 44 years of professional acoustics consulting experience covering terrestrial and underwater acoustics in a wide range of industries with expertise in sound and vibration measurement, noise and vibration modelling and compliance assessments.

Mr Huson states: I have experience as an expert witness at Planning Tribunals/Courts, in the High Court and have been invited to provide submissions to two Senate Inquiries.

3.6.2. Professor Mariana Alves Pereira Professor Degree in Physics, Masters in Biomedical Engineering and Doctoral in Environmental Sciences.

Professor M Alves Pereria is a founder member of the International Acoustics Research Organization (IARO), an international group of researchers with a mission to investigate acoustical environments, especially with respect to features that affect humans and animals, and to publish the results.

IARO holds the ethics approval for the CSI-ACHE, the Citizen Science Initiative into Acoustical Characterisation of Human Environments, the results of which are publicly disseminated. The International Acoustics Research Organization represents a group of scientists who, collectively, hold over 200 years of scientific experience in the field of infrasound and low frequency noise, and its effects of human health. Since 2016, IARO researchers have been recording and analysing acoustical data in and near homes located in the vicinity of onshore wind power stations, in the following countries (alphabetical):

Australia, Canada, Denmark, England, France, Germany, **Ireland**, New Zealand, **Northern Ireland**, Portugal, Scotland, Slovenia, and The Netherlands.

Prior to 2016, all IARO scientists were already working either in acoustics alone or in acoustics and health. All research conducted by IARO is part of the Citizen Science Initiative for Acoustic Characterization of Human Environments (CSI-ACHE).

3.6.3. Susan Crosthwaithe Citizen's Initiative.

Personal Statement: I am retired having enjoyed 27 years in hospitality, preceded by a primary school teaching career, a distinction in geography being my primary subject.

In 2011, seeing the potential devastation to the tourism industry through the proliferation of turbines across South West Scotland, I took an interest in windfarm development. I headed the first International Community Windfarm Conference in Scotland in November 2011 where I met many professionals with expertise on the impacts of windfarm development on the environment who were on our speakers panel chaired by MEP Struan Stevenson: Head of Policy JMT Helen McDade, Dr Malcolm Swinbanks, Dr Chris Hanning, National grid expert Colin Gibson, Engineer and Chair of IESIS Ian MacLeod, Stuart Young and Dick Bowdler (who had a very different view on ILFN to the other panellists)

Following a trip to Geneva in December 2012, in support of Christine Metcalfe's successful complaint to the UNECE Compliance Committee, (ACCC/C/2012/68) citing a breach of the Aarhus Convention, with John Campbell QC and Pat Swords, Christine has continued endeavours to illustrate how windfarm developments continue to be in breach of articles of the Aarhus Convention.

I have been assisting and representing communities faced with inappropriate wind turbine planning applications as well as assisting residents adversely impacted by operational wind turbine noise.

In 2017, as a consequence of the reported health impacts on residents in Fairlie, from the Hunterston Test Facility Turbines (**Ref: Annex 6** Para's 5.16 & 5.19) Mr Grosvenor came to Scotland where we met. I organised the Glasgow Wind Turbine Noise Conference in the September of that year introduced by Melvin Grosvenor when Dr John Yelland, Professor Mariana Alves Pereira, and Patrick Dugast presented: http://www.windsofjustice.org.uk/2017/10/presentations-at-thewind-turbine-noise-infrasound-seminar-glasgow-22 september-2017/

We have worked together, tirelessly to raise awareness of the devastating impact of ILFN on windfarm neighbours. We have represented communities at Inquiries and those already exposed to wind turbine noise pollution.

I have been a researcher for IARO since 2019 and joined the Independent Noise Working Group (INWG) in 2021.

3.6.4. Grosvenor Consultancy and Citizen's Initiative are equipped with Specialist Environmental Soundscape Analytical Monitoring Equipment (SAM). As combined researchers operating SAM, we draw on the expertise and experience of IARO.

3.6.5. Adherence to ETSU - R - 97 and the IoAGP WTN guidance and compliance monitoring fails to assess the full acoustic environment at any assessment location and only considers A Weighted sound data.

Also to in compliance with ETSU -R-97 (and when conducting a broad range of acoustic environmental assessments), Acousticians work with A-weighted sound, as this is supposed to align with the human hearing system based on the misguided and flawed premise that: 'what you can't hear cannot harm you'. In this system the level of each frequency is adjusted to account for the fact that humans are not equally sensitive to all frequencies.

3.6.6. The Monitoring equipment is a SAM Scribe Full Spectrum (FS) system - Soundscape Analytics Monitoring, developed in Palmerston North, New Zealand. SAM Model Mk2 is collecting data at exposed WTN locations in Scotland.

3.6.7. Adherence to ETSU - R - 97 and the IoAGP WTN guidance and compliance monitoring fails to assess the full acoustic environment at any assessment location and only considers A Weighted sound data.

3.6.8. SAM provides two-channel monitoring (identified in Red and Blue) with sampling rates up to 44.1 kHz, which is designed to capture recordings of sonic environments with high precision, especially in the infrasonic and low-frequency bands. Data streams are delivered via USB to a Windows notebook computer and stored as uncompressed wav files to a hard disk. GPS information is stored in the files as metadata and also includes a digital signature. Each wav file corresponds to a 10-minute (600-seconds) recording of the sonic environment. The system can accurately record from 0.1–1000 Hz, as per the manufacturer frequency response of the two electret condenser microphones. All measurements reported cover the range from 0.5–1000 Hz and were captured with a sampling rate of 11.025 kHz. All recordings included a standard reference calibration tone at the start and end, produced with a Type I calibrator (part of the SAM Scribe system) at 1000 Hz/94 dB. Calibration of the SAM Scribe system rests on 1) the manufacturer's frequency-response curve for the microphone and 2) calibration against a certified Larsen-Davis 831 sound level meter in the range of 6.3-1000 Hz. SAM not only gathers the data to be analysed by the IARO team, but it allows us to instantly compare the acoustic environment in different weightings including A Weighting and Unweighted data.

3.6.9. Figure 4 demonstrates the effect of this method on analyses in the infrasound and low-frequency parts of the sound spectrum. The SAM monitoring was conducted in Scotland on 25 October 2022, at 965m distance from the nearest wind turbine at 110m to blade tip.

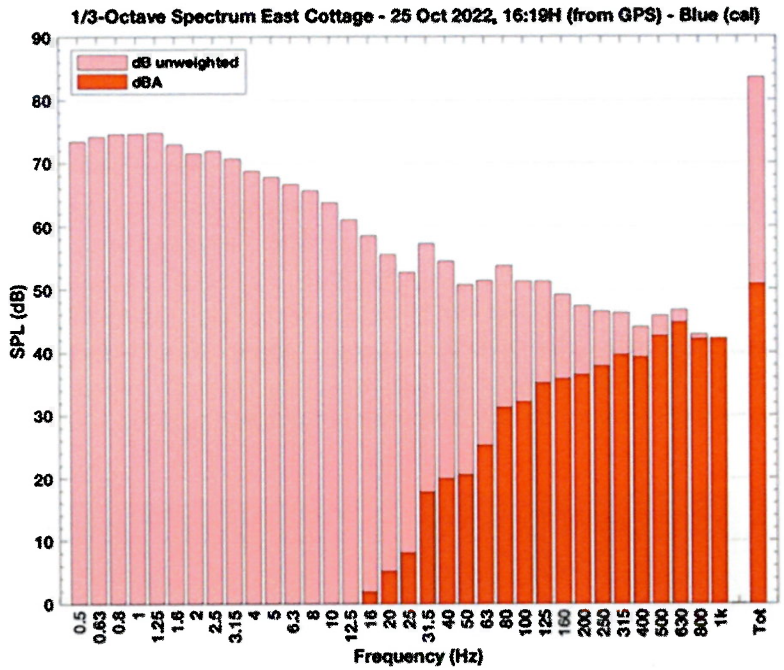

Figure 4.
Shows a spectrogram with each frequency band 1/3 of an octave wide.

3.6.10. Figure 4 above shows a Spectrogram in 1/3 octaves for the Blue channel microphone at the location in Scotland from 16:50H 25 October 2022. The Unweighted acoustic energy identified in pink and A-weighted in red. The total acoustic energy at this location (receptor) is shown in the final bar on the right.

3.6.11. Figure 5 & 6 below are comparative examples of the significant variation in monitoring data outcome between adherence to ETSU R 97 A Weighted acoustic assessment and Un Weighted, whereby, the A Weighted acoustic data is truncated to the left (Lower Frequencies) of the slide.

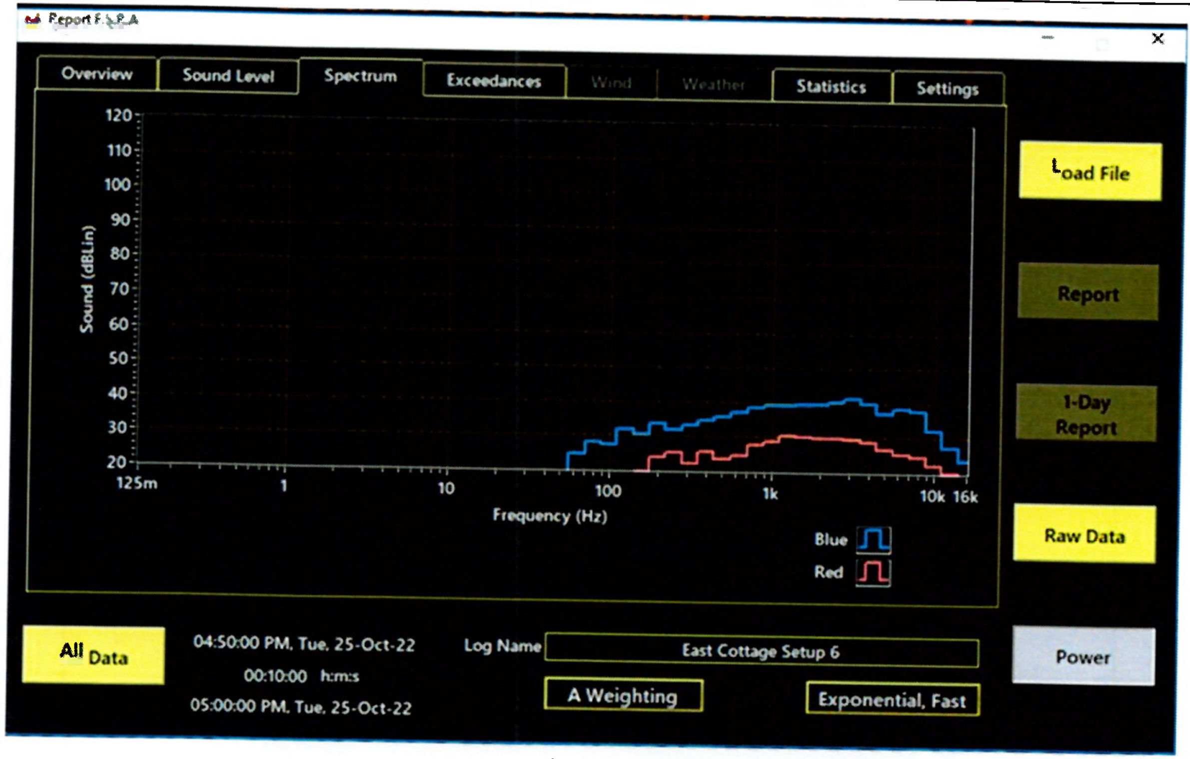

Figure 5.

SAM F.S.R.A Report - A Weighted spectra in monitoring in Scotland Tuesday 25 October 2022.

Note: The Blue Microphone was installed outside - hence the greater (louder) sound levels and the Red Microphone inside, hence the lower (quieter) sound levels. Note: Below 100 Hz there is no evidence of any monitoring data, this graphically demonstrates that ETSU - R- 97 fails to assess the full acoustic environment.

Perhaps the adage of - *'what you cannot hear cannot harm you'*,

to in this case - what *'you can't see cannot harm you.*

Figure 6 below exposes the full WTN - acoustic sound pressure levels.

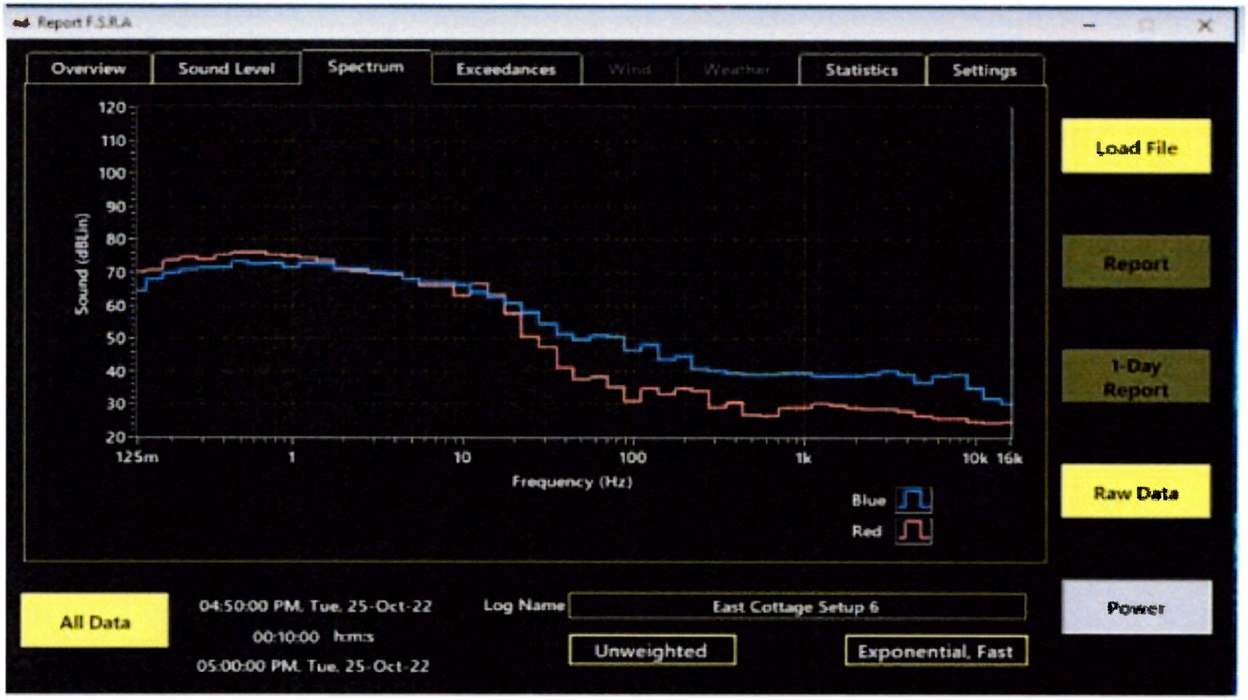

Figure 6.

SAM F.S.R.A Report - Unweighted spectra in Scotland Tuesday 25 October 2022. Note: The Blue microphone was installed outside and the Red Microphone inside. Note: To the left greater Low Frequency sound levels inside(red channel) at around the peak, which is even greater than the outside Blue Channel -to the right of the spectra, which as expected the outside Blue Channel reverts to the higher level.

The difference between the SAM unweighted and A-weighted spectra is significant, as seen above in Figure 5 & 6 of the two screen capture spectrograms from monitoring in Scotland. These very clearly demonstrate that any analysis of sound in the infrasound or low-frequency range of the spectra must be taken into account and monitoring in A-weighting corrupts the results.

The overall (total) sound level analysis approximately 35 dB less using A-weighting.

4. Direct references to the Applicant's Appendix 12.1 Wind Turbine Noise and further comments.

4.1. The Applicant's position from Para 2.5 *Wind Energy Development Guidelines*, 2006 details their rationale for the adherence to the ETSU - R -97 WTN guidance and for the setting of in this case acceptable WTN limits. The following extracts confirm this approach.

2.5.4 *The WEDG states that a 'fixed limit of 43dB(A)* ***will protect sleep inside properties during the night'****, however, whilst it is not explicit within the WEDG guidance, the addition of a nighttime 'background noise +5 dB' parameter is commonly applied in wind turbine noise assessments. This is detailed in numerous examples of planning conditions issued by local authorities and An Bord PleanÆla. On that basis, the night-time noise limits used in this assessment have been based on 43 dB or background noise + 5 dB, whichever is the greater.*

Note: Grosvenor Consultancy's team of experienced and qualified professionals, consider the statement at Para 2.54 above '*The WEDG states that a 'fixed limit of 43dB(A)* ***will protect sleep inside properties during the night'*** is fundamentally flawed. This submission will provide substantive evidence to the contrary, that in an increasing number of instances, sleep disturbance is a significant material matter of concern despite compliance with the WTN conditions. This was also found in evidence within the recent High Court Judgement, as being significant contributing factor to the substantive nuisance endured by the Plaintiffs.

2.5.5 *It is widely agreed that the limits proposed in the WEDGs were drafted to broadly align with the UK guidance ETSU-R-97 'The Assessment and Rating of Noise from Wind Farms'. In 2013, this UK guidance was supplemented by a document produced by the Institute of Acoustics' (IOA) 'A good practice guide to the application of ETSU-R-97 for the assessment and rating of wind turbine noise' (IOA GPG). Given the lack of detail in parts of the WEDG, information contained in ETSU-R-97 and the IOA GPG is often used to supplement the WEDGs and to inform wind farm noise assessments in Ireland.*

4.2. Para's 2.6 ETSU-R-97 *The Assessment and Rating of Noise from Wind Farms* discusses the background to the adoption of ETSU and concludes at 2.6.2 and 2.6.4:

2.6.2 'The WGNWT comprised a number of interested parties including, amongst others, Environmental Health Officers, wind farm operators, independent acoustic consultants and legal experts who':

'...between them have a breadth and depth of experience in assessing and controlling the environmental impact of noise from wind farms.'

2.6.4 The basic aim of the WGNWT in arriving at the recommendations was the intention to provide:

'Indicative noise levels thought to offer a reasonable degree of protection to wind farm neighbours, without placing unreasonable restrictions on wind farm development or adding to the costs and administrative burdens on wind farm developers or local authorities.'

4.3. Yet whilst appearing to be even handed and even considerate, in seeking to; '*offer a reasonable degree of protection to wind farm neighbours*' there was an over- riding caveat as highlighted at Para 2.6.5:

ETSU-R-97 makes it clear from the outset that any noise restrictions placed on a wind farm must balance the environmental impact of the wind farm against the national and global benefits that would arise through the development of renewable energy sources:

'The planning system must therefore seek to control the environmental impacts from a wind farm whilst at the same time recognising the national and global benefits that would arise through the development of renewable energy sources and not be so severe that wind farm development is unduly stifled.'

(However, in this case the Applicant appears to justify a proposal to site 7 large 180m to blade tip turbines in unacceptably close proximity to residents at under 800m).

4.4. The applicant further seeks to reinforce their position at Para's 2.6.11 & 2.6.12:

ETSU-R-97 provides a robust basis for determining the noise limits for wind turbine(s) and since its introduction has become the accepted standard for such developments across the UK.

2.6.12 As detailed above, for this assessment the ETSU-R-97 guidance has been used to supplement the guidance provided within the WEDG. The noise limits have been derived in accordance with WEDG 2006.

Members of the Noise Working Group:

Mr R Meir, Chairman	DTI
Dr M L Legerton, Secretary	ETSU
Dr M B Anderson	Renewable Energy Systems
Mr B Berry	National Physical Laboratory
Dr A Bullmore	Hoare Lea and Partners
Mr M Hayes	The Hayes McKenzie Partnership
Mr M Jiggins	Carrick District Council
Mr E Leeming	The Natural Power Company Ltd
Dr P Musgrove	National Wind Power Ltd
Mr D J Spode	North Cornwall District Council
Mr H A Thomas	Isle of Anglesey County Council
Ms E Tomalin	EcoGen Ltd
Mr M Trinick	Bond Pearce Solicitors
Dr J Warren	National Wind Power Ltd

Figure 7.
Reference the Applicant's Para 2.6.2 List of Members of ETSU Noise Working Group.

4.5. The Applicants reference at 2.6.2 to *'The WGNWT,* which identified the composition of the ETSU -R -97 Working Group in the form of 'a *number of interested parties'* which included, *'independent acoustic consultants'*. To be open and transparent Figure 7 above, is an extract from the ETSU - R -97 published report which included a list of the published list of the Working Group Members and their affiliations at that time.
However, it is notable that there were no qualified health professionals within the original ETSU Working Group to inform the Working Group and feed back to the lead Government Department responsible, which back in 1996/97 was the Department of Trade and Industry (DTI).

4.6. Furthermore, it is beyond any disagreement that the size and generation capacity of on shore wind turbines has increased exponentially, since the original ETSU WTN Assessment guidance in was published in 1997. Notably, from turbines at 60m to blade tip with generational capacity of 600kW, increasing to 100 125m to blade tip 2 - 2.5MW turbines, during the broad period of 2005 - 2010, From 2015 - 2019 to wind turbines of at around 150m to blade tip at 3 -4 MW, from approximately 2020 to date, we are experiencing applications in the UK (specifically in Scotland) for even larger scale wind turbines, in some case in excess of 200m to blade tip, with the commensurate increase in generation power output up 6-7MW.

4.7. The Seskin application is a case in point, as advised by the Applicant's Table 1.1 Cumulative Wind Farm Developments, extracted below:

Table 1.1 Cumulative Wind Farm Developments

Wind Farm/ Wind Turbine	Number of Turbines	Status	Make and Model of Turbine Considered in Modelling
Gortahile Wind Farm	8	Operational	Nordex N90 2500 HS 2.5MW, 80 m hub. Standard blades.
Bilboa Wind Farm	5	Permitted	Vestas V117 4.2 MW SO2, 78 m hub, serrated blades
White Hill Wind Farm	7	Permitted	Vestas V162 6.2MW, 100 m hub, serrated blades

Figure 8.
Applicant's Table 1.1 Cumulative Wind Farm Development.
Note the sequential increase in both generation capacity and hub height.
Gortahile wind turbines at 2.5MW hub height of 80m.
Bilboa 4.2MW hub height 78m.
White Hill Wind Farm 6.2MW hub height 100m. Note: subsequent information advises that the White Hill WF data is flawed.
Table 1.1 is fundamentally flawed as the crucial blade tip heights of each of these wind turbines have been omitted.

4.8. In respect of the Gortahile Wind turbines, an online search advised that the rotor diameter is 90m - blade length 45m tip height 125m. The turbines apparently have been in operation from 2010.

4.9. In respect of Bilboa Wind Farm, this development was consented on appeal. Chapter 1 EIAR confirms at Para 1.3.2.

'1.3.2 Consented Modification On 26th January 2021, a planning application (Ref: 21/15) was submitted by the Applicant to CCC for: 'Permission for development consisting of alterations to a previously permitted wind farm development (Planning Register References: Carlow County Council 11/154: An Bord Pleanala PL 01.240245) The proposed alteration will consist of increasing the maximum turbine blade diameter of the permitted turbines from 93m up to a maximum of 120m'.

Based on this information with a reported hub height of 78m and a blade length of 60m, the blade tip height of the Bilboa wind turbines can be assumed to be 138m.

4.10. With respect to the consented White Hill Farm Wind Turbines, our clients have provided evidence that the Applicant's information at Table 1.1 *Cumulative Wind Farms* is flawed.

Para1.0 Description of the Proposed Development States:

The Planning application seeks permission for 10 year planning permission for a proposed development generally described as follows:

*1. 7 no, wind turbines with a hub height of **104 metres**, a rotor diameter of 162 metres and an overall tip height of 185 metres. The rated output for each turbine based on the model selected, is **7.2MW**, resulting in a total rated output of 50.4MW for the project.*

4.11. Referring back to Appendix 12.1, the Applicant correctly state at Para 2.8 *WSP BEIS Report*:

2.8.1 In February 2023, WSP published 'A review of noise guidance for onshore wind turbines' ('WSP BEIS report') (7), The report, which was subsequently re-issued as version 4 in May 2023, was commissioned by (the former) UK Government Department for Business, Energy & Industrial Strategy (BEIS). The primary aim of the review was to make a recommendation on whether, in view of government policies on noise and Net Zero, and available evidence, the existing UK guidance requires updating.

4.12. And that at Para 2.8.2 The WSP BEIS report concluded that:

'the guidance would benefit from further review and updating of the aspects identified. This could be supported by currently available evidence, which is summarised in this report. However, the study has also highlighted gaps in the state of knowledge, which should be addressed by further research, to support any updates to the guidance.'

4.13. It is important to state that given the information we have highlighted at Para 4.6 above, a review of the out of date ETSU WTN guidance was entirely necessary and justified.

However, due to significant and ongoing concerns over an extended period, regarding the application of the ETSU Guidance assessment methodology, along with the excessively restricted Scoping consultation process, (which was limited only to invited participants already involved in the application of ETSU) prior to the commencement of the *WSP On shore WTN review*, it was considered essential that INWG also undertake an extensive review of the WSP BEIS report, once this report was published in February 2023.

4.14. In support of our objection and for openness and transparency, we have submitted:

Annex 3. INWG responds to WSP Report 15 April 2023, "A review of noise guidance for onshore wind turbines". This is detailed critique of the *WSP On shore WTN review* commissioned by BEIS. The INWG review submitted to BEIS sets out in detail our profound concerns regarding the WSP report's recommendations. We consider these do not seek to address the ongoing failure of ETSU and subsequent IoA Good Practice Guidance, to adequately safeguard the residential amenity of wind turbine neighbours.

INWG have also raised further concerns to BEIS and the recently formed Department of Energy Security and Nett Zero, (DESNZ). This is despite the *re-issued WSP report as version 4 in May 2023*. Note: All of INWG's Work Packages and subsequent papers can be accessed at https://inwg.org.uk/

4.15. It is of further note that Annex 3 INWG's review of the WSP report includes; *IARO Scientific Commentary at Appendix 9.*

The Scientific Commentary on the UK Government's Department of Business, Energy and Industrial Strategy (DBEIS) "Scoping review of current onshore wind turbine noise assessment guidance"

The IARO Scientific Commentary informatively states:

The International Acoustic Research Organisation (IARO) submitted an unsolicited response to the DBEIS survey during 2021 <u>but this response was rejected by WSP so is not included in the WSP review</u>. Details of the IARO response with an additional scientific commentary is available on their website, open here. The IARO document provides a highly critical appraisal of ETSU-R-97 and provides an insight into recent developments into wind turbine low frequency noise.

4.16. Furthermore, the commentary highlights: *The IARO scientific commentary section H; EXCLUSION OF INFRASOUND & LOW FREQUENCY NOISE (paras 42 to 62) present compelling new evidence relating to wind turbine low frequency sound, its characteristics and effects. The following IARO scientific commentary statements are especially relevant:*

4.17. In this context, we refer back to Figure 7. *Reference the Applicant's Para 2.6.2 'List of Members of ETSU Noise Working Group'* and our Para 4.5 above which states:

However, it is notable that there were no qualified health professionals within the original ETSU Working Group, which IARO highlight in Figure 8 below:

Para 9 – *"Medical expertise is conspicuously absent from the list of the Members of the Working Group responsible for ETSU-R-97, and yet, ETSU-R-97 is touted as appropriate for the protection of Public Health against wind turbine noise".*

Para 11 – *"Unsurprisingly, given the absence of representatives of the medical community, noise limits suggested by ETSU-R-97 do not prioritize, or even conscientiously consider, the health and well-being of UK citizens."*

Para 67 – *"It is shocking that a policy-decision document which has served as the core document for wind turbine noise assessments, with direct implications on Public Health, and where scientific evidence is of critical importance, is absent of any accountability or responsibility."*

Para 78 - *"If the medical community was not represented in the preparation and publication of ETSU-R-97, how can the UK Government allow ETSU-R-97 be used to establish public policy with direct implications on Public Health?"*

Figure 9.

Extract from INWG 9 *Appendix IARO Scientific Commentary.*

In respect of statements at Para 4.5 & Para 4.17 above.

Our combined evidence in this objection is material for the consideration by the decision maker's of this proposed application and the reliance by the Applicant on the compromised ETSU -R - 97 Guidance and WSP WTN review.

4.18. Moving on we have extracted key statements from INWG's *"A Review of noise guidance for onshore wind turbines"*

The WSP BEIS report considered a number of studies which investigated claimed links between adverse health symptoms and infrasound emissions from wind turbines. The report notes on page 116 that:

*Overall, the findings from the existing evidence base indicate that infrasound from wind turbines at typical exposure levels has no direct adverse effects on physical or mental health, and reported symptoms of ill-health are more likely to be *psychogenic in origin.*

Note: Oxford Dictionary definition of *psychogenic - having a psychological origin or cause, rather than a physical one.

INWG's response is:

> On what basis should medically unqualified acousticians, (as are the WSP authors) opinions on the health and wellbeing of adversely affected residents, become accepted as a statement of fact, on which large scale planning decisions are made and on which government policy is determined?

4.19. On the topic of infrasound and low frequency noise, the advice contained in the WSP BEIS report highlights unsound information:

> *Whilst it may be feasible to measure infrasound from wind turbines, the current weight of evidence (see WSP BEIS report) indicates that wind turbine infrasound has no adverse effects on human health at typical exposure levels and that it is not necessary to consider wind turbine infrasound when determining development applications.*
>
> *Furthermore, assessment on the basis of **'A' weighted sound levels (the approach in the ETSU-R-97 assessment methodology) provides sufficient control over the potential impact of low frequency noise.***

4.20. This statement is totally contradicted by the WHO in the 2018 European Community Noise Guidance which state:

> *Standard methods of measuring sound, **most commonly including A-weighting, may not capture the low-frequency sound and amplitude modulation** characteristic of wind turbine noise (Council of Canadian Academies, 2015).*

4.21. The INWG WSP critique extract below, references the following:

> Then at page 232, WSP BEIS report authors' are mischievously recommending that government make a position statement indicating that; *"infrasound from wind turbines at typical exposure levels has no direct adverse effects on health".* These conclusions and recommendation are completely at odds with the evidence review findings by the INWG at Work Package 2.1, and more recent evidence, bringing to mind the age old saying; *"The absence of evidence is not evidence of absence".*
>
> and;
>
> The INWG findings from 2015 are summarised in the WP 2.1 Executive Review at Para 5; *"The evidence regarding low frequency noise (LFN), a significant component of WTN including AM, is compelling. Despite the wind industry's continual denial of the significance of LFN, the available evidence demonstrates conclusively that:*
>
> - LFN including infrasound is an integral component of WTN;
> - Complaints regarding WTN currently classified as AM or EAM or OAM by the wind industry is an obfuscation of the true nature of the problem;

- Conditions giving rise to noise complaints are often characterised by ‘sensation’ as being the major form of disturbance. In some cases, the ‘noise’ may not even be audible;
- **Noise measurement using the A weighting may be unsuitable for WTN where low frequency components are present;**
- Noise measurements should be made inside homes when investigating noise complaints;
- Noise measurements where LFN is present should be made using suitable instrumentation. IEC 61672 compliant ‘Class 1’, instrumentation may be unsuitable for LFN measurement or where background noise levels are low as in typical rural areas.”

4.22. In conclusion: INWG's critique provides substantive evidence to the decision makers of the Seskin wind turbine development proposal and;

Following this review of the WSP report, the INWG make the following recommendations to the UK & Scottish Government, expanded below in Figure 9a below.

ONE	Reject the recommendations made by WSP in their review for ETSU-R-97 to be retained albeit with some revisions.
TWO	Replace ETSU-R-97 with BS4142:2014+A1:2019 as the official guidance for wind turbine noise assessment.
THREE	Reject the WSP suggested proposal for a government position statement on low frequency noise. This proposal is unsupported by the evidence and would conflict with the World Health Organisation (WHO) position.
FOUR	Conduct independent research into the effects on health and well-being of wind turbine noise including impacts from long term exposure, low frequency noise, infrasound, amplitude modulation and tonal noise as recommended by the WHO.
FIVE	Introduce licencing and regulation of wind power generation by a national agency such as the Environment Agency. This to include continuous monitoring and recording of noise and turbine data (SCADA) with the data available for compliance and complaint purposes.

Figure 9a.
Extract INWG's '*A Review of noise guidance for onshore wind turbines*' 15 April 2023.
Five Recommendations to BEIS and subsequently to DESNZ.

5. Review of Adverse Health Impacts arising from WTN & World Health Organisation's Position.

5.1. The WHO position on Environmental Noise has been subjected revisions since 1999, when the Community Noise Guidelines were first understood to have been published.

This WHO document on the *Guidelines for Community Noise* is the outcome of the WHO-expert task force meeting held in London. United Kingdom, in April 1999. It bases on the document entitled "Community Noise" that was prepared for the World Health Organization and published in 1995 by the Stockholm University and Karolinska Institute.

Figure 10.
Extract: Introduction - WHO Guidelines for Community Noise 1999.

5.2. In fact this dated report published in 1999, states: *Since 1980 WHO has addressed the problem of Community Noise. In 1992 the WHO regional office for Europe convened a task force which set up Guidelines for Community Noise presented in this document.* The Preface Fig 11 below, sets out the perimeters of the objectives of the guidelines.

Preface

Community noise (also called environmental noise, residential noise or domestic noise) is defined as noise emitted from all sources except noise at the industrial workplace. Main sources of community noise include road, rail and air traffic, industries, construction and public work, and the neighbourhood. The main indoor sources of noise are ventilation systems, office machines, home appliances and neighbours. Typical neighbourhood noise comes from premises and installations related to the catering trade (restaurant, cafeterias, discotheques, etc.); from live or recorded music; sport events including motor sports; playgrounds; car parks; and domestic animals such as barking dogs. Many countries have regulated community noise from road and rail traffic, construction machines and industrial plants by applying emission standards, and by regulating the acoustical properties of buildings. In contrast, few countries have regulations on community noise from the neighbourhood, probably due to the lack of methods to define and measure it, and to the difficulty of controlling it. In large cities throughout the world, the general population is increasingly exposed to community due to the sources mentioned above and the health effects of these exposures are considered to be a more and more important public health problem. Specific effects to be considered when setting community noise guidelines include: interference with communication; noise-induced hearing loss; sleep disturbance effects; cardiovascular and psycho-physiological effects; performance reduction effects; annoyance responses; and effects on social behaviour.

Figure 11.
Extract: Preface 1999 WHO Community Noise Guidelines.

5.3. The WHO 1999 Community Noise Guidance does not reference wind turbine noise. All other main sources of community noise are considered, including *barking dogs*. Indeed the extract of the Preface does not identify Wind Turbines, as at that time there were very few turbines operating within quiet rural environments. As discussed previously, the ETSU Working Group was formed in 1996. However, it is clear the WHO does raise the concern that the general population is increasingly exposed to community noise due to the sources mentioned. Specific effects to be considered include noise-induced hearing loss; sleep disturbance effects; cardiovascular and psycho-physiological effects; performance reduction effect, etc;

However, it is abundantly clear that the WHO in 1999 recognised that sleep disturbance was and still is a fundamental concern, especially in quiet rural locations selected for hosting wind turbines which are exponentially increasing in size, as previously discussed. Reference Figure 12 below.

Sleep disturbance is a major effect of environmental noise. It may cause primary effects during sleep, and secondary effects that can be assessed the day after night-time noise exposure. Uninterrupted sleep is a prerequisite for good physiological and mental functioning, and the primary effects of sleep disturbance are: difficulty in falling asleep; awakenings and alterations

of sleep stages or depth; increased blood pressure, heart rate and finger pulse amplitude; vasoconstriction; changes in respiration; cardiac arrhythmia; and increased body movements. The difference between the sound levels of a noise event and background sound levels, rather than the absolute noise level, may determine the reaction probability. The probability of being awakened increases with the number of noise events per night. The secondary, or after-effects, the following morning or day(s) are: reduced perceived sleep quality; increased fatigue; depressed mood or well-being; and decreased performance.

For a good night's sleep, the equivalent sound level should not exceed 30 dB(A) for continuous background noise, and individual noise events exceeding 45 dB(A) should be avoided. In setting limits for single night-time noise exposures, the intermittent character of the noise has to be taken into account. This can be achieved, for example, by measuring the number of noise events, as well as the difference between the maximum sound level and the background sound level. Special attention should also be given to: noise sources in an environment with low background sound levels; combinations of noise and vibrations; and to noise sources with low-frequency components.

Figure 12.
Extract: WHO 1999 Community Noise Guidelines.
Referencing major adverse impacts of environmental noise to human health from Sleep Disturbance.

5.4. It is also notable, that the WHO state; ***Special attention should also be given to: noise sources in an environment with low background sound levels; combinations of noise and vibrations; and noise sources with low frequency components***.

5.5. The salient question to decision makers, which include Government and Public Authorities, including those tasked with determining this Seskin Wind Turbine proposal.

Why are acousticians commissioned by Wind Turbine Developers, constantly seeking to down play residents complaints and deny the reported debilitating health impacts from adversely impacted residents, especially those who suffer continuous sleep disturbance?

Can it really be the case, that all other sources of environmental noise nuisance from whatever source rightly needs to be addressed, but only wind turbine noise is benign and causes no adverse effects?

This evidence from the WHO, totally contradicts the unfounded claim by the WPS authors;

'Overall, the findings from the existing evidence base indicate that infrasound from wind turbines at typical exposure levels has no direct adverse effects on physical or mental health, and reported symptoms of ill-health are more likely to be psychogenic in origin'

5.6. To clarify, extracts from the updated WHO 2018 European Environmental Noise Guidance are copied below:

"The current evidence on health outcomes related to wind turbine noise is <u>unavailable, or of low/very low quality</u> and mainly comes from cross-sectional studies. ***Methodologically robust longitudinal studies with large samples investigating the quantitative relationship between noise from wind turbines and health effects ARE NEEDED."*** (Emphasis added by report author).

It is abundantly clear completely independent scientific research free of any bias or predetermined outcomes is desperately needed. It is imperative that local communities have full confidence in the transparent independence of the research.

5.7. Importantly, there is a significant step forward in an admission by WHO on Page 85 of the 2018 Guidance, that;

"Wind turbines ***can generate infrasound or lower frequencies of sound*** *than traffic sources. <u>However, few studies relating exposure to such noise from wind turbines to health effects are available.</u> It is also unknown whether lower frequencies of sound generated outdoors are audible indoors, particularly when windows are closed".*

Both of these statement by WHO acknowledge there is a need for further studies and that wind turbines can generate infrasound, or lower frequencies of sound.

5.8. In evidence submitted to the Conjoined Public Inquiry reference: WIN 370-4 Craiginmoddie Wind Farm, South Ayrshire, KA26. WIN 370-5 Carrick Wind Farm, South Ayrshire, KA19. WIN 370-6 Knockcronal Wind Farm, Straiton, South Ayrshire, KA19, Mr WL Huson stated at Para's 68, 85 & 86:

68 The issue associated with the larger wind <u>turbines is that they emit resonant infrasound tones in the presence of wind even when they are not rotating</u>.

85 *The use of A-weighted sound levels for the assessment of a wind farm will not quantify infrasound, or low frequency noise impacts correctly.*

86 *Unfortunately, low frequency sound and infrasound are a common feature of modern wind turbines.*

5.9. Furthermore, Mr Huson stated at Para's 89, 90 & 91:

89 *However, it has been postulated by Kelly (1982) that lightweight building structures can be excited by infrasound pressure from wind turbines and can be one of the major causal agents responsible for the annoyance of nearby residents. Part of the conclusions in Kelly's paper follows: "In this paper we have presented evidence to support the hypothesis that one of the major causal agents responsible for the annoyance of nearby residents by wind turbine noise is the excitation of highly resonant structural and air volume modes by the coherent, low frequency sound radiated by large wind turbines. Further, there is evidence that the strong resonances found in the acoustic pressure field within rooms actually measured indicates a coupling of subaudible energy to human body resonances at 5, 12 and 17-25 Hz, resulting in a sensation of whole-body vibration. The audible sounds indoors associated with the impulsive excitation of the structure appear to be due to the coupling of energy from the higher frequency discrete bands in the impulse to higher frequency room resonances related to the air volume itself."*

90 *My own measurements of infrasound inside residences near Macarthur and Cape Bridgewater show infrasound pressure levels similar to those measured by Kelly in 1982. Infrasound causing whole-body vibration is a plausible explanation for the commonly reported symptoms described by residents living near to wind farms.*

91 *Huson (2015) also covers the propagation of infrasound so that the 'vibration' experienced in homes by people near a large wind farm can be estimated. Infrasound levels can vary significantly over a short time period (seconds) depending upon the phase relationships between each turbine rotor and with local wind speed variations.*

92 *Infrasound measurements from a residence located* ***5.4km*** *away from the nearest turbines in the Macarthur array of 140 V112-3MW units and 1.3km away demonstrate very little infrasound attenuation in the near field and that the infrasound levels at this distance (****5.4km****) are comparable to those reported by Kelly(1982).*

5.10. Notably, the Figures 4, 5,& 6 above, clearly demonstrate the presence of ***infrasound or lower frequencies of sound***. Subsequent periods of monitoring with SAM monitoring equipment and analysed by IARO at the Rural location in Scotland, during the three monitoring periods detailed below.

Figure 13 below, is an analysis of the constant wind turbine acoustic pollution present at a Rural Farm in Scotland between the period of 22 Feb - 17 March 2023, where the residents are consistently reporting debilitating WTN impacts.

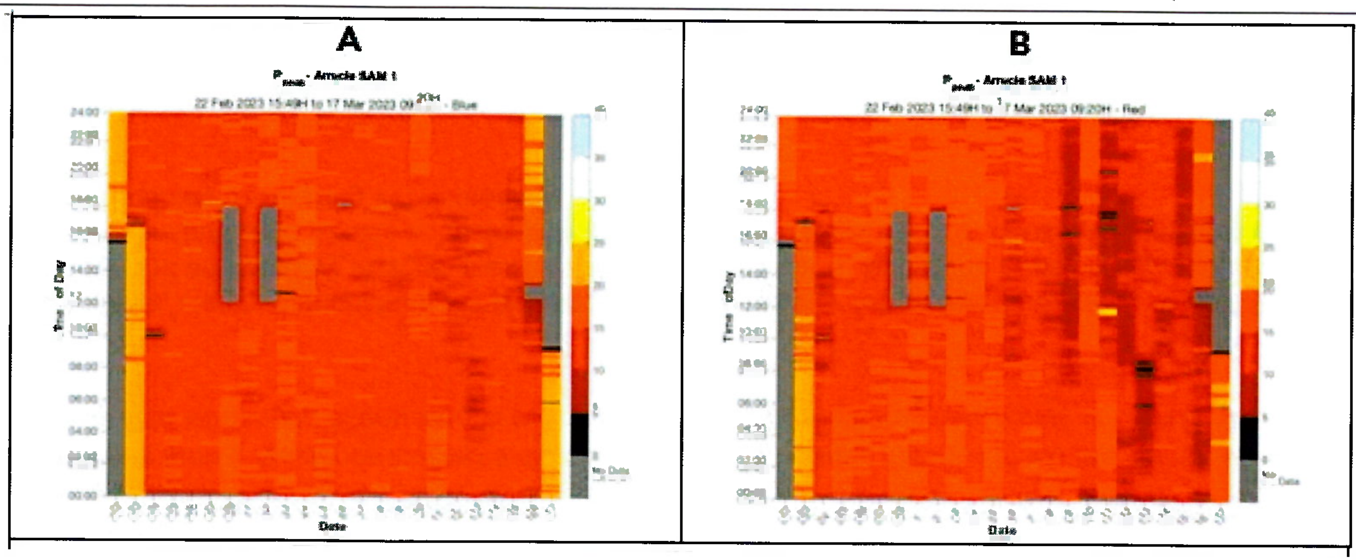

Figure 56. Time-of-Day vs. Day plots for peak harmonic prominence (P_{peak}) over all harmonic series, from SAM 1 Rural Sheep Farm, 22 Feb–17 Mar 2023 (3175 10-minute sound files). Each column refers to a 24-hour day with 144 slots, each slot corresponding to a 10-minute sound file. The colour indicates the level of P_{peak} within that 10-minute slot (in dB), as shown in the colour legend on the right. A. Blue microphone. B. Red microphone.

There are less than a handful of 10-minute sound files with no detectable P_{peak} (black bars) for the Blue channel (**A**) and only a dozen of such situations for the Red channel (**B**). Most of the time, P_{peak} exceeded 10 dB over background level. On 22–23 Feb and 16–17 Mar, P_{peak} exceeded 20 dB, mostly in the Blue channel. Except for the sporadic appearance of black slots, the saturation over time demonstrated by this plot means that Rural Sheep Farm residents were continuously exposed to infrasonic acoustic phenomena for (at least) 24 consecutive days.

Figure 13.

For illustrative purposes only.

Extract: From IARO Acoustic *Report on the High-Resolution Infrasonic and Low-Frequency Sound Recordings Conducted Within a Rural Farm in Scotland in 2022 and 2023.*

5.11. To provide further background information and context, in respect of Figure 13 above, the following statements have been extracted from the; IARO Acoustic '*Report on the High-Resolution Infrasonic and Low-Frequency Sound Recordings Conducted Within a Rural Farm in Scotland in 2022 and 2023*':

1. *There are five Wind Power Plants (WPPs) within 7 km of the Rural Sheep Farm. According to Mr & Mrs. Z and the other Rural Farm residents, however, severe health deterioration only began after the installation of the WPP A, adjacent to their property.*

2. *Noise measurements conducted in accordance with UK legislated and recommended practices yielded no explanation for the health complaints and deemed the location within acceptable noise exposure levels.*

3. *High-resolution acoustic recordings were conducted at Rural Sheep Farm during three time periods: 28–31 March 2022, 3–26 October 2022, and 22 February–17 March 2023. Close to 1140 hours of recordings (6839 10-minute recordings) were captured in 9 different locations within the Farm. The train of pressure pulses, arriving regularly every 0.5–2 seconds, that characteristically emanate from industrial wind turbines were present in practically all recordings, evidencing, in effect, a nearly continuous exposure to this infrasonic agent, at all hours of the day and night.*

4. *The pressure pulses generated by industrial wind turbines, defined as Wind Turbine Acoustic Signature (WTAS), appear in spectrograms as a harmonic series of frequencies with the wind turbine Blade-Pass Frequency (BPF) as the fundamental frequency, and as positive, negative, or dipolar pressure pulses in the time-domain signal. It has been correlated to sleep interference and can contribute to the onset of other adverse health effects.*

5. *The BPF is specific to each wind turbine model under full-speed operation, although determining what the BPF is and whether the turbines are running at full speed is problematic. At Rural Sheep Farm several BPFs were identified consistent with the five models of wind turbines used in the neighbouring WPPs, including the A WPP.*

5.12. The continual emerging evidence reported by residents living in the proximity of wind turbines worldwide, is proving to be contrary to the Applicant's statements at Appendix 12.1 Para 3.2.11:

3.2.11 It is noted that research into infrasound is ongoing but the WSP BEIS report concluded that:

'It is expected that further evidence from ongoing studies into wind turbine infrasound effects will emerge soon, in particular from the NHMRC studies in Australia. However, based on the existing scientific evidence, it does appear probable that the above findings will not be contradicted by newer evidence.' and at Para 3.2.12

3.2.12 *Since the publication of the WSP BEIS report, the study that was granted funding by NHMRC (the National Health and Medical Research Council of Australia) was published in the Environmental Health Perspectives (EHP) journal which is published by the United States National Institute of Environmental Health. The study (*14 incorrect reference No is 15*) aimed to test the effect of exposure to 72 hours of infrasound (**designed to simulate a wind turbine infrasound signature**) exposure on human physiology, particularly sleep. The study concluded that:*

'Our findings did not support the idea that infrasound causes WTS1. High level, but inaudible, infrasound did not appear to perturb any physiological or psychological measure tested in these study participants.'

5.13. It is of significant concern that the study referenced, was apparently conducted in laboratory conditions for a minimal period of 72 hours. Following publication, IARO has engaged in discussions with Tonin a co author of the study, as detailed in **Annex 5.** IARO Review. *The Health Effects of 72 Hours of Simulated Wind Turbine Infrasound: A Double-Blind Randomized Crossover Study in Noise-Sensitive, Healthy Adults - PMC (nih.gov).*

5.14. IARO's conclusions state:

In conclusion, the effort expended by these authors to conduct this study is laudable (particularly given the position of the Australian NHMRC), even though, scientifically, within the realm of Medical Sciences and dose-response relationships, its results are inconsequential for the investigation into wind turbine noise and health.

5.15. The applicant at 3.2 Infrasound, Low Frequency Noise and Vibration, further discusses this topic from Para's 3.2.1 to 3.2.13.

We have conducted a further review of the information submitted in these paragraphs

At Para 3.2.2, reference is yet again made to the dated and familiar May 2006 Hayes McKenzie Partnership report, when notably the majority of wind turbines in operation at that time were under 100m to blade tip and the generational capacity under 2MW, (reference Para 4.6 above.)

***In 2004**, the former DTI commissioned The Hayes McKenzie Partnership to report on claims that infrasound or LFN emitted by wind turbine generators (WTGs) were causing health effects. Of the 126 wind farms operating in the UK, five had reported LFN problems, therefore, such complaints are an exception, rather than a general problem that exists for all wind farms. Hayes McKenzie investigated the effects of infrasound and LFN at three wind farms for which complaints had been received and the results were reported in **May 2006** (9).*

The report concluded that:

- *'infrasound associated with **modern** wind turbines is not a source which will result in noise levels which may be injurious to the health of a wind farm neighbour;*
- *low frequency noise was measurable on a few occasions but below the existing permitted Night-time Noise Criterion. Wind turbine noise may result in internal noise levels within a dwelling that is just above the threshold of audibility, however at all sites it was always lower than that of local road traffic noise;*

- *that the more common cause was of complaints was not associated with LFN, but the occasional audible modulation of aerodynamic noise especially at night. Data collected showed that the internal noise levels were insufficient to wake up residents at these three sites.* ***However once awoken, this noise can result in difficulties in returning to sleep.'***

5.16. Our position is that the findings of this report, are materially not relevant to this proposal, as in terms of size and power output this proposal cannot be considered to be comparable with those in back in 2006. This also applies to recently consented Wind Turbine developments and those currently being considered for consent in the UK or Ireland, certainly from 2020 today in 2024, some 20 years later. The only relevant data in the HMP study, is the acknowledgement that even back in 2004, '*this noise can result in difficulties in returning to sleep',* which regretfully still holds true today.

5.17. At Para 3.2.3 reference is made to another report dated 2005 concerning ground vibration, which again although interesting, is of limited value today in 2024. Also at Para's 3.2.5 & 3.2.6 reference is made to an in house IoA Bulletin Article (2009) and a Geoff Leventhall study (2009). All of these sources have consistently been cited as relevant since they were published within numerous Wind Farm Application proposals.

5.18. The Applicant then references the *Hunterston National Off shore Wind Turbine Test Facility* (NOWTTF) case, identified at Para 3.2.7:

> *During a planning Appeal (PPA-310-2028, Clydeport Hunterston Terminal Facility, approximately 2.5 km south-west of Fairlie, 9 Jan 2018), the health impacts related to LFN associated with wind turbines were considered at length by the appointed Reporter (Mr M Croft). The Reporter considered evidence from Health Protection Scotland and the National Health Service. In addition, he also considered LFN surveys undertaken by the Appellant and the Local Authority, both of which demonstrated compliance with planning conditions and did not identify any problems attributable to the turbine operations; some periods with highest levels of low frequency noise were in fact recorded when the* ***turbines were not operating****.*

5.19. Grosvenor Consultancy's team has firsthand experience and expert knowledge, regarding this case. (Ref Para 3.5.3 Susan Crosthwaithe statement.)

The above statement by the Applicant although correct, actually highlights one of the failures of ETSU operational WTN conditions, to protect the Residential Amenity of those adversely impacted by WTN, particularly at the lower noise frequencies.

It is of profound interest, that Applicant correctly states:

> '*some periods with highest levels of low frequency noise were in fact recorded* ***when the turbines were not operating'***

5.20. In fact Rita Holmes, who at that time was one of the complainants and for information, continues to hold the position of Chair of Fairlie Community Council. Mrs Holmes provided substantive evidence of her experiences suffering from adverse impacts directly arising from the 2 Hunterston Turbines, at a Conjoined Inquiry Wind farm inquiry held in 2023, in respect of the planning Appeal case (PPA -310-2028) referenced by the Applicant at Para 3.2.7.

5.21. Mrs Holmes extensive evidence, which includes detailed background to the Hunterston case, is provided for reference at **(Annex 6)**. *'Hunterston National Offshore Wind Turbine Test Facility. Hearing Statement Rita Holmes._Chair of Fairlie Community Council'.*

This evidence is also of significant relevance to this proposal, due to the Applicant's referencing this Appeal case to support of their case.

We have provided extracts from **Annex 6** below, for ease of reference and to provide specific context to the statement that; '*when the turbines were not operating'.*

1. The National Offshore Wind Turbine Test Facility (NOWTTF) at Hunterston close to Fairlie in North Ayrshire was commissioned to test offshore turbines on shore. The initial planning consent for the operational testing was for a period of five years.

The two operational turbines at that time, were the largest wind turbines ever to be constructed on shore in the UK and were operational between December 2014 and October 2017. These comprised of a ***Siemens 6MW turbine and a 7.2MW Mitsubishi Sea Angel turbine to a maximum height of 198.5m.*** *The turbines were commissioned and operated by SSE.*

I am not a fan of nuclear power, but fully understand the need for safe and secure decommissioning and clean up, as well as the viable options. So, I was totally pro wind energy. I still appreciate its place in electricity generation, but I now do not support the push for larger more powerful wind turbines on land as I know the adverse effects that the non ionising radiation, i.e., Infrasound Low Frequency Noise had on my neighbours and me. My experience of the effects from the two huge wind turbines at Hunterston have made me realise that Wind Energy, like Nuclear Power has its severe and negative health impacts for those living within the range of the Infrasound Low Level Frequency sound pressure wave propagation, from large scale wind turbines.

Low frequency noise monitoring commenced on Thursday 20th October in Fairlie. This has been set up in response to a specific low frequency noise complaint raised by a local resident who is concerned that the low frequency noise is making them dizzy and having an impact on their health and balance. The equipment for this testing is likely to be removed during w/c 14th November and we anticipate that the results of this survey will be available in December. It was noted that during the recent testing the Mitsubishi turbine had been operating on a pretty intermittent basis.

My name is Rita Holmes, I have been a resident of Fairlie since 1972, enjoying robust good health and well used to noise from the unloading activities at the coal terminal jetty which is 900 Metres due west of us. I never had cause to complain about audible noise from the wind turbines, so the noise from the wind turbines, which I refer to as causing my symptoms, was below 20Herz and inaudible. I also had my hearing and balance tested when I first experienced symptoms. Apart from a few frequencies in the extremely high and low range, my hearing was fine and balance also.

Thankfully, they have now gone, as, during Covid 19, I would not have been able to escape. We never knew when the Mitsubishi Sea Angel would be operational, so in effect, there was no way of planning to be away from home, when it was operational. So, I took every opportunity to be away from home, staying overnight in the Central Hotel, visiting friends when I had meetings in London or Manchester and staying with relatives. My home became *unliveable in, when the wind turbines were turning. However, at least, I knew that my ill health was due to the wind turbines, many people did not and were left wondering what on earth was wrong with them. I did go to my doctor and tell him about the effects and how it definitely was the wind turbines.*

I did not have to see the turbines to know they were turning, I felt the effects of them turning immediately. I also knew, without seeing them, when they had stopped. When they turned I was ill, when they stopped I was fine and it had nothing to do with me being anti wind energy, or a NIMBY, in fact I am the opposite and do not mind them aesthetically. I know without any doubt whatsoever, that my symptoms were due to the wind turbines when they turned.

Please note that I use the term "turn" and not "operate" as the Company SSE tried to discredit my evidence by claiming, that on two occasions I had complained of detrimental effects, when the wind turbines were ***"non operational".*** *It emerged on investigation, that* ***"non operational"*** *did not mean that they were not turning. The wind turbines had been "idling". In fact, merely allowing the blades to idle in the wind was enough to produce ILFN, Infrasound Low Frequency Noise which can play havoc with the neurological system. The effects of ILFN from these large high power wind turbines were something one would not wish to happen to any other human being or living creature, so to hear that another community or person might have to put up with ill health due to large turbines near them fills me with fear for those people and anger at a system that allows the injustice of it, due to the lack of understanding from those with no experience of the severe effects and developers and their consultant acousticians who lie about the dangers from ILFN.*

5.22. It is important at this juncture we refer back to Mr WL Huson's evidence at Para 68:

The issue associated with the larger wind turbines is that they emit resonant infrasound tones in the presence of wind even when they are not rotating.

Indeed, due to the increasing length and essential elasticity of the blades in this case the Applicant is proposing blades at 75m in length (*Vestas V150 which has a 150m rotor diameter).* Basic physics and aerodynamics dictate that wind turbine blades resonate even when they are not rotating, or when idling as in this mode the blades are not fully stressed. A simple example of vibration resonances is in the tapping of a tuning fork.
It is beyond credibility, that even a student in acoustics or physics, are not familiar with this concept. (Figure 14a below, is an example of the flexibility and elasticity of unstressed wind turbine blades waiting for shipment).

5.23. In fact, Dr John Yelland in his November 2015 INWG WP1 Work Package: '*The Fundamentals of Amplitude Modulation of Wind Turbine Noise*'. **(Annex 7)** Examines the operational necessity for the elasticity of Wind turbine blades, the length of which have considerably extended by the wind industry since 1997. It is widely acknowledged and even stated by the industry, that this is to optimise and maximise the extraction of kinetic energy from any available wind passing over the blades to increase generation output over the past decades from under 1MW to 6- 7MW.

At the time of publishing Work Package 1 in 2015, the length of wind turbine blades were approximately between 30 - 45 metres.

Dr Yelland states at Para 3.3 which is extracted below in Figure 14:

'Because of the vast area of a modern turbine blade the acoustic power of the very low frequency noise can be considerable'.

5.24. It is also apparent this continued operational development, is without even acknowledging or fully understanding, the negative and adverse impacts on residents, who are effectively being compelled often against their free will and legitimate concerns to be wind turbine neighbours. We also urge the decision makers of this proposal to read in WP1 in full.

3.3 Transient Stall Pressure Pulses at Blade Zenith

When a blade stalls and loses the force of the wind it also rebounds due to its elasticity (see Figures 6 and 7), generating a sound pressure pulse at the BPF. Because of the impulsive nature of the rebound its harmonics reach up into the lower part of the audio spectrum, i.e. above 20 Hz. When the BPF is close to a blade resonance frequency, or a subharmonic thereof, the blade oscillation can build in amplitude. Thus transient stall generates very low frequency noise as well as increasing the level of aerodynamic noise. Because of the vast area of a modern turbine blade the acoustic power of the very low frequency noise can be

Page 9 of 32 11 November 2015

considerable. Its directivity differs from that of the aerodynamic noise; the blade acts as a dipole source, propagating equally upwind and downwind, although the wind shear still enhances the downwind propagation.

The higher nocturnal wind shear can thus increase peak wind turbine noise at night by three different mechanisms. In addition to the higher aerodynamic noise emission levels from the turbines from transient blade stall and higher noise immission levels at homes due to wind shear enhanced noise propagation there will also be very low frequency noise due to blade rebound and possible resonance.

Although blade stall has been described as transient most aerofoils have a hysteresis loop in their stall characteristic, in the case of turbine blades exacerbated by their considerable elasticity. The duration of stall is therefore a significant part of the blade passing period, as at zenith the vertical velocity component of the blade motion obviously passes through a minimum of zero.

Figure 14.
Extract: WP1 Dr J Yelland WP1 *The Fundamentals of Amplitude Modulation of Wind Turbine Noise*. Elasticity of Wind Turbine Blades.

Figure 6: Unstressed but considerably curved blades awaiting shipment.

Figure 14a.

Extract from WP1 Figure 6 demonstrating elasticity and flexibility of unstressed turbine blades awaiting shipment

Figure 15.

Photos of the controlled demotion of SSE's Siemens Offshore Test Turbine at the Hunterston Test Facility on 26 September 2019. Despite being granted consent Appeal Ref PPA -310-2028 - 9th January 2018 to continue operations for a further 2 years, both the Siemens and Mitsubishi turbines ceased operations prior to January 2018.

5.25. Moving on from responding in detail Applicant's statement at Para 3.2.7, with reference to the Hunterston Appeal ref (PPA -310-2028) we also submit substantive evidence at **Annex 8** IARO '*Commentary on "Wind turbine noise and human health impacts in Fairlie, North Ayrshire" produced by Health Protection Scotland, July 2017'.* in response to Para 3.2.8:

3.2.8 The Reporter concluded that:

- *The literature reviews by bodies with very significant responsibilities for the health of local people found insufficient evidence to confirm a causal relationship between wind turbine noise and the type of health complaints cited by some local residents;*

- *The NHS's assessment is that concerns about health impact are not supported by good quality research; and*

- *Although given the opportunity, the Community Council failed to provide evidence that can properly be set against the general tenor of the scientific evidence.*

5.26. In addition, Rita Holmes evidence at **(Annex 6).** '*Hunterston National Offshore Wind Turbine Test Facility. Hearing Statement Rita Holmes. Chair of Fairlie Community Council',* includes impact statements from local resident's adversely effected by the 2 Hunterston Turbines. These residents fully engaged with their local GP's and the NHS and Health Protection Scotland and received no assistance.

In fact Mrs Holmes states in evidence:

4. Does the Reporter's (PPA -310-2028) *<u>recommendations and decision in reality</u>, honestly reflect the background and outcome of this case that led to the halting of testing and operations of both of the offshore turbines at around the time of the appeal decision in January 2018?*

However, at least, I knew that my ill health was due to the wind turbines, many people did not and were left wondering what on earth was wrong with them. ***I did go to my doctor and tell him about the effects and how it definitely was the wind turbines.***

I did phone and write to ***Health Protection Scotland (now Public Health Scotland)*** *and despite them telling me that my symptoms might well be from ILFN they assured me that there was no evidence in the literature to prove this. I have since looked at the papers and studies on ILFN and wind turbines and I found empirical evidence from all around the world .* ***So no help from PHS, no help from Ayrshire and Arran Health Board who advised North Ayrshire Council and no help from the GP practice.*** *Our GP advised in writing that their insurance did not cover them if they got involved.*

I drove us into Largs, 5km away and we made emergency appointments to see a doctor. But, what can your doctor do for wind turbine symptoms...offer anti nausea pills, sympathy, but I did ask that I could register by phone when I was being affected. <u>The doctor also told me that Ayrshire and Arran Health Board`s claim at a North Ayrshire Planning Committee meeting that there was no epidemiological evidence was irrelevant and invalid as there was no code for GPs to register wind turbine symptoms for the Health Board statistics.</u>

5.27. *The IARO 'Commentary on "Wind turbine noise and human health impacts in Fairlie, North Ayrshire" produced by Health Protection Scotland, July 2017'* **(Annex 8)** was prepared on behalf of the Fairlie residents, in response to Burcote Wind Appeal against North Ayrshire Council refusing consent for 10 x 149.9m to blade tip turbines at the Rigghill Wind Farm nr Skelmorlie in North Ayrshire 5.28. The IARO Commentary was authored by Professor Mariana Alves - Pereria.

The introduction states:

1. *I have been asked to provide a commentary on the document produced in July 2017, by Health Protection Scotland (HPS), today Public Health Scotland (PHS) (Doc1). I have also been asked to include a review of three emails, exchanged between Mr. Paul Brennan (Environmental Health Officer, North Ayrshire Council) and Ms. Joy Tomlinson (Interim Director of Public Health, National Health Services of Ayrshire and Arran) on 27 May—5 June, 2020 (Doc2).*

2. *My area of expertise is the biological response to infrasound and low frequency noise exposure, in which I began working in 1988, integrated in a multidisciplinary team of medical scientists within the Portuguese Air Force. Although a copy of my CV as well as a list of Publications has already been submitted to the Reporters of this Appeal Hearing, I would like to reiterate my knowledge base for this subject matter: I hold a Bachelor of Science degree in Physics from the State University of New York at Stony Brook, a Master in Science degree in Biomedical Engineering from Drexel University in Philadelphia, PA., and a Doctorate degree in Environmental Sciences from the Nova University of Lisbon, Portugal.*

19. *This means that the research publication that was deemed "sound and reliable" by HPS, one in which "the findings add to the existing body of epidemiological evidence on the relationship between exposure to wind turbine noise and adverse health effects," admits that none of the 36 studies that were included in the systematic review covered infrasound and low frequency noise health effects.*

Is this not incongruent?

20. *Another incongruence emerges with the acknowledgement that:*

"Noise annoyance is not usually studied directly as a health outcome" (p. 7);

And yet, it is accepted that:

"There was evidence of a threshold effect with a reduction in reported annoyance with noise levels below 35 dB(A) (…) The main conclusions are that there is sufficient evidence to confirm that wind turbines noise increases the risk of annoyance and sleep disturbance; with risk increasing as noise exposure increased (a positive dose response relationship)" (p. 7).

21. *It is, to me, extraordinary that despite the acknowledgement that "noise annoyance" is not a usually studied health outcome, the use of "noise annoyance" is nevertheless accepted by a medical practitioner as a bona fide parameter to assess health effects caused by exposure to a physical agent of disease.*

Usually, it is the professional acousticians who insist on the notion that "noise annoyance" is an objective measure of human health, but medical practitioners are expected to know better.

T. Conclusions and Recommendations

81. *The institutions that, in Scotland, are mandated to protect human health against environmental hazards <u>self-report a lack of expertise in this scientific field when the environmental hazard is infrasound and/ or low frequency noise.</u>*

82. *As a result, they are unable to carry out and implement their obligations which include surveillance and monitoring of environmental hazards.*

83. *<u>Consequently, Scottish citizens with environmental health complaints that are suspected of being related to excessive exposure infrasound and low frequency noise (whatever the source) go ignored, and often even ridiculed.</u>*

84. *Since it is the health of Scottish citizens that is at play here, and since HPS/PHS has admitted to its lack of expertise of this subject, this would be my first suggestion to the appropriately competent decision-makers—a fairly inexpensive first step that could provide invaluable epidemiological data (if properly done):*

Implement a mandatory notification rule for all Medical Practitioners (General Practitioners in particular) so that all patients exhibiting specific signs and symptoms suspected of being related to 'noise' exposure could be formally counted and associated with a specific geographic location and/or occupation.

85. *My second suggestion would be to the Reporters of the Appeal Hearing, to uphold the decision by North Ayrshire Council which denied permission for the installation of the Rigghill wind power station.*

5.29. Our respectful professional position, is that the above Conclusions and recommendations are also relevant for urgent consideration and adoption by the commensurate Public Authorities in Ireland, especially as consents for even larger scale turbines are being sought alarmingly close to rural residents.

5.30. The applicant then concludes the topic at Appendix 12.2 at Para 3.2.13:

Para 3.2.13 *It is therefore not considered necessary to carry out specific assessments of LFN and it has not been considered further in the noise assessment.*

5.31. At this juncture, we consider it is important to reference in further support of our evidence and case, the published peer reviewed **Annex 9 *Chapter Infrasound Exposure: High-Resolution Measurements Near Wind Power Plants.*** Huub Bakker, Mariana Alves-Pereira, Richard Mann, Rachel Summers and Philip Dickinson.

The Abstract, introduction and conclusion have been included here, but it is essential that the decision makers for the Seskin Wind Turbine proposal, read the whole chapter.

Abstract

This chapter focuses on infrasonic (20 Hz) noise exposure as captured in and around homes located in the vicinity of wind power plants. Despite persistent noise complaints by local residents, no satisfactory acoustical event has yet been identified to justify this troublesome (worldwide) situation. Continuous (days), high-resolution recordings—spectral segmentation of 1/36 of an octave and 1-second temporal increments— have been acquired in many homes across the world revealing the presence of wind turbine acoustic signatures. These consist of trains of airborne pressure pulses, identified In the frequency domain as harmonic series with the fundamental frequency equal to that of the blade-pass frequency of the wind turbine. This report documents three such cases (Portugal and Scotland). The highest peaks of the wind turbine acoustic signature (up to 25 dB over background noise) occurred within the 0.5–5 Hz window which is classically defined as below the human hearing threshold; and yet these 'inaudible' phenomena appear to trigger severe biological reactions. Based on the prominence of the peaks in the harmonic series, a new measure is proposed for use in determining dose–response relationships for infrasonic exposures. This new methodology may be applicable to infrasonic exposures in both environmental and occupational settings.

Introduction

Hearing loss, speech intelligibility and noise annoyance are some of the most studied impacts of noise exposures on human health and well-being. A common denominator of these three outcomes is the audibility of the sound. Exposure to loud noise over extended periods of time can cause hearing impairment; noisy environments can interfere with the correct understanding of speech; and certain types of continuous or intermittent sounds can cause people to feel annoyed by noise, which can, in turn, exacerbate underlying disorders or diseases. There are, however, additional features of sonic environments that are unrelated to the human audibility of sound, but that can also deleteriously affect human health and well-being, specifically, infrasound (20 Hz).

Conclusions

This chapter provides a different approach to the measurement and analysis of infrasound in and around homes located in the proximity of wind power plants. Examples show how using higher temporal- and spectral-resolutions (1 second and 1/36 of an octave), and without any frequency weighting, can reveal acoustical features in the infrasonic range that may indicate a causal relationship with self-reported medical symptoms. This possibility is usually considered non-existent since the infrasonic range is generally viewed as inaudible, and thus innocuous, to humans. The suggestion therefore arises that *current noise protection procedures are insufficient to protect public and occupational health. The approach used by these authors offers a more solid framework with which to pursue the establishment of dose–response relationships for infrasonic exposures. Future studies are being extended into noisy occupational environments and different environmental settings, where wind power is not the acoustic source.*

5.32 We also introduce, **Annex 4 *Clinical Protocol for Evaluating Pathology Induced by Low Frequency Noise Exposure .*** This paper was submitted at Euro Noise 2015 31 May - 3 June, Maastricht.

Extracts from final Para:

5. Looking Forward.

In the interest of becoming a responsible and mature human society, activities that are deleterious to human health and wellbeing should not be hidden, obfuscated, or otherwise camouflaged. History unequivocally demonstrates the benefits of dealing outright with any potential human-health issue. It is recognized that the production of electrical energy has become the warp and woof of modern societies, and hence the urgency to procure new ways of harvesting energy that can be rapidly (and inexpensively) transformed into electrical energy. There need not be, however, such antagonistic, acrimonious and spiteful endeavours between ILFN disturbed families and industry, be it in of the energy, transportation, military, entertainment or manufacturing sectors of society......... It is hoped that this report will contribute to a symbiotic relationship between the ILFN-generating industries and world citizens.

5.33. The Applicant's Appendix 12.2 Section 3 *Amplitude Modulation of Aerodynamic Noise* (AM) considers this topic between Para's 3.3.1 to 3.3.14. Grosvenor Consultancy as a founder Member of the INWG are fully conversant with the concerns regarding AM and during 2015 INWG submitted extensive evidence in the form of Work Packages; (indeed Dr Yelland's WPI referenced above, was part of our studies) prior to and in response to the WSP Parsons Brinkerhoff report referenced at the Applicant's Para 3.3.7.

3.3.7 Their report (17), 'Wind Turbine AM Review – Phase 2 Report' was published in August 2016 at the same time as the release of the IOA AMWG Final Report, and concluded that there is sufficient robust evidence that excessive AM leads to increased annoyance from wind turbine noise and recommended that excessive AM is controlled through a suitably worded planning condition, which will control it during periods of complaint

5.34. It is not our intention to review in detail the Applicant's Section 3 AM at this stage, or any proposed AM planning condition due to time constraints, but if required to do so at a later date, we would be able to respond in detail acknowledging that the published decision date for this proposal is relatively short at 7 July 2024.

This also applies to an extensive review of the Applicant's Operational WTN Methodology, especially regarding Cumulative Noise, although we will briefly highlight our considerable concerns later in this submission at Section 8.

5.35. It is however incumbent on us to respond to what appears to be carefully crafted and sanitised Para 3.3.13 below, which omitted to comment on the full extent of the adverse impacts reported by Justice Emily Egan's Irish High Court Judgement.

*3.3.13 Persistent OAM can be a source of nuisance to wind farm neighbours. Indeed, in a recent decision of the Irish High Court on the 8th of March 2024, the court found that frequent and sustained periods of OAM arising from the operational Ballyduff Wind Farm was an unreasonable interference with a neighbour's use and enjoyment of their property which was located approximately **359 m** from the nearest turbine. The issue of damages and/or an injunction were held over for later determination by the court but in the meantime, the court directed all parties to engage in mediation with a view to devising 'appropriate mitigation measures and if possible, to resolve all outstanding issues between them'. In summary, therefore, where OAM arises mitigation is possible and is the appropriate response.*

5.36. *We take this opportunity to reiterate our Para 3.3 above:*

*The JUDGMENT of Ms. Justice Emily Egan delivered on the 8th day of March 2024, found in favour of the Plaintiffs, but extracts from this Judgement show **(Annex 2)** cannot be relied upon to protect the amenity of any neighbouring residents to the proposed Seskin wind turbine development, in the event of any complaints of WT Noise nuisance. Likewise, in our professional judgement this also applies to the consented Bilboa and White Hill Farm wind turbines.*

5.37. Justice Emily Egan's 195 page Judgement (**at Annex 2a**) records the serious impacts from both audible WTN. some of which is attributed to OAM, but also Low Frequency Noise which Para 3.3.13, the Applicant notably makes no reference:

Para 9 of the Judgement is materially relevant, when considering the nature of wind turbine noise victim's consistent reported complaints;

Ms Justice Emily Egan reports:

9. Wind turbine aerodynamic noise is typically broadband in nature in the sense that it is evenly distributed across the frequency spectrum; but it can <u>exhibit lower frequency content</u>. <u>Sound with significant lower frequency content is both more intrusive and less effectively attenuated by barriers such as windows, walls and insulation.</u>

5.38. The Judgement's Introduction states:

Introduction 1.

*The plaintiffs are two couples[1] who claim <u>they have been interfered with, over a substantial period of time, in the use and enjoyment of their homes,</u> at Ballyduff, Enniscorthy County Wexford. The claim is for private nuisance in the form of noise **and vibration** generated by two nearby wind turbines, owned and operated by the defendant. The plaintiffs also complain of shadow flicker.*

*2. Ms. Webster and Mr. Rollo ("the Webster Rollos"), own Hill House (HH), and until recently Ms. Carty and Mr. Shorten ("the Carty Shortens") owned Nettlefield (NF). The nearer of the two turbines, Turbine 2, ("T2") is located some **359 m** from the Carty Shorten house and some **369 m** from the Webster Rollo house and the further turbine, Turbine 1, ("T1") is some **652 m** from the Carty Shorten house and some **655 m** from the Webster Rollo house.*

5.39. As Annex 2 includes salient comments from the Judgement and as this objection is already lengthy, we have limited the extracts to those below.

<u>How often the noise occurs and the time of day or night when the noise occurs</u>

I accept the evidence of the plaintiffs' experts and the plaintiffs themselves that the conditions so demonstrated occur commonly and on a sustained basis. I also accept that these unreasonably intrusive conditions are particularly prevalent during the most sensitive times of the day; in the early morning and at night and in the evenings.

51. *.... Ms. Webster recounts that when the noise and vibrations from the turbine are intense, she experiences a feeling of anxiety and overall unease that she cannot shake off.*

52. *Ms. Webster's evidence was that, when turning quickly, T2 emits a range of distinctive sounds. In addition to a swishing sound, it emits whoomph and whump sounds and intermittent louder thumping or whacking noises. These sounds are often accompanied by disturbing vibration, meaning that she could regularly "feel" as well as hear the noise. This is perceived as pressure coming from the air as the blades rotate, which feels like "a pummelling inside [her] body". All of this, Ms. Webster states, is a frequent characteristic of the WTN, particularly at night.*

55 However, without such masking noise, one can hear the WTN in all areas of the house, The WTN frequently intrudes to the extent that Ms. Webster finds it difficult to concentrate or relax. At its worst, and particularly at night, Ms. Webster described a sensation of being able to hear and feel every rotation of the turbine. Ms. Webster accepted that other sounds - such as passing cars or farm machinery might also occasionally be heard in her bedroom with the window closed. However, such noise ceases at a certain point in the day. By contrast, when it is turning rapidly, the noise and vibrations of the turbine intrude into Ms. Webster's bedroom, even when the window is closed, on a "24/7" basis.

56 . It was put to Ms. Webster that the defendant's experts would say that it was "beyond the realm of physics" that the WTN could be heard in the master bedroom at the front of HH, but the defendant's experts did not give such evidence. Although Mr. Carr did not hear WTN in the master bedroom of HH at the time of his site visit, he only spent between five and ten minutes in the bedroom on this occasion.

57 Ms. Webster's evidence was that the WTN and vibrations pass through the gable wall into the master bedroom. She stated that, in her experience, the WTN was much louder, more annoying and more easily audible than it appeared on the internal audio recordings taken by her experts in HH in2017 and 2020/2021.

Impact on the Webster Rollo relationship

65. Ms. Webster's evidence was that after a few years of living with the turbine, her 16 year relationship with Mr. Rollo started to disintegrate. In Ms. Webster's viewthe pervasive 24 noise and ongoing lack of sleep caused by the WTN was a significant factor in the destruction of the relationship. Her belief is that the WTN brought the couple to the stage where they were both so exhausted, discouraged and low that they could no longer fight for the relationship. Ms Webster was worried for Mr. Rollo's safety and well-being, and she suffered episodes of panic and tearfulness.

Mr Rollo's evidence:

80 ..... Mr. Rollo stated that, even with the windows closed, and despite wearing professional noise cancelling headphones, the noise and vibrations caused by the turbine still disturbed his sleep. Like Ms. Webster, Mr. Rollo's sense is that the noise and vibrations come though the walls of the house. At times, the whole house vibrates with the noise. As a result, all attempts to mask the WTN using both professional noise cancelling headphones and industrial earplugs (which he had obtained from work) were unsuccessful ***because, he could still feel the noise "through my bones".***
Emphasis added .

Evidence of Ms. Joan Carty and Mr. Ross Shorten

85. Ms. Carty and Mr. Shorten owned NF until comparatively recently and sold it to Ms. Maura McGinn in August 2021 (as to which see further below). Ms. Carty described the range of sounds emanating from the turbine, the most difficult and intrusive of which is a loud whomping or thumping sound with associated reverberation and vibration. This loud whomping and thumping noise is very hard to listen to for any period of time and is audible from every room in the house. Mr. Shorten's evidence was to a similar effect; he recounted that the noise, the vibration and the sense of pressure in the air are overpowering and upsetting. All of the above emphasis' from the extract are added.

Evidence of Ms. Ashley Doran

98. *Ms. Ashley Doran lives at Ballyduff. Ms. Doran's house is located 313 metres from the Webster Rollo's house. There is a distance of* ***601*** *metres between T2 and Ms. Doran's house and a distance of* ***808*** *metres between T1 and Ms. Doran's house.*

99. *Ms. Doran stated that the turbines make a deep, heavy reverberating noise which she describes as groaning and whomping sounds. Reverberations are experienced both inside and outside the house. The WTN is disturbing and disorientating making it hard to focus or concentrate. On occasion the intensity of the sound and vibration makes her dizzy and queasy. At times, the sound of the turbines hurts her ears. It is difficult to cope with the inconsistency of the WTN which varies from "quiet" to "thunderous" depending on the meteorological conditions. The WTN disturbs her sleep and Ms. Doran has started sleeping in the room furthest from the turbine. Both she and her husband sleep with earphones which they use to mask the sound of the turbines. Overall, although Ms. Doran's husband, finds the turbine "a bit annoying" he manages to put it out of his head and get on with things.*

6. Wind Turbine Acoustic Pollution propagation, over longer distances.

6.1. It is also of considerable concern, that there is a lack of consideration or awareness of substantive evidence of the lengthy propagation distances of Infrasound and Low frequency wind turbine acoustic pollution. At Para 5.10 Mr Huson states:

> 92 *Infrasound measurements from a residence located* ***5.4km*** *away from the nearest turbines in the Macarthur array of 140 V112-3MW units and 1.3km away demonstrate very little infrasound attenuation in the near field and that the infrasound levels at this distance (****5.4km****) are comparable to those reported by Kelly(1982).*

Mrs Rita Holmes states in her evidence, (Annex 6).

> *The effects of the two wind turbines at Hunterston could be felt as far away as the north end of Largs which is approximately 10km from Hunterston.*

At Para 5.9 it was noted that:

1. *There are five Wind Power Plants (WPPs) within 7 km of the Rural Sheep Farm. According to Mr & Mrs. Z and the other Rural Farm residents, however, severe health deterioration only began after the installation of the WPP A, adjacent to their property.*
2. Yet the SAM monitoring identified BPF of the five models of wind turbines used at the neighbouring WPP at a <u>7km distance</u>.
3. *The BPF is specific to each wind turbine model under full-speed operation, although determining what the BPF is and whether the turbines are running at full speed is problematic. At Rural Sheep Farm several BPFs were identified consistent with the five models of wind turbines used in the neighbouring WPPs, including the A WPP.*

6.2. At Para 2.18 we reference the Applicant's LVIA that:

> *'<u>There are two substantial population centres within **5km** of the Proposed Project, Oldleighlin and Ballinabrannagh</u>. The closest District Town to the Proposed Project is Bagenalstown which is 9.6km to the southeast of the Proposed Wind Farm; Castlecomer is another District Town which is located 10.2km to the west of the nearest Proposed turbine (T01). Carlow Town is located 10.8km from the nearest Proposed turbine (T02)'.*

This is of significant material concern given that as previously stated, the proposed large scale wind turbines at Seskin are to be located between White Hill and the Bilboa turbines, which effectively fill the gap between the operational Gortahile turbines, thus creating combined clusters of 26 turbines, as identified in the Applicant's Figure A1 IA Cumulative Wind Farm Locations map.

6.3. As previously stated at Para 2.18, with regards to **Annex 1:** *'The health effects of wind turbine infrasound based on its propagation on the people in the surroundings of wind turbines in Finland.'* A *Pilot study shows no significant reduction in damage caused by infrasound until more than 15 kilometres from windfarms.*

6.4. Extracts from this study state:

1.6 *There was no significant p-value for the damage increasing directly according to the distance (km) in the statistical analysis. The significant p-value was reached for the damage according to the map model describing the total exposure. In addition to that, symptoms were explained by person's gender and age. Other background variables did not explain the symptoms statistically significantly.*

1.7 *The most typical symptoms were sleep disturbance or change in the need for night's sleep, fatigue and various pains.*

1.8 *The results of the study show that there were remarkably more harmful health effects caused by the wind turbine infrasound in the exposure zones 1–2 of the map model than further away. The most important result of this study is that the risk distance grows if the height, amount or efficiency of the wind turbines increases or with time in a long-term exposure. This means that the risk distance depends on the circumstances. In the areas with wind turbines around the residential area there were harmful health effects as far as about 15–20 km from wind turbines, under the circumstances when this pilot study was conducted.*

4.6 ***3. Survey****. A study commissioned by the Government showed that infrasound-induced sleep disturbances and severe or extreme indoor disturbances were four times more common in wind power areas than road traffic-induced sleep disturbances in general [3].*

4.7.10. *More and more high-capacity power plants are planned in Finland, which will inevitably lead to serious social and health problems and rising costs throughout the country. A large number of families have already been reported in Finland who have had to leave their homes due to the health effects of wind power, and there are even more who would move away if it were financially possible. Negative developments are also visible in our indicators of well-being. As infrasound exposure worsens, the safe environment also decreases all the time.*

7. Danish Doctors Evidence Annex 10.

7.1. We also draw attention to further empirical research from Demark (**Annex 10**). ***'A third of Groningen villages visit the doctor because of complaints about wind turbines'***

7.2. We consider It is off high significance that local medical Doctors are reporting the following concerns and noting that these are in direct response to a Wind Turbine Noise Health Study by the '*Netherlands Institute for Health Care Research'*, identified as the '*Nivel' report.*

Extracts from Annex 10:

Van Manen, like colleagues approached by AD , is therefore outraged by a recent *Nivel report*, which claims just the opposite. According to the *Netherlands Institute for Healthcare Research*, between 2012 and 2021, general practitioners did not diagnose acute or chronic health problems more often in people living near wind turbines than in people further away.

"Blob work," says former general practitioner and epidemiologist Dick Bijl about the Wind Turbine Health Outlook study. *'Nivel* looked at a connection between postal code areas ***and the codes** with which general practitioners register the diagnoses of their patients. *"Methodologically there is a lot to comment on. You really cannot draw this conclusion,"* says the scientific advisor of the doctors' collective Wind Wiki.

But according to GP Anneke Bodde from Denekamp, politicians and administrators *'suffer from tunnel vision'. "I am very concerned about how the government is working. The only goal seems to be the installation of wind farms.* *<u>While it has been proven that constant noise increases the risk of cardiovascular disease.</u> Yet only the favorable studies are selected."*

7.3. Comment: The above statement "*<u>While it has been proven that constant noise increases the risk of cardiovascular disease".</u>* is confirmed by the WHO extracts at Para 5.2 above. Also at Annex 4. *b) the physiological pathways responsible for inadequate quality of sleep, for hypersensibility and intolerance to sound, and for cardiovascular disease.*

Many are at their wits' end. Pet: "*The insomnia leads to stress, anger, fatigue and increased levels of irritation and alertness. Parents complain about unruly children and learning delays. I see arguments, depression and suicidal tendencies". But despite all the cries for help from politicians, nothing is improving. As a doctor I feel powerless."* As a human being he is sometimes *'fierce'*.

7.4. Comment: The above statement sleep disturbance re; "*The insomnia leads to stress, anger, fatigue and increased levels of irritation and alertness"* is confirmed by WHO at Para 5.3, the Irish High Court Judgement at Para 5.35 & extracts at Para 65, 80 & 99. Note there are other references which have not been included in both Annex 2 extracts and Annex 2a the full High Court Judgement. The Finish study Annex 1 and at Para 6.4 & the extracts from the study at sub Para's 1.7 & 4.6.

According to Bodde and her colleagues, the **ICPC codes used in the Nivel** study are not at all suitable for scientific conclusions. *"I can write down complaints such as anxiety or sleep problems under many different codes. At the same time, the system is not detailed enough to indicate whether a diagnosis is related to nuisance caused by wind turbines."*

7.5. Comment: The above statement is confirmed by Rita Holmes in Annex 6: '*The doctor also told me that Ayrshire and Arran Health Board`s claim at a North Ayrshire Planning Committee meeting that there was no epidemiological evidence was irrelevant and invalid as there was no code for GPs to register wind turbine symptoms for the Health Board statistics'.*

Also referenced at Para 5.26, Ref Annex 8 - Sub Para 84. *'Implement a mandatory notification rule for all Medical Practitioners (General Practitioners in particular) so that all patients exhibiting specific signs and symptoms suspected of being related to 'noise' exposure could be formally counted and associated with a specific geographic location and/or occupation'.*

Flevoland general practitioner Paul Kemps is also not happy with the Nivel study. ***In the past, wind turbines in the agricultural municipality of Dronten were located far away from the four residential areas. In recent years, dozens of turbines of more than 200 meters high have been built, including one row close to the village of Swifterbant.***

It shows in a nutshell what he believes is lacking in the report. *"The Nivel looks back ten years. But at that time, windmills were a lot smaller and located further away from residential areas. This study has no predictive value whatsoever, nor for what is happening now,"* the doctor warns.
Kemps experiences 'a general picture of unrest and dissatisfaction' among some of his patients. *"One person says it 'drives him crazy', others continuously hear a hum in the house and still others continuously lower the shutters. The nuisance is horrible and there is no solution. Yes, shut down those turbines. But that doesn't happen."*

7.6 Comment: Applicant reference dated studies, which the majority of Developers consultant acousticians constantly emphasise in their Operational WTN assessments. Annex 4: *However, upon a closer examination, significant design flaws rendered most of these studies useless [31, for example]. While this may not have been a concerted effort, it is however a consequence of the perpetuation of an historical fact: acousticians, usually with no medical background, are generally greatly involved in noise-impact study designs.*

In Meeden, the hum also regularly keeps GP Pet awake. Yet he does not want to emphasize that. *"I don't want to be the cause of polarization within our village.* ***The farmers on whose land the turbines were placed were also never able to know this in advance****."*

7.7 Comment: We draw attention to our previous Para 2.12:

It is also of note that this Applicant's statement, advises that the 5 NAL receptors listed above, are identified as involved landowners. However, whether financially involved or not, wind turbine acoustic pollution, cannot be emolliated by any apparent contractual involvement with the Applicant.

It is also of increasing concern that involved landowners or others, who maybe contractually involved without prior knowledge of the potential for adverse WTN are likely to be excluded from raising subsequent complaints, once wind turbines commence operations.

8. Review of the Applicant's Cumulative WTN limits.

8.1. It is important to note that as previously discussed in detail, the WEDG and ETSU WTN limits as required are applied in dBA which does not represent the whole acoustic pollution immissions generated by operational wind turbines.

Appendix 12.2 The Executive Summary states:

> *The NALs were chosen to represent the noise sensitive receptors located closest to the Proposed Wind Farm. The modelling results for the NALs has been presented within the main body of this report whilst an assessment for all NSRs has been included within an Annex to the report. For the assessment locations where no background noise measurements were undertaken, noise data collected at proxy locations deemed representative of the expected background noise environment was used to assess the wind turbine noise impact at those receptors. For clarity all NSRs are also labelled with the letter 'H' (Houses) within the rest of the Environmental Impact Assessment Report (EIAR).*
>
> Two sets of noise limits have been derived; the Total WEDG Noise limits apply to the cumulative noise level of all turbines operating in the area including the Proposed Project, whilst the Site-Specific Noise limits apply to operational noise from the Proposed Project only.

8.2. Furthermore, the Applicant states:

> *Based on the guidance in the WEDG 2006, at the majority of NALs, the daytime Total WEDG Noise Limit was set at 40 dB(A) where background noise levels were <30 dB, and 45 dB(A) or background plus 5 dB whichever is the greater where background noise levels were >30 dB. The night time Total WEDG Noise Limit has been set at 43 dB(A) or background plus 5 dB whichever is the greater. At NALs where noise limits have already been set due to the nearby permitted Bilboa Wind Farm and White Hill Wind Farm, the consented noise limits included within the planning conditions for the wind farms were used to set the Total WEDG Noise Limits.*

8.3. and that:

> *A cumulative assessment was undertaken at the NALs where predictions from the Proposed Wind Farm were found to be within 10 dB of the noise predictions from all other wind farm developments. The assessment of likely cumulative noise levels undertaken at the NALs shows that the Proposed Wind Farm can operate concurrently with the other wind farm developments in the area, whilst meeting the Total WEDG Noise Limit, at all NALs. At NAL15 a marginal exceedance was initially predicted in full mode for a candidate turbine during the daytime period at 6 ms-1 (0.7 dB) but predictions in this assessment have been reduced assuming mitigation in the form of mode management, in order to ensure that the cumulative noise predictions (**from the combined operation of all schemes detailed above**) operate within the Total WEDG Noise Limit NALs 4-6 were assessed separately due to existing noise limits and being in very close proximity to the permitted Bilboa Wind Farm, these are discussed further below.*

8.4. We consider that is unacceptable at this stage of planning, to propose any mitigation in the form '*of mode management*' for any of the operational turbines as this indicates that the Applicant is drawing attention to potential WTN limit exceedances, once all of turbines are in full operation.

8.5. Given our past experience, as previously referenced:

1. The BPF is specific to each wind turbine model under full-speed operation, although determining what the BPF is and whether the turbines are running at full speed is problematic. At Rural Sheep Farm several BPFs were identified consistent with the five models of wind turbines used in the neighbouring WPPs, including the A WPP.

It will be problematic to accurately identify any operational exceedances from specific turbines, in the event of any complaints from any of the local residents. We consider there will be a lack of control available to the Council, as the Environmental Health Department will find that it will be also problematic to apportion accurate levels of noise exceedances to particular turbine/s that are non compliant in one or more of the four operational wind farms, especially due to the close proximity of each of the turbine clusters.

8.6. Furthermore, the Applicant proposes a '*Backstop Noise Limits'* option:

> *At NAL4, NAL5 and NAL6 (located between the permitted Bilboa Wind Farm and the Proposed Wind Farm) noise limits for the permitted Bilboa Wind Farm have already been established. On that basis, a Cumulative Noise Condition has been proposed for these receptors whereby the Proposed Project would be conditioned to ensure that the cumulative wind turbine noise from the combined operation of the permitted Bilboa Wind Farm and the Proposed Project would be below the Cumulative Noise Limit (equal to the Total WEDG Noise Limit). In the event that noise from the permitted Bilboa Wind Farm increased to use a greater amount of the Cumulative Noise Limit than predicted, then the Proposed Project would then need to operate to a proposed set of more restrictive Backstop Noise Limits, which in this case would be more restrictive and potentially require a combination of low noise mode and switch off in specific wind conditions (if backstop is triggered).*

8.7. We are totally opposed to this unsound and unsafe proposition, which deeply concerning. In our expert opinion, the proposed *Backstop Noise Limits*, are considered to be further material grounds for the refusal of the Seskin proposal.

8.8. We raise the material question, how would the '*Backstop Noise Limits'* be monitored by the Council, as we respectfully consider it could be difficult to enforce against either the Seskin or Bilboa wind turbine operators, as which particular wind turbine operator would be deemed to be responsible, in the highly probable event of WTN complaints.

It should not be the responsibility of the complainant to indicate which turbines they consider maybe the cause, or source of any potential WTN nuisance.

8.9. It is abundantly clear that the proposed location of Seskin WPP is cumulatively unacceptably close to both the combined Gortahile, Bilboa and the White Hill Farm wind turbines.

8.10. We also note that the Applicant states at:

> *5.5.2 The closest operational wind farm to the NMLs is the existing Gortahile Wind Farm which is over 2.5 km away at its closest point and was not heard during site visits. The contribution to overall background noise levels from the existing Gortahile Wind Farm at the NMLs used for this assessment is judged to be negligible and therefore this has not been considered further.*

In terms of the ambient background noise levels this approach is valid. However, the confirmation of a Gortahile separation distance of 2.5 km from the nearest proposed Seskin turbine is informative, in respect of the cumulative noise impacts, especially given that the consented Bilboa Wind turbines are located between Gortahile and Seskin. Each of the operators of the 4 wind turbine clusters are separate commercial entities and therefore, as previously stated, are likely to seek to protect their own commercial interest in maintaining maximum generation capacity at all times.

9. Conclusion.

9.1. At the outset of this submission on behalf our clients, we stated at Para 2.2:

> 2.2 The extent of these concerns are such, that we have no alternative to conclude that in the light of the information contained in Appendix Table 1.1 *Cumulative Wind Farm Developments* and Figure A1 1A *Cumulative Wind Farm Location*, and the assessed risk of adverse residential amenity impacts, it would be irresponsible for Carlow Community Council to consent the proposed Seskin Wind Turbines, which clearly would occupy the open land between the consented Bilboa Turbines and White Hill Farm Turbines.

9.2. We have significant concerns that any potential adverse impacts arising from the cumulative operation of the Gortahile, and consented Bilboa and White Hill Farm wind turbines are unknown, especially given that is clear that the Applicant has sought to justify their proposal on the grounds, that the population is of low density and therefore, by definition the residential amenity of the current residents is of reduced value or consideration.

9.3. Our position is that it is therefore, unacceptable for the Seskin proposal to be consented, without first assessing the potential cumulative WTN impacts on the local residents from the Gortahile, Bilboa and White Hill Farm, **with all of these consented and operational wind turbines in full operation**.

9.4. It is also of considerable concern, that the Applicant's Cumulative WTN Assessment appears to be in error. The Table 1.1 *Cumulative Wind Farms* in respect of the consented White Hill Farm WTN immissions, specifies 7 Vestas V162 6.2 MW turbines at 100m hub height.

At Para 4.10 whereas, the specifications provided by our clients state that these are, 7 Turbines with a hub height of 104m a rotor diameter at 162m and with an output of 7.2MW.

9.5. It is of note that the consented Bilboa and White Hill Farm Wind Turbines are considerably larger and more powerful than the operational Gortahile Wind Turbines. It is also of note that the proposed Seskin turbines, are also larger and more powerful.

9.6. It is also of considerable concern, that the separation distances and number of local residents from the proposed Seskin Turbines, as detailed at Para 2.15, have been confirmed as 41 residences between 720m and 999m, and a additional number of 63 between 1004m and 1550m. We do not consider that this of a particular low density, to justify a further large scale cluster of operational wind turbines. We would fully appreciate the fact that many of these residents would be legitimately concerned regarding unacceptable adverse impacts on their residential amenity.

It is our substantive case that, given the expansive evidence we have presented, these residents are at risk of Wind Turbine acoustic pollution from both audible WTN and ILFN.

9.7. We note that the Applicant has submitted Appendix 5.1 *Wind Farm & Health Literature Review Chapman 2015.* The content of which seeks to undermine and discredit the reported adverse impacts by effected residents.

We also note that this Appendix is dated 2015, which again is prior to the Wind Industry collectively substantially increasing the size of their turbines.

However, due to the short time we have been provided to prepare this objection, we have not had the opportunity to review this Appendix in detail. If required with an agreed time extension, we would be prepared to respond in detail.

9.8. However, in response to Appendix 5.1, we refer to Annex 2 & 2a: The JUDGMENT of Ms. Justice Emily Egan delivered on the 8th day of March 2024, which found in favour of the Plaintiffs.

this states at Para 78:

78. Overall, I find that Ms. Webster's diary entries, like her oral evidence, presented a balanced and truthful account of her experience of the WTN. I make a similar finding in relation Mr Rollo's diary entries up until mid to late 2020[13].

9.9. We also directly reference Annex 10.This highlights deeply concerning statements from front line Danish Medical Practitioners, faced with assisting their patients. Their concerned statements are consistent with the evidence we have presented throughout this objection.

9.10. It is clearly apparent that Wind turbine developers and their consultants, are applying the ETSU R 97 1999 Guidance and its derivatives to constantly and sequentially maximise wind energy generation capacity and therefore, output.

9.11. Regretfully, it is also clearly apparent that this is without undue consideration of the serious consequences to vulnerable wind turbine '*neighbours*' adversely impacted by WTN. Our statement at Para 4.3 concerning the Applicant Para 2.6.5 is clearly evident, that this is the case:

4.3 Yet whilst appearing to be even handed and even considerate, in seeking to; '*offer a reasonable degree of protection to wind farm neighbours*' there was an over- riding caveat as highlighted at Para 2.6.5:

ETSU-R-97 makes it clear from the outset that any noise restrictions placed on a wind farm must balance the environmental impact of the wind farm against the national and global benefits that would arise through the development of renewable energy sources:

'The planning system must therefore seek to control the environmental impacts from a wind farm ***whilst at the same time recognising the national and global benefits that would arise through the development of renewable energy sources and not be so severe that wind farm development is unduly stifled.'***

9.12. Finally, it is completely unacceptable for the Applicant to consider at Para 3.3.13; that in the event of unresolved WTN complaints; as in the Ballyduff wind farm case that wind turbine neighbours, '*who claim they have been interfered with over 'a substantial period of time'*, who appear to have effectively been forced as a final resort, to pursue a highly costly and traumatic Private Nuisance case against wind turbine operators, up to the High Court.

For the Applicant to consider that: *this is an appropriate response to resolve all outstanding issues between them,* is unconscionable.

> *3.3.13 Persistent OAM can be a source of nuisance to wind farm neighbours. Indeed, in a recent decision of the Irish High Court on the 8th of March 2024, the court found that frequent and sustained periods of OAM arising from the operational Ballyduff Wind Farm was an unreasonable interference with a neighbour's use and enjoyment of their property which was located approximately 359 m from the nearest turbine.* ***The issue of damages and/or an injunction were held over for later determination by the court but in the meantime, the court directed all parties to engage in mediation with a view to devising 'appropriate mitigation measures and if possible, to resolve all outstanding issues between them'. In summary, therefore, where OAM arises mitigation is possible and is the appropriate response.***

9.13. Especially, as Justice Emily Egan's High Court Judgement records that:

> *The plaintiffs are two couples[1] who claim they have been interfered with, over a substantial period of time, in the use and enjoyment of their homes,*
>
> *65. Ms. Webster's evidence was that after a few years of living with the turbine, her 16 year relationship with Mr. Rollo started to disintegrate. In Ms. Webster's view the pervasive 24 noise and ongoing lack of sleep caused by the WTN was a significant factor in the destruction of the relationship. Her belief is that the WTN brought the couple to the stage where they were both so exhausted, discouraged and low that they could no longer fight for the relationship. Ms Webster was worried for Mr. Rollo's safety and well-being, and she suffered episodes of panic and tearfulness.*

9.14. We repeat, that we consider that consenting the proposed Seskin wind farm would create an unacceptable risk of adverse WTN impacts to the local resident's Residential Amenity.

END.

Supporting Annex's.

Annex 1 Finnish Study *Pilot study shows no significant reduction in damage caused by infrasound until more than 15 kilometres from wind farms*

Annex 2 & 2a Extracts from and full JUDGMENT of Ms. Justice Emily Egan delivered on the 8th day of March 2024.

Annex 3. **INWG responds to WSP Report 15 April 2023,** ***"A review of noise guidance for onshore wind turbines"***_ Annex

4. IARO *Clinical Protocol for Evaluating Pathology Induced by Low Frequency Noise Exposure* .

Annex 5. IARO Review *The Health Effects of 72 Hours of Simulated Wind Turbine Infrasound: A Double-Blind Randomized Crossover Study in Noise-Sensitive, Healthy Adults - PMC (nih.gov).*

Annex 6. *Hunterston National Offshore Wind Turbine Test Facility. Hearing Statement Rita Holmes._Chair of Fairlie Community Council'.*

Annex 7. INWG WP1 Work Package: '*The Fundamentals of Amplitude Modulation of Wind Turbine Noise*'.

Annex 8. IARO '*Commentary on "Wind turbine noise and human health impacts in Fairlie, North Ayrshire" produced by Health Protection Scotland, July 2017*'

Annex 9. Chapter Infrasound Exposure: High-Resolution Measurements Near Wind Power Plants

Annex 10. '*A third of Groningen villages visit the doctor because of complaints about wind turbines*'

Grosvenor Consultancy
Seskin Planning Application Reference 2460122.

Annex List.

Response to Applicant's

Operational Wind Turbine Noise Report.

Annex 1 Finnish Study *Pilot study shows no significant reduction in damage caused by infrasound until more than 15 kilometers from wind farms*

Annex 2 & 2a JUDGMENT of Ms. Justice Emily Egan delivered on the 8th day of March 2024, found in favour of the Plaintiffs, but extracts from this Judgement show (Annex 2 & Annex 2a

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Annex 9 Chapter Infrasound Exposure: High-Resolution Measurements Near Wind Power Plants

Annex 10. '*A third of Groningen villages visit the doctor because of complaints about wind turbines'*

END.

Grosvenor Consultancy
Seskin Planning Application Reference 2460122.

Annex 1.

Response to Applicant's

Appendix 12.2 Operational Wind Turbine Noise Report

The health effects of wind turbine infrasound based on its propagation on the people in the surroundings of wind turbines in Finland:

Statistical analysis

Mehtätalo, E., M.Sc. (Agric. and For.)
Mehtätalo, M., M.Sc. (Agric. and For.)
Peltoniemi, P., M.A. (Phil.)

Pilot study shows no significant reduction in damage caused by infrasound until more than 15 kilometers from wind farms

Credit: Suomen ympäristöterveys (Finnish Environmental Health) 2019/01/10 syte.fi ~~ Abstract:

The pilot study carried out in Satakunta and Northern Ostrobothnia in Finland shows that the damage caused by infrasound from wind power plants will only decrease significantly more than 15 km away from wind turbines. The study was carried out by the Finnish Association for Environmental Health (SYTe) in the spring 2016.

– It has been noticed from experience that after the construction of wind power plants, usually within a few months, people in the surrounding area have begun to get a wide range of symptoms, says Markku Mehtätalo, Chairman of the Finnish Association for Environmental Health.

– It is possible to study the matter quite easily and the Finnish authority responsible for the public health, the Department of Health and Welfare (THL), has tried to do this, for example, Mehtätalo continues. However, in THL's study in 2016, it was assumed that the symptoms would decrease significantly in the first 10 km, with more symptoms near the wind turbines. The study did not take into account the impact of wind farms elsewhere in the environment.

– But it is known from experience that the symptoms of people do not usually decrease at this distance, says Mehtätalo. Measurements have also shown that the infrasound pulses from the wind turbines that are currently being built will not be significantly reduced at this distance. Other risk factors very close to the wind power plants are audible sound and electromagnetic fields.

The research material was collected from Satakunta and Northern Ostrobothnia

The sample of the pilot study meets the requirements of a statistical analysis. The data was collected from Satakunta and Northern Ostrobothnia, mainly from areas where wind turbines were built 0.5– 1.5 years before the interview (see Figure 1 from Northern Ostrobothnia). The subject of the study was about 50 families, with symptoms of each family member found out. A total of about 200 people were involved in the study.

– In addition, the pilot study took into account the location of all wind power plants in Finland and did not exclude beforehand the possibility that the effect of the wind farms could be greater and reach longer than the impact of a single, clearly separated area, says Mehtätalo.

Nocturnal disturbance is a typical symptom caused by infrasound

(Note: *1.1 Excessive noise is harmful to human health, particularly through adverse effects on sleep (WHO 2011[1]). Regulation of wind turbine noise is recognised as necessary to prevent adverse effects on the human population.* Dr C Hanning INWG WP3.2 CD)

The basic research question was whether the family had noticed changes in health status in the last six months or a year within. The wording of the question regarding the time was dependent on when the impact of the nearest wind turbines could have started. The interviewees were not told in advance about the possible connection with wind turbines.

– The majority of respondents were unable to name a change in their overall health status. However, they gave many responses to separate symptomatic questions, says Mehtätalo.

– The most typical was sleep disturbance or change in the need for night's sleep, fatigue and various pains. Only very few, some respondents, considered wind power plants as a possible cause.

Harmful or severe symptoms three times more common near wind turbines

The responses were categorized according to the severity of the symptoms and subjected to a statistical analysis. There were about three times more harmful or more serious symptoms near wind turbines (less or about 15 km from wind power plants) than further away (see Figure 2).

– Based on the analysis, it seems strongly that, after the construction of wind power plants, the majority of people in the surroundings of wind turbines are having concomitant symptoms. Most of the symptoms are typical stress symptoms, says Mehtätalo.

Although some people have suspected that the symptoms are caused by wind turbines, especially if the wind power plants are visible or if they have heard beforehand about their potential harmful health effects, people have symptoms regardless of attitude. –The pilot study shows that the symptoms are not caused by attitudes, says Mehtätalo.

The occurrence of symptoms decreased significantly only over 15–20 km from the wind power plants (see Figure 2). If there are wind turbines in different directions and a person stays a lot in the area, the risk of symptoms increases.

The assumed harmful area caused by infrasound is too small

– Later in 2017, based on infrasound measurements made in different parts of Finland, it has been found out that 15–20 km is a typical distance where the infrasound pulses of wind turbines can be detected by measurements to travel in almost all circumstances, says Mehtätalo [1–4]. According to an American study, infrasound travels under favourable conditions to a distance of 90 km from wind farms [5].

If the sample of the pilot study is representative, about 400,000 of the Finns suffer from symptoms due to wind turbines and only about 10,000 of them combine the symptoms with wind power plants. Because of the small amount of research data, strong conclusions must be taken with caution.

– However, the study clearly shows that in all previous studies, the harmful area has already beforehand been presumed to be too small, says Markku Mehtätalo. – Among other things, the extensive, in-depth material of another American study, used in several publications, has been gathered within a radius of 11.7 km from wind turbines. For this reason, the harmful health effects cannot be found in the studies, because the symptoms do not vary at this distance, he concludes. – syte

INTRODUCTION.

1. The purpose of the pilot study was to find out the effects of wind turbine infrasound on the health of the people in the surroundings of wind turbines. The material of the study was collected in Satakunta and Northern Ostrobotnia in Finland (see Figure 1) in spring 2016.

1.1 The study was sampled from two (2) different registers by simple random sampling. One register was the customer register of a company in Northern Ostrobotnia, the other was a register of members of an association in Satakunta. An interview method was used as a method for collecting research material. A total of 193 people from 46 families participated in the survey. They came from areas where the wind turbines had been built and started 0.5–3 years before the interview. As the limit of the exposure time was kept three years, and no family with a longer exposure time was accepted to the sample of the study. The distance of each family to the nearest wind turbine(s) as well as the building and starting time of the wind turbine(s) were found out for the interview. Some of the interviewees lived near wind turbines, some at a distance of tens of kilometers.

1.2 In addition to that, a map model was developed to describe the exposure zones, in other words the propagation, continuity and magnitude of the wind turbine infrasound, on a map of Finland (see Figure 1).

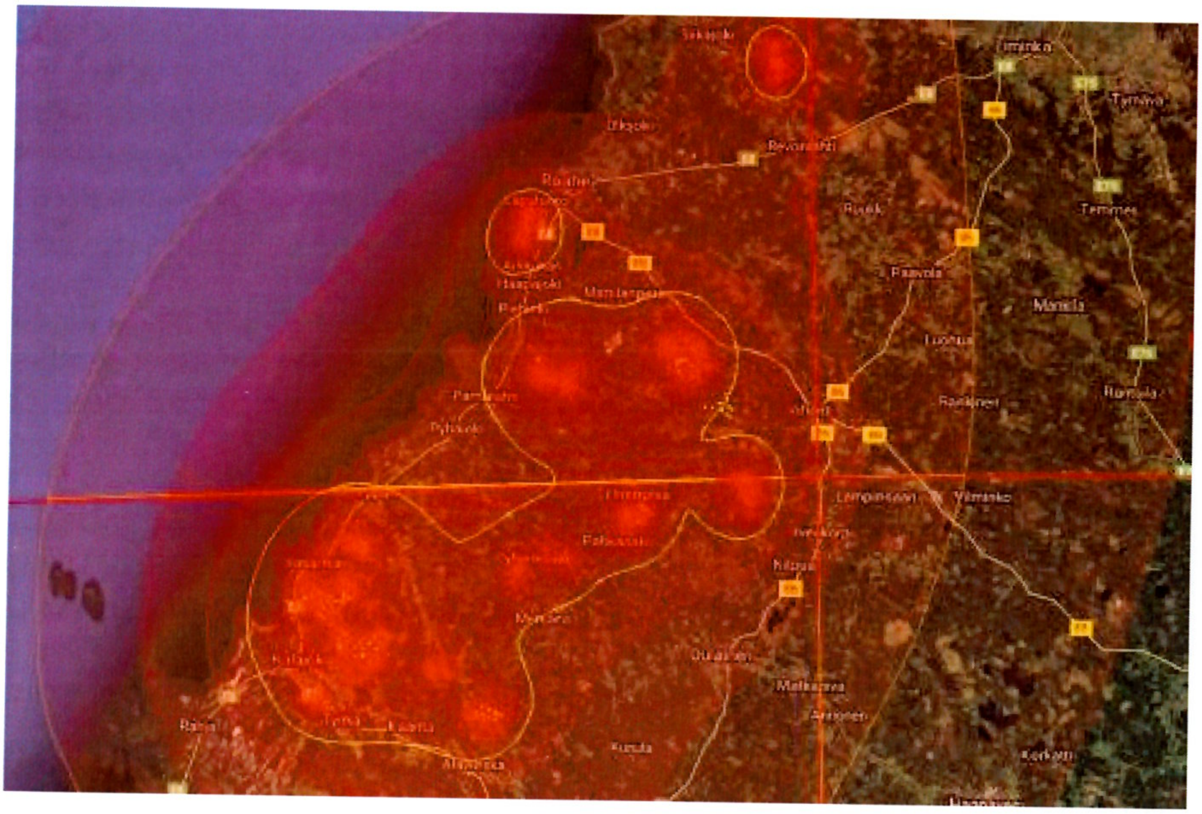

Figure 1. The area in Northern Ostrobotnia is located in the south of Oulu Province in Finland. The wind turbine infrasound is almost continuous in the yellow-bounded area (the zone 1 in the map model).

1.3 As the statistical method of the study was used the linear mixed model to test the statistical significance of the research material. The symptoms of the people were explained either by the direct distance (km) to the nearest wind turbine or by the exposure zone of the map model. Other explanatory variables included the register used, the gender and age of the person and his or her awareness in advance of potential harmful health effects from wind turbines.

1.4 The distance less than 15km from wind turbines was divided in four (4) distance classes for a visual observation. The differences in answers between them were small and varied clearly only in the next class where the distance to the nearest wind turbine was more than 15 km (see Figure 2). The harmful or severe symptoms were clearly more common less than, or about 15km from wind turbines than those further away.

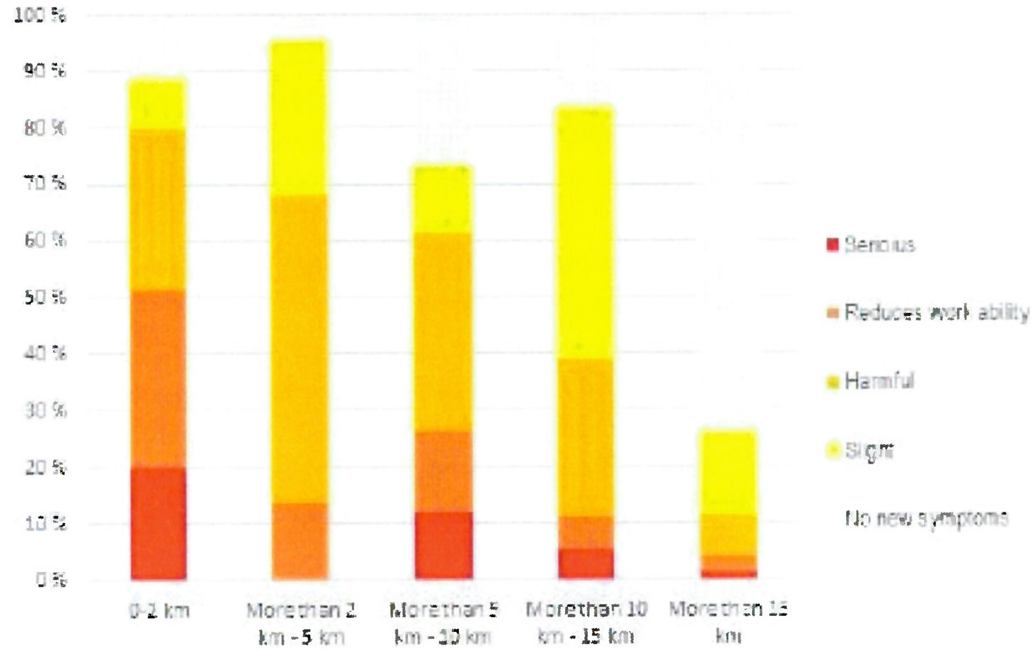

Figure 2. Symptoms according to the direct distance less than or about 15 kilometers to the nearest wind turbine and further away, more than 15 kilometers to wind turbines.

1.5 The map model included three (3) different exposure zones (see Figure 3). In the first zone nearest wind turbines there was quite strong infrasound in all wind directions. In the second zone there was wind turbine infrasound often, due to the wind directions. In the third zone there was almost no wind turbine infrasound according to the computational model. The map model explained symptoms better than the direct distance to the nearest wind turbine.

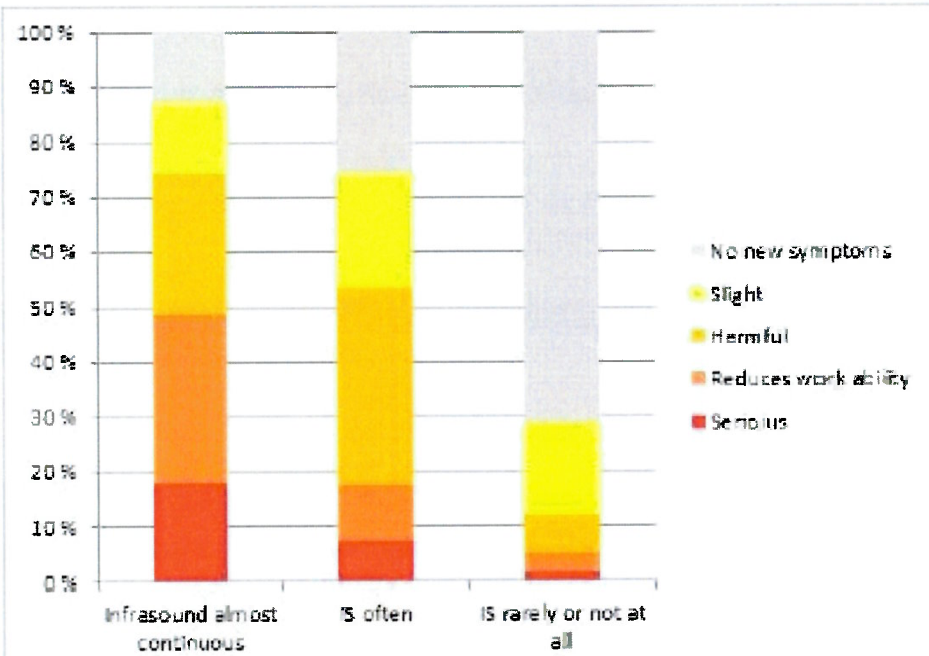

Figure 3. Symptoms of almost continuous or often persistent infrasound exposure in the exposure zones of the map model (less or about 15 km from wind turbines and further, more than 15–20 km from wind turbines).

1.6 There was no significant p-value for the damage increasing directly according to the distance (km) in the statistical analysis. The significant p-value was reached for the damage according to the map model describing the total exposure. In addition to that, symptoms were explained by person's gender and age. Other background variables did not explain the symptoms statistically significantly.

1.7 The most typical symptoms were sleep disturbance or change in the need for night's sleep, fatigue and various pains.

1.8 The results of the study show that there were remarkably more harmful health effects caused by the wind turbine infrasound in the exposure zones 1–2 of the map model than further away. **The most important result of this study is that the risk distance grows if the height, amount or efficiency of the wind turbines increases or with time in a longterm exposure. This means that the risk distance depends on the circumstances. In the areas with wind turbines around the residential area there were harmful health effects as far as about 15–20 km from wind turbines, under the circumstances when this pilot study was conducted.**

1.9 Thus, the potential damage should be investigated within a sufficiently long radius of the wind turbines, taking into account all wind turbines in the vicinity as well as the most typical wind directions. This study confirms the results of a long-term study of Ceranna and Pilger (2004–2016) about the propagation of the wind turbine infrasound.

Original Finnish: Tuulivoimaloiden infraäänen vaikutus sen leviämisen perusteella voimaloiden ympäristössä olevien terveyteen Suomessa Tilastollinen analyysi

Français: Effets nocifs des infrasons émis par les éoliennes sur la santé des riverains

Deutsch: Die gesundheitlichen Auswirkungen von Infraschall emittiert durch Windenergieanlagen auf die Anwohner in der Umgebung von WEA in Finnland, basierend auf der Schallausbreitung Statistische Analyse

Additional information: Suomen ympäristöterveys ry [Finnish Association for Environmental Health]

More:

Infrasound causes harmful health effects as far as 15-20 km from wind turbines — The risk distance grows if the efficiency, amount or height of the wind turbines increases or in a long-term exposure

—Finnish: Infraääni aiheuttaa terveyshaittoja jopa 15-20km:n etäisyydellä tuulivoimaloista

The propagation area of infrasound from wind turbines has expanded quickly in Finland in 2016-2017

—Finnish: Tuulivoimaloiden infraäänen leviämisalue on laajentunut nopeasti Suomessa vuosina 2016-2017

Pilot study shows no significant reduction in damage caused by infrasound until more than 15 kilometers from wind farms

—Finnish: Pilottitutkimus osoittaa infraäänihaitan vähenevän merkittävästi vasta yli 15 kilometrin päässä tuulivoimaloista

—German: Die Pilotstudie zeigt eine signifikante Verringerung der Symtome von den Infraschallemissionen erst in über 15 Kilometer Entfernung von Windkraftanlagen

2 Citizens Initiative.

2. We also have a citizens' initiative under way as the pilot study has been interrupted apparently due to lack of funding. There is a huge boom in wind power expansion in Finland and people need our help.

2.1 As the pilot study, we have completed a master's degree that is interdisciplinary. Our studies, Master of Agriculture and Forestry (MMM), include required studies in statistical mathematics, which is considerably more than, for example, the degree program of a Finnish doctor, licentiate in medicine.

2.3 Statistical mathematical research has also been assisted by the University of Eastern Finland, which has taken care of all possible risk analyzes, such as the impact of a family with children, age, register quality, etc. The docent of epidemiology he has audited the statistical analysis.

2.4 The creator of the infrasound model is a very talented physicist who has worked as a researcher at the State Technical Research Centre in Finland. The infrasound model uses the Danish professor's model as a basis.

2.5 Wind power is still a strongly political issue in Finland, and scientists and authorities are 'constantly protecting their backs'.

2.6 Power plant locations. The locations of wind turbines in Finland are marked on the map template used in the modelling from maps and project zoning documents.

2.7 Infrasound emission The frequency range of infrasound, the emission and propagation of which is described by the modelling, is 0.4–8 Hz with the maximum power (MW) of the wind power plant being between 0.4 and 3 Hz. The selected frequency range is based on numerous measurements in Finland and abroad (Huson 2015, Tv-ky 2015, Cooper 2015).

For the calculation, the following approximate formula was derived between the rated power of each wind turbine and the infrared emission power // infrasound pressure level produced by it (cf. Möller et al. 2010):

En (Pn) = 0.0155 Pn4 + 0.0774 Pn3 + 0.1282 Pn2 + 0.6238 Pn + 0.9583 where En is the normalized infrasound pressure level En (3 MW) = 1 and Pn = (P - 2.9000 MW) / 1.5174 MW, where P is the rated power of the wind turbine.

The Lambertian distribution E (θ) ~ cos (θ) with respect to the axis of rotation of the rotor has been used as the directional distribution of the infrasound emission (see Ceranna et al. 2005).

2.8 Damping: The geometric attenuation of the point radiator has been used as the infrasound attenuation, E (r) ~ 1 / r2, which means an attenuation of 6 dB when the distance is doubled. This may be too strong attenuation, at least in favourable weather conditions for the propagation of infrasound, taking into account measurements e.g. In Australia, where wind farm infrasound has been measured to attenuate by about 3 dB as the distance doubles (Huson 2015). The use of 6 dB attenuation is the current work estimate. However, a fairly common inversion weather condition in Finland weakens the damping.

Terrain shapes have not been taken into account in the modelling. The details of the uniform terrain type prevailing in Finland do not protect against the propagation of infrasound on a large scale. On the other hand, on a small scale, terrain shapes can provide protection, i.e. the infrasound pressure level may vary locally. "

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3. Notes from Finland: In response to the publication of the June 2020 Finnish Government sponsored research, which apparently seeks to discredit and undermine the conclusions of the earlier Pilot Study initiated by Finnish Association for Environmental Health (SYTe) in the spring 2016.

"Infrasound Does Not Explain Symptoms Related to Wind Turbines". Maijala, P. et al, June 2020

In this study, the experimental part was mixed with a test set-up by a cold stress test. During it, infrasound was given and the skin's electrical conductivity response was measured at the same time.

This Dr. Panu Maijala told us at a private meeting of our community group that in fact the doseresponse was found when a cold stress test was not given during infrasound sample. When the cold stress test was included, the result of the whole study was mixed. Ice-cold water really affects the electrical conductivity of the skin quickly and effectively. So they did scientific fraud!

in addition, the sound samples were only 10 seconds and were given several times. So far too short for the heart to have reacted.

But keep in mind. THL (The Department of Health and Welfare, which carried out this study at the request of our government) conducted this environmental study at exactly the same time and a dose-response relationship was found here. According to THL, 1/3 had severe symptoms However, they fraudulently refuted this result with that experimental study above.

This was the result of the environmental research:

"At a distance of less than 2.5 km from the nearest wind farm 15% of the respondents associated their symptoms with the infrasound of wind farms. In the whole study area, i.e., 20 km at a distance from the nearest wind farm, the symptoms of wind farm infrasound were combined by 5% respondents. About one-third of those who experienced the symptoms felt that their symptoms were severe, and the spectrum of symptoms was very wide. Many factors such as the location of the home near wind farms, chronic diseases, functional symptoms and disturbances, wind turbines experiencing disruption and wind turbines Considering health risks were more common in those who associated their symptoms with wind farms infrasound." https://tietokayttoon.fi/documents/1927382/2116852/11-2020Tuulivoimaloiden+infra%C3%A4%C3%A4ni+ja+terveys.pdf/b5dc1005-24c9-67c3-087c8846e1e48a18/11-2020-Tuulivoimaloiden+infra%C3%A4%C3%A4ni+ja+terveys.pdf?version=1.0&t=1587361982000

Point out there that the 10-minute average was up to 104 dB of wind turbines at less than 2 Hz. That breaks the heart, but only slightly slower than at 14 Hz (it's a study by the University of Mainz).

More in this citizens' initiative. https://www.kansalaisaloite.fi/fi/aloite/8104 Read Chapter 3 on Finnish research.

4. Opposition to Finnish Government wind power research.

"Infrasound does not explain Symptoms Related to Wind Turbines"

GOVERNMENT'S ANALYSIS, ASSESSMENT AND RESEARCH ACTIVITIES Published 22nd June 2020

4.1 Title of the citizens' initiative.

"WIND POWER PLANTS RENEWABLE WITHOUT IMMEDIATE - NATURE AND SAFE LIVING ENVIRONMENT OWN" Google translation.

Date of initiative 3/10/2020.

Content of the initiative:

4.2 Legislation on wind farms does not take into account the real environmental impact of power plants on nature, the landscape and human health. On the basis of international scientific research evidence, we demand that the Environmental Protection Act be reformed without delay and that all wind farms already in operation be made subject to an environmental permit. Due to the combined size, power and sound effects of the planned onshore and offshore wind farms, we demand that Parliament take the necessary steps immediately to suspend the construction of new wind farms.

Extract Chapter 3:

4.3 The final report of the wind power study commissioned by the Government was published in its entirety on June 22, 2020. The study consists of three different areas:

1. Recording of infrasound caused by wind turbines - measurements.
2. Listening test,
3. Survey [3].

4.4 The Finnish authorities did not acknowledge the health damage caused by wind power in the study. In the following, the main results of the Government's commissioned study and their significance in the light of other studies are reviewed.

4.4.1 1. Measurement of sound power level. VTT was responsible for recording infrasound for several months. It should be noted that the recordings were made in the impact areas of 3–3.3 MW power plants. This does not correspond to the power class of the planned wind turbines, which is up to 14 MW. Nevertheless, the study confirmed in the measurement section implemented by VTT that the power levels as 10-minute averages in the measured target homes were alarmingly high, up to 104 dB. It is also noteworthy that it was an average of 10 minutes. It was a filtered, not up-to-date measurement, so it does not show what the peak power level was.

4.4.2 The recent review of wind farms [19] rightly pointed out that the measurements were made in only two dwellings and that, on this basis, a generalization was made that the situation would apply to the situation of all dwellings in wind farms. Measurements based on two dwellings do not meet the scientific approach.

4.4.3 Long-term indoor noise measurements carried out in connection with the study showed that the long-term average indoor noise levels measured in dwellings exceeded the maximum permissible night-time noise levels laid down in the Housing Health Regulation by more than 10 dB. The measurements had been made in accordance with the environmental administration's noise measurement guidelines, so the measurement results could be considered reliable and should have led to immediate action by the authorities to eliminate the noise nuisance. However, nothing has been done.

4.5 **2. Listening test.**

4.5.1 The National Institute of Occupational Health and the University of Helsinki were responsible for the planning and implementation of the listening test for the wind power survey commissioned by the Government. The total duration of the infrasound exposure measurement was 3-4 hours. It included one 10-minute period and about 20 also 10-minute periods containing intermittent 10-second recorded infrasound sections.

4.5.2 The infrasound exposure times used in the listening experiment were short. In addition, the overall duration of the trial raises questions about the application of the trial to long-term adverse events.

4.5.3 Participants in the experimental study also testify that several sections confusing the experimental order were made in the experimental part. During the exposure, it was claimed that this was a relaxation period, and during the exposure, cold stress tests that had severely stressed the body had apparently also been performed. The test was also confused with audible noise. These have apparently lost the responses caused by the infrasound pulse by statistical means. In scientific research, this should not happen.

4.5.4 The results of the experimental study focused mainly on determining whether there are statistically significant differences between symptomatic and asymptomatic individuals in wind power areas. These were not found. The review of wind power research [19] also draws attention to the fact that these were recorded, not authentic, conditions.

4.6 **3. Survey**. A study commissioned by the Government showed that infrasound-induced sleep disturbances and severe or extreme indoor disturbances were four times more common in wind power areas than road traffic-induced sleep disturbances in general [3].

4.6.1 In addition to this, the infrasound caused by car traffic is usually noise and therefore differs from the narrowband infrasound produced by wind turbines. The study also proved that lifestyle, age, or gender did not explain the symptoms. Neither the perception of the landscape impact of wind farms, the flicker of power plants, the opinion of wind power as a form of energy production, access to information or satisfaction with one's own municipal decisions, trust in the public sector or attitude towards the wind power company's health effects explained the symptom.

4.6.2 The outcome of the study was not taken seriously, as the study had been conducted in areas where complaints of adverse health effects had become highest. Thus, the study did not take into account that the complaints were about the causal link between the symptoms that emerged from other studies. It is possible that not all wind power areas will identify a possible causal link as well as the areas studied. Since symptomatology and chronic diseases were statistically significantly dependent on the distance from wind farms, the logical conclusion would have been to follow the precautionary principle and the actions of the authorities in already built wind farms.

4.6.3 The dose-response relationship was found in a survey conducted by THL. At a distance of less than 2.5 km, serious diseases were three times more common than at a distance of 20 km. This strengthens the causal relationship. The findings relate to Chapters 3 and 4 of the research publication [3].

4.7 **3.1. Significance of experimental research**

4.7.1 At a wind power seminar at STM in the fall of 2017, it was pointed out that experimental research would most likely highlight a potential adverse effect. A THL survey revealed a dose response, but with a manifestly erroneous test method, the result was reversed. For research on the health effects of wind power, a medical application could have been found in Finland for experimental research, which still offers a way to determine the response of the nervous system caused by infrasound independently.

4.7.2 Following a wind power study led by our authorities, one of the world's most respected researchers in cardiovascular surgery, Professor Christian-

Friedrich Vahl and his research team, insisted that the power level of wind turbines should not exceed 90 dBz (dBz is is continuous, chronic [20]. VTT's average measurement reveals that power levels above 90 dBz are most likely to be found in numerous homes in the vicinity of wind farms.

4.7.3 Professor Christian-Friedrich Vahl has led the research team that published the report of his multi-year scientific infrasound study on 11 May 2020 [20]. The result of the study is that infrasound impairs the function of the heart muscle by up to 20%. Indeed, Professor Vahl points out that infrasound is energy that also damages other organs.

4.7.4 Under the leadership of Dr. Mariana Alves-Pereira of Portugal, a study published on 9 January 2019 proves that narrowband low-frequency sound causes visceral damage [21]. The steady noise of the sound did not prove to cause visceral damage in the study. Alves-Pereira has been awarded twice for its research on vibroacoustic diseases.

4.7.5 A German study [22] confirms that inaudible infrasound below 80 dB causes an autonomic nervous system stress response. The study was performed in healthy subjects as a double-blind study. The level of significance was very significant. In a functional magnetic resonance imaging study, it was found that the auditory cortex, the tonsil nucleus, and the region of autonomic nervous system regulation were activated upon infrasound exposure. This can manifest as heart, hormonal or fluid imbalance or high blood pressure.

4.7.6 In the case of long-term exposure, an inaudible infrasonic signal can cause a pathogenic (i.e., disease-causing) effect on organ systems in humans and animals living in wind farms. According to a study by Weichenberger [22], infrasound symptoms are not explained by nocebo, an exacerbation effect in which negative expectations have negative effects. The study proved that infrasound has a direct stress effect.

4.7.7 The conclusions of the experimental part of the study commissioned by the Finnish Government differ completely from the new, peer-reviewed infrasound studies carried out in Germany. The German document mentions a long-term exposure study that proved that the stress effect did not disappear in chronic exposure. According to Simone Kuhn, a professor of psychiatry who led the research team, it may be that what we cannot hear cannot be consciously regulated either [23].

4.7.8 In military medicine, the detrimental health effects of infrasound have been known for decades, and protection against infrasound is a matter of occupational safety, especially in the air and naval forces [25]. Sound pressure levels are not the biggest problem, but frequencies that hit the specific resonant frequencies of the human body, such as the heart at 1 Hz, the body's water mass at 7.7 to 8.8 Hz, and the brain at 10 Hz. The property of wind turbines, on the other hand, is that they are capable of producing the low frequency levels characteristic of the specific resonance of the body at such a power that they cause health damage.

4.7.9 Although the Finnish authorities did not acknowledge the health damage caused by wind power in a politically-guided study published by the Government, a thorough foreign peer-reviewed scientific study testifies to a serious environmental health damage. Internationally renowned medical researchers have taken a prominent position on the disadvantages. In Finland, the experiences of the inhabitants of the west coast confirm the results of studies conducted elsewhere in the world. **Experiences around wind farms are converging around the world.**

4.7.10 More and more high-capacity power plants are planned in Finland, which will inevitably lead to serious social and health problems and rising costs throughout the country. **A large number of families have already been reported in Finland who have had to leave their homes due to the health effects of wind power, and there are even more who would move away if it were financially possible. Negative developments are also visible in our indicators of well-being. As infrasound exposure worsens, the safe environment also decreases all the time.**

5 7. Finally

5.1 The operations of foreign wind power companies have in practice been shut down due to the health and environmental damage caused by the companies in their home country. The construction of wind farms has slowed sharply in many Central European countries due to strong public opposition. It has led to difficulties in the industry and even bankruptcies. Foreign wind power companies are now looking for new market areas, for example in Finland, because the construction and size of wind power plants are not yet restricted in our country, as in other countries. Designers in the field are developing new, ever larger wind power models for sale specifically in the Nordic countries.

5.1.2 The international peer-reviewed studies compiled for this initiative and the THL survey undoubtedly show the serious environmental and health disadvantages of wind farms. Renewable energy must not be produced by destroying biodiversity.

All wind farms must be made subject to an environmental permit, taking into account the health risks posed by infrasound. The state authority needs to monitor the implementation of current noise legislation now and after the implementation of the amendments. Our right to a peaceful habitat, nature, diversity and our recreational areas, and their preservation for future generations, must be the responsibility of the authorities.

Authors:

Citizens' initiative.

Tapio Kivistö has written about audible noise. Tapio has some technical higher professional education.

Margareta Haverinen Brandt (in the Citizens' Initiative) Brita Brandt Helsinki, is an opera singer with a doctorate in musicology. He is a class teacher at the Sibelius Academy. Margareta has written about infrasound transmission and propagation.

Anna Saari has a Master's degree in philosophy and has written about the constitution (in Finnish).

Elina Mehtätalo Master of Agriculture and Forestry Sciences. Education is very interdisciplinary. including statistical maths.

The Wind Power Review (Appendix 19 in the Citizens' Initiative,

https://www.dropbox.com/s/dj773n0izqp3yrf/Tutkimuskatsaus_Tuulivoiman%20haitalliset%20terveysvaikutukset.pdf)

has been compiled by a Finnish professor, Emeritus, Kimmo Suomi, together with Pirjo Keronen.

END

Grosvenor Consultancy
Seskin Planning Application Reference 2460122.

Annex 2.

Response to Applicant's

Appendix 12.2 Operational Wind Turbine Noise Report - Para 3.3.13.

Extracts Justice Emily Egan High Court Judgement. Delivered on 8 March 2024.

Extracts from the recent High Court case in Ireland, between MARGARET WEBSTER AND KEITH ROLLO & ROSS SHORTEN AND JOAN CARTY as Co PLAINTIFFS and MEENACLOGHSPAR (WIND) LIMITED as DEFENDANTS. The JUDGMENT of Ms. Justice Emily Egan delivered on the 8th day of March 2024, found in favour of the Plaintiffs. (This Judgement is provided by email.)

Note: Extract of Para 6 states;

*6. .... It should be noted that this is the first private nuisance claim in relation to WTN that has run to judgment in this jurisdiction, or it appears in the United Kingdom. The only comparable authority cited to me by the parties is a judgment of the Supreme Court of Victoria of New Zealand of 12th March, 2022, Noel Uren v *Bland Hills Wind Farm Pty Ltd [2022] VSC 145.*

This Judgement known as Bald Hills for reference as the above spelling of *Bland Hills is incorrect.

Para 9 of the Judgement is significantly relevant when considering the nature of wind turbine noise victim's consistent complaints; Ms Justice Emily Egan reports:

9. Wind turbine aerodynamic noise is typically broadband in nature in the sense that it is evenly distributed across the frequency spectrum; but it can exhibit lower frequency content. Sound with significant lower frequency content is both more intrusive and less effectively attenuated by barriers such as windows, walls and insulation.

Relevant extracts from the Judgement are provided below:

Introduction 1.

The plaintiffs are two couples[1] who claim <u>they have been interfered with, over a substantial period of time, in the use and enjoyment of their homes,</u> at Ballyduff, Enniscorthy County Wexford. The claim is for private nuisance in the form of noise and vibration generated by two nearby wind turbines, owned and operated by the defendant. The plaintiffs also complain of shadow flicker.

2. Ms. Webster and Mr. Rollo ("the Webster Rollos"), own Hill House (HH), and until recently Ms. Carty and Mr. Shorten ("the Carty Shortens") owned Nettlefield (NF). The nearer of the two turbines, Turbine 2, ("T2") is located some 359 m from the Carty Shorten house and some 369 m from the Webster Rollo house and the further turbine, Turbine 1, ("T1") is some 652 m from the Carty Shorten house and some 655 m from the Webster Rollo house. Each of the turbines are 74.5 m in hub height and as they are located on a *height, the height difference between the plaintiffs' houses and T1 and T2 respectively is 169 m and 152 m. The relative locations of the turbines and the plaintiffs' houses means that the prevailing south westerly winds blow from the direction of the turbines towards the plaintiffs' houses. It is also common case that because the plaintiffs' houses are located in the lee of a hill (on which the turbines are placed), they are sheltered from the prevailing wind and are in a "wind shadow" (which I understand to mean a location that is generally calm and sheltered).*

It is clear, that the plaintiff's continued exposure to the wind turbines audible Amplitude Modulation characteristic was the main focus and cause of their nuisance case, along with exposure to Low Frequency WTN - sound pressure waves.

Informative extracts (in full) from the Judgement are copied below, in respect of comparisons between this case in terms of the plaintiffs' recorded adverse impacts and those consistently reported by residents who complain of wind turbine noise and any lack of mitigation of those impacts, particularly in regards the quiet enjoyment of their homes and sleep disturbance.

'How easily the noise can be avoided/ Measures to reduce or modify the noise The plaintiffs' ability to avoid the WTN externally is extremely limited. Internally, shutting the windows and attempting to mask the noise may assist. However, such measures will often be ineffective to mitigate sleep impacts in particular.

How often the noise occurs and the time of day or night when the noise occurs

I accept the evidence of the plaintiffs' experts and the plaintiffs themselves that the conditions so demonstrated occur commonly and on a sustained basis. I also accept that these unreasonably intrusive conditions are particularly prevalent during the most sensitive times of the day; in the early morning and at night and in the evenings.

Issue 10: Does the court find that the WTN is a substantial interference with the plaintiffs' use and enjoyment of their land? Is liability in nuisance established?

On the other hand, I find that the WTN poses a nuisance to the plaintiffs in the evenings and at weekends when one could reasonably expect to be enjoying recreation in the garden and/or peace in one's dwelling. Demonstrably the WTN also poses a nuisance at night and in the early morning when a quiet environment is at a premium'.

Extracts from the plaintiffs evidence of the adverse impacts they experienced, given the comparative relevance to other WTN victims complaints in Scotland and worldwide are extracted in full below:

51. Ms. Webster's evidence is that the WTN is annoying and ever changing. The noise varies with wind direction and windspeed which dictate blade orientation and speed of rotation respectively. Windspeed is of more obvious influence than wind direction; in general, the faster the rotors turn, the worse the noise. In addition, time of day and weather impact on the intensity of the WTN. The noise is considerably louder at night and in winter. It also varies according to whether there is rain, cloud cover or clear skies. Taking into account atmospheric conditions, the effect of the WTN is more often than not "very intense". Ms. Webster recounts that when the noise and vibrations from the turbine are intense, she experiences a feeling of anxiety and overall unease that she cannot shake off.

52. Ms. Webster's evidence was that, when turning quickly, T2 emits a range of distinctive sounds. In addition to a swishing sound, it emits whoomph and whump sounds and intermittent louder thumping or whacking noises. These sounds are often accompanied by disturbing vibration, meaning that she could regularly "feel" as well as hear the noise. This is perceived as pressure coming from the air as the blades rotate, which feels like "a pummelling inside [her] body". All of this, Ms. Webster states, is a frequent characteristic of the WTN, particularly at night.

55. The turbine is audible both outside and inside the house at all times of the day including at night with the windows closed. It is audible in all rooms of the house even in the sitting room which was the furthest room away from the turbine. When the turbine is rotating quickly, the WTN is not merely audible but dominant both inside and outside the house, with the windows open and closed. The sounds of daily activities such as boiling a kettle, using the washing machine or watching television generally mask the WTN. However, without such masking noise, one can hear the WTN in all areas of the house, The WTN frequently intrudes to the extent that Ms. Webster finds it difficult to concentrate or relax. At its worst, and particularly at night, Ms. Webster described a sensation of being able to hear and feel every rotation of the turbine. Ms. Webster accepted that other sounds - such as passing cars or farm machinery might also occasionally be heard in her bedroom with the window closed. However, such noise ceases at a certain point in the day. By contrast, when it is turning rapidly, the noise and vibrations of the turbine intrude into Ms. Webster's bedroom, even when the window is closed, on a "24/7" basis.

56. The HH master bedroom is at the front of the house, but its gable wall faces broadly (if obliquely) towards T2. It was put to Ms. Webster that the defendant's experts would say that it was "beyond the realm of physics" that the WTN could be heard in the master bedroom at the front of HH, but the defendant's experts did not give such evidence. Although Mr. Carr did not hear WTN in the master bedroom of HH at the time of his site visit, he only spent between five and ten minutes in the bedroom on this occasion.

57. ***Ms. Webster's evidence was that the WTN and vibrations pass through the gable wall into the master bedroom. She stated that, in her experience, the WTN was much louder, more annoying and more easily audible than it appeared on the internal audio recordings taken by her experts in HH in 2017 and 2020/2021.***

58. Prior to the erection of the turbine, Ms. Webster had slept well. Her evidence is that the WTN causes three different kinds of sleep disturbance. The first is difficulty in falling asleep. Ms. Webster states that there have been countless nights when she can hear the WTN in her bedroom and needs to use music or other background sound to distract attention from this unpleasant sound and aid sleep. This occurs at least ten times a month. Second, when the WTN is at its worst, it can completely wake her up "bolt upright". What wakens her is not so much the absolute level of the noise but a change in its character which has a jarring effect, particularly if she is in a light sleep. These sudden awakenings occur ten to fifteen times a year. Third, even when the WTN is lower, there is a general detrimental impact on sleep quality; although she would sleep through the night, Ms. Webster nonetheless wakes exhausted. To mitigate the noise from the turbines, Ms. Webster tried to sleep with the windows closed as often as possible, which particularly, in the summer months can be quite uncomfortable.

Interactions with Mr. Brazil

60. In July 2017, the Webster Rollos alerted the director of the defendant company, Mr. Brazil to their experience of the noise. Initially, Mr. Brazil suggested improving their windows and insulation towards which he would contribute €4,000. The Webster Rollos felt that insulation was a large financial undertaking which would not in any event be effective as against low frequency WTN.

62. The plaintiffs asked Mr. Brazil if the turbines could be turned off or turned down at night or at weekends. This request was not acceded to.

Impact on the Webster Rollo relationship

65. Ms. Webster's evidence was that after a few years of living with the turbine, her 16 year relationship with Mr. Rollo started to disintegrate. In Ms. Webster's view the pervasive 24 noise and ongoing lack of sleep caused by the WTN was a significant factor in the destruction of the relationship. Her belief is that the WTN brought the couple to the stage where they were both so exhausted, discouraged and low that they could no longer fight for the relationship. Ms Webster was worried for Mr. Rollo's safety and well-being, and she suffered episodes of panic and tearfulness.

Noise diaries

69. ***An intermittent but consistent feature of the diary is that it records the Webster Rollo's relief and gratitude when the turbines are quiescent marred by trepidation of the inevitable recommencement of the noise. The strong impression is of being unable to control one's own private environment which is dominated by the turbine. Ms. Webster encapsulated this in stating that she and Mr. Rollo felt *"at the mercy of whatever way the turbine was going to be acting on a particular day to ensure that it produced a maximum output of energy."***

75. Ms. Webster also emphasised that in addition to windspeed and speed of rotation , wind direction and weather conditions have a huge impact on how noise and vibration would be experienced. The latter two of these factors are not captured by the SCADA data. She further emphasised that one should not interpret a particular diary entry in isolation. Rather, entries have to be placed in the context of the days that surround them. Several days of lack of sleep tend to wear one down, reduce tolerance and increase frustration levels which might naturally influence diary entries later in the relevant sequence.

76. This in my view is the case for Ms. Webster's diary entry of 3rd December, 2021 which records: "Turbine very loud all day and night. Turing very fast and "aggressive" almost when outside feels like I'm being pummelled by force from turbine if I stand in back yard near driveway". Counsel pressed Ms. Webster on a 10 minute segment of SCADA data captured at 2pm on 3rd December. Such an exercise entirely glosses over the fact that the preceding night's SCADA data - again only put to Ms. Webster in re-examination - shows that windspeed and speed of rotation were indeed high. This dovetails with Ms. Webster's diary entry for 2nd December which records "very loud" noise that night. A different picture however emerges during the day of 3rd December. Although I accept that Ms. Webster's experience of being "pummelled" occurred when she went outside late in the evening (at which stage the wind had picked up), it is fair to say that the SCADA data suggests that during much of the day windspeed and speed of rotation were not high when compared to conditions at the time of the court's visit (indeed they are generally lower). The point, however, is that this entry followed what could fairly be described as a bad week. Ms. Webster describes the WTN during the preceding week as "very noisy", as making"whooshing and clapping" sounds at night and "very distracting". As stated, it is also recorded as "very loud" overnight on 2nd/3rd December. Ms. Webster was not challenged on any of these entries, whether by reference to the SCADA data or otherwise. Ms. Webster also records an earache for the whole of the preceding week which of course will accentuate the impact of WTN (and, I assume of all noise). In reality, the entry for 3rd December, 2021 is probably more consistent with Ms. Webster's experience of the week as a whole than with the specific day it records. ***The entry also supports the impression of Prof. Kevin Gournay, Chartered***

Psychologist - who gave evidence on behalf of the plaintiffs - that Ms. Webster's level of tolerance of the WTN is decreasing over time. *Overall, I find that the entry for 3rd December, 2021 represents a rare and uncharacteristic occasion on which Ms. Webster allowed her more generalised frustration – most likely accentuated by physical discomfort resulting from persistent earaches - to bleed into a specific diary entry. Whilst I accept Prof. Gournay's view that such increasing sensitivity is not unusual, I have nonetheless* been cognisant of it.

The observation by Ms. Justice Emily Egan at Para 76 is particularly significant, in that;

'it is fair to say that the SCADA data suggests that during much of the day windspeed and speed of rotation were not high when compared to conditions at the time of the court's visit (indeed they are generally lower). The point, however, is that this entry followed what could fairly be described as a bad week.

Furthermore, Ms Justice Emily Eagan states at Para 77 & 78:

77. In my view, the themes pursued in this part of the cross examination ought to have been put to the plaintiffs' experts-which did not occur. This is because, whilst it is clear that windspeed and speed of rotation heavily influence the level and characteristics of WTN, a range of other factors are also highly relevant. Such factors include relatively small changes in wind direction and blade pitch and, as Ms. Webster states, prevailing meteorological conditions. These factor all influence thump AM, which is described as the most intrusive aspect of the WTN at Ballyduff. Demonstrably, Ms. Webster, as a lay witness, is unqualified to explain such matters. Rather, she stated that the diary is intended to be experiential and deferred to experts to explain what factors might influence or explain the characteristics of the WTN which she records in her diary entries.

78. ***Overall, I find that Ms. Webster's diary entries, like her oral evidence, presented a balanced and truthful account of her experience of the WTN. I make a similar finding in relation Mr Rollo's diary entries up until mid to late 2020***[13]*. From over three years of diary entries, the defendant pointed to only a handful of diary entries which it contends are inconsistent with the SCADA data. Of these, I find that only one – that of 3rd December, 2021 – can fairly be characterised as inconsistent with the SCADA data for the day on question. Further, this inconsistency pertains to only part of the relevant 24 hour SCADA data and further arises only if one considers the diary entry in isolation from the week of which it forms part. As Ms. Webster states:* ***"We are people living in our home; it is not a scientific experiment, it's our home and we are experiencing this on a continuous basis".*** *Bearing in mind the quality of other evidence supporting Ms. Webster's account of the overall characteristics of the WTN, I attach very little weight to a frailty in a single diary entry.*

Mr Rollo's evidence:

80. ***The impact of the noise affected Mr. Rollo most profoundly through his sleep.*** *At night, the turbine frequently makes a thumping, whacking and slapping noise; like the side of the house was being hit by something. When it was suggested to him that shutting the windows would diminish the sound, Mr. Rollo accepted that the turbine is less noisy with the windows closed. However, although on windy winter nights he would sleep with the windows closed, Mr. Rollo's general preference is to sleep with the windows slightly open. In any event,* ***Mr. Rollo stated that, even with the windows closed, and despite wearing professional noise cancelling headphones, the noise and vibrations caused by the turbine still disturbed his sleep. Like Ms. Webster, Mr. Rollo's sense is that the noise and vibrations come though the walls of the house. At***

times, the whole house vibrates with the noise. As a result, all attempts to mask the WTN using both professional noise cancelling headphones and industrial earplugs (which he had obtained from work) <u>were unsuccessful because, he could still feel the noise "through my bones"</u>. Emphasis added .

81. *When unable to sleep, Mr. Rollo moved to the sitting room because it was at the front of the house and did not have a gable wall facing the turbine. <u>Although the noise intruded, as it did in every room of the house,</u> he would try to sleep with the television on to mask it.* ***However, Mr. Rollo's sleep pattern remained extremely disrupted, and on many nights, he would get no more than two hours sleep.*** *This meant that he frequently rose feeling exhausted and stressed. This exhaustion was hazardous as Mr. Rollo's job involves working at heights.* Emphasis added.

82. *Mr. Rollo's evidence was that the constant noise and lack of sleep "broke [him] down". He developed mental health problems and ultimately contemplated suicide. In late 2020, Mr. Rollo's solicitor became concerned and referred him to Prof. Gournay who recommended that he see his General Practitioner, Dr. Ford. Dr. Ford in turn referred Mr. Rollo into a self-harm counselling programme where he attended ten or twelve sessions. After the conclusion of this programme, Mr. Rollo's employer arranged further counselling which concluded very recently.*

83. *In early 2021, Mr. Rollo accepted that because of the dark thoughts he was having, he had to leave the house urgently. He moved out in March 2021, initially staying with family friends. Mr. Rollo's current residence is about half an hour from HH in an estate in Wexford town.*

84. *On leaving the house, Mr. Rollo's sleep pattern initially improved but then disimproved again. He is still suffering from depression and continues to take anti-depressant medication.*

Evidence of Ms. Joan Carty and Mr. Ross Shorten

85. *Ms. Carty and Mr. Shorten owned NF until comparatively recently and sold it to Ms. Maura McGinn in August 2021 (as to which see further below). Ms. Carty described the range of sounds emanating from the turbine, the most difficult and intrusive of which is a loud whomping or thumping sound with associated reverberation and vibration. This loud whomping and thumping noise is very hard to listen to for any period of time and is audible from every room in the house. Mr. Shorten's evidence was to a similar effect; <u>he recounted that the noise, the vibration and the sense of pressure in the air are overpowering and upsetting</u>.* Emphasis added.

86. *The couple's evidence was that as a result of the WTN, and its associated vibrations, it was impossible to sleep in the master bedroom, even with the window closed. The noise intrusion forced them to vacate the master bedroom which is a dormer and move to a somewhat quieter bedroom downstairs. However, the WTN still disturbed their sleep.*

87. *Because of the WTN, Ms. Carty and Mr. Shorten no longer enjoyed visiting NF. <u>They found the WTN to be extremely intrusive during a 5 day period they spent working on the patio outside their house in August 2017.</u> Even with a music speaker outside to try and mask the WTN (albeit at a volume at which they could still converse), they were disturbed by the whomp whomp sound as the blades cut through the air. Ms. Carty said that after the turbine started turning, <u>she never again sat on the patio to read. In addition, they stopped having guests to the house because they were embarrassed about the noise and intrusion from the turbine.</u>*

88. When the couple raised these difficulties with Mr. Brazil, he indicated that he might, in due course, be prepared to buy NF as he had known that it had was previously on the market. He also arranged for monitoring equipment to be installed at NF on the understanding that the results would be furnished to the Carty Shortens. Although Mr. Shorten requested this data both verbally and in writing, it was never furnished.

89. The couple's evidence was that the house was placed on the market in September 2018 and was ultimately sold at a price significantly below its full value, to Ms. McGinn.

90. Two additional witnesses as to fact were called by the plaintiffs

Evidence of Ms. Maura McGinn

91. The plaintiffs called Ms. Maura McGinn, the current occupant of NF. She purchased NF from the Carty Shortens on 12th April, 2021. Ms. McGinn stated that the WTN was pretty obvious when she viewed the house. She knew that she could not have afforded to buy the house were it not for the presence of the turbines.

92. On her first night in the house, Ms. McGinn was shocked by the WTN which was exceedingly loud and kept her awake. Ms. McGinn was concerned that she made a mistake in purchasing the house and worried that she would be unable to sleep in the master bedroom upstairs. However, Ms. McGinn "persevered" and continues to sleep upstairs.

93. Ms. McGinn does not generally spend the whole week in the house as she works in Dublin a few days a week. When she is going to bed at night, the rhythmic nature of the noise can "get in on" her and it canbe hard to fall asleep. Alternatively, she might wake to the WTN and then find it more difficult to get back to sleep. As she points out, when you hear the turbine, it is very difficult to un-hear it. Overall, although the turbine can interrupt her sleep, Ms. McGinn stated she was a good sleeper.

94. The turbine generally makes noise all the time, apart from on very still days. The noise outside is louder and stronger. Inside the noise is much quieter downstairs, but it can definitely be heard upstairs. Ms. McGinn describes the noise as a "whoomph, whoomph, whoomph kind of noise".

95. In general, Ms. McGinn is careful not to focus on the noise and tries not to let it bother her. She would be afraid that if she did focus on the WTN for too long, it would start to get in on her.

96. Ms. McGinn is from a large family and lots of people come to visit. She finds herself being quite defensive of the turbine and therefore warns her family about the turbine before they visit. Whenever workmen come to the property, they refer to the turbine and to the noise. Her surveyor recommended that she put in additional insulation for the house. Although she followed this advice, this made no real difference in the noise levels.

97. Under cross-examination, Ms. McGinn confirmed that she did not regret buying the property. Her first night in the property had been a particularly noisy night and her general approach is to try not to pay too much attention to the turbine. She has managed to get used to the noise or has learnt to ignore it such that she conceded[14] that "it doesn't seem... to be creating a terribly great problem for[her]in [her]enjoyment of the property".

Evidence of Ms. Ashley Doran

98. *Ms. Ashley Doran lives at Ballyduff. Ms. Doran's house is located 313 metres from the Webster Rollo's house. There is a distance of 601 metres between T2 and Ms. Doran's house and a distance of 808 metres between T1 and Ms. Doran's house.*

99. *Ms. Doran stated that the turbines make a deep, heavy reverberating noise which she describes as groaning and whomping sounds. Reverberations are experienced both inside and outside the house. The WTN is disturbing and disorientating making it hard to focus or concentrate. On occasion the intensity of the sound and vibration makes her dizzy and queasy. At times, the sound of the turbines hurts her ears. It is difficult to cope with the inconsistency of the WTN which varies from "quiet" to "thunderous" depending on the meteorological conditions. The WTN disturbs her sleep and Ms. Doran has started sleeping in the room furthest from the turbine. Both she and her husband sleep with earphones which they use to mask the sound of the turbines. Overall, although Ms. Doran's husband, finds the turbine "a bit annoying" he manages to put it out of his head and get on with things.*

There is consistency between the personal evidence in these witness statements and the adverse impacts consistently reported by residents in Scotland and elsewhere.

Of particular significance, is the witnesses evidence in respect of the impact of low frequency WTN which confirm the extent these adverse impacts have had on these witnesses.

For ease of reference, samples of these impacts are provided below:

Ms. Webster recounts that when the noise and vibrations from the turbine are intense, she experiences a feeling of anxiety and overall unease that she cannot shake off.

These sounds are often accompanied by disturbing vibration, meaning that she could regularly "feel" as well as hear the noise. This is perceived as pressure coming from the air as the blades rotate, which feels like "a pummelling inside [her] body". All of this, Ms. Webster states, is a frequent characteristic of the WTN, particularly at night.

However, without such masking noise, one can hear the WTN in all areas of the house, The WTN frequently intrudes to the extent that Ms. Webster finds it difficult to concentrate or relax. At its worst, and particularly at night, Ms. Webster described a sensation of being able to hear and feel every rotation of the turbine,...

Ms. Webster's evidence was that the WTN and vibrations pass through the gable wall into the master bedroom.

......were unsuccessful because, he could still feel the noise "through my bones".

........remained extremely disrupted, and on many nights, he would get no more than two hours sleep

Although the noise intruded, as it did in every room of the house,.......

The couple's evidence was that as a result of the WTN, and its associated vibrations, it was impossible to sleep in the master bedroom, even with the window closed........

...... he recounted that the noise, the vibration and the sense of pressure in the air are overpowering and upsetting,......

Reverberations are experienced both inside and outside the house........

It is however abundantly clear, the compelling witness evidence presented and accepted by Ms. Justice Emily Egan in this High Court case, totally contradicts wind turbine operator's repetitive statements in response to consistent complaints of residents:

"In terms of low frequency noise, this is something that is not generally audible or perceptible to humans and occurs at similar levels to pre-existing background levels. Multiple organisations and studies from around the world, including the World Health Organisation, indicate that there is no evidence that any infrasound/low frequency noise from wind turbines directly causes health impacts or can otherwise impact on the amenity of those living or working near wind turbines".

END.

THE HIGH COURT

[2024] IEHC 136

[2018 8457 P]

BETWEEN:

MARGARET WEBSTER AND KEITH ROLLO

PLAINTIFFS

AND

MEENACLOGHSPAR (WIND) LIMITED

DEFENDANT

AND

[2018 8458 P]

BETWEEN:

ROSS SHORTEN AND JOAN CARTY

PLAINTIFFS

AND

MEENACLOGHSPAR (WIND) LIMITED

DEFENDANT

JUDGMENT of Ms. Justice Emily Egan delivered on the 8th day of March 2024 Index

Glossary

GLOSSARY Term	**Definition**
Aerodynamic Noise	Noise emitted by a wind turbine due to the passage of air over the blades.
Amplitude modulation, AM	In the context of wind turbine acoustics, this normally refers to a periodic variation in the sound level of the broadband spectrum of the aerodynamic sound.

AM Value	In broad terms I refer to this as the measurement of the peak to trough differential in AM noise levels
Background Noise	The ambient noise level already present within the environment in the absence of wind farm operation.
Bin	A bin is a subset or group into which data can be sorted; in the case of windspeeds, bins are often centred on integer windspeeds with a width of 1 m/s. For example, the 4m/s windspeed bin would include all data with windspeeds of 3.5 to 4.5 m/s.
Blade Pitch	The pitch motor turns (or pitches) blades out of the wind to control the rotor speed, and to keep the rotor from turning in winds that are too high or too low to produce electricity.
Broadband	A wide range of sound frequencies
BS 4142	*BS4142: 2014 Method for rating and assessing industrial and commercial sound.* BS 4142 is a method to assess the impact on humans in residential premises. It is appropriate for assessing sound levels outside a building that are from: industrial premises, manufacturing premises or fixed installations, mobile plants, vehicles, trains or ship movements.

Cut-in Windspeed	The windspeed at which a turbine produces a net power output.
dB	Decibel, the unit of measure of sound.
dBA	A-weighted decibels, the unit of measure of sound adjusted to reflect the perception of sound to the human ear.
Defra Guidance	*Windfarm Noise Statutory Complaint Methodology, 2011* A methodology developed by the Department for Environment, Food and Rural Affairs for the assessment of statutory noise nuisance complaints pertaining to wind turbine noise.
Draft WEDG 2019	Draft revised Wind Energy Development Guidelines issued by the Department of Housing, Local Government and Heritage in December 2019 and since withdrawn.
EPA	Environmental Protection Agency
EPA NG3	*EPA Guidance Note on Noise Assessment of Wind Turbine Operations at EPA Licensed Sites, EPA NG3* (June, 2011).
EPA NG4	*Environmental Protection Agency Office of Environmental Enforcement (OEE) Guidance Note for Noise: Licence Applications, Surveys and Assessments in Relation to Scheduled Activities* (January, 2016)

ETSU — *ETSU-R-97: The Assessment and Rating of Noise from Wind Farms* published by the Department of Trade and Industry in 1996. ETSU is the primary framework by which planning conditions pertaining to wind farms are set in the United Kingdom

ETSU Review — *A Review of Noise Guidance for Onshore Wind Turbines produced by WSP UK Limited* commissioned by the Department for Business, Energy and Industrial Strategy and published in February 2023.

Façade Level — The noise level closer to a façade of a building which is subject to a higher noise level than in an open area (free field conditions) due to reflections.

Fixed noise limit — A noise condition in a planning permission which does not limit WTN by reference to background noise levels but instead sets a fixed limit (or a range of fixed limits)

Free Field — An environment in which there are no reflective surfaces affecting measurements within the frequency region of interest.

GPG — *A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise*' published by the Institute of Acoustics (IOA) in 2013.

Hertz (Hz)	Hertz, the unit of measure for the frequency of a sound in cycles per second.
Hub	The centre of the rotor
Hub Height	Height of wind turbine tower from the ground to the centre-line of the turbine rotor.
10-metre standardised windspeed	A formula pursuant to which, irrespective of the hub height of the turbine, windspeed is extrapolated down to a 10 metre height using a standard wind shear profile.
Hub Height Windspeed	The windspeed at the hub height of the turbine or at the centre of the rotor.
IOA	The Institute of Acoustics
IOA RM	A reference method published by the Institute of Acoustics in 2016 for measuring and rating amplitude modulation in wind turbine noise.
ISO 1996-2	A standard published in 1996 by the International Organization for the standardisation of measurements "*Acquisition of data pertinent to land use*" ("ISO 1996-2")"
ISO 1996-2, 2017	The 2017 edition of ISO 1996-2
L5	The sound level exceeded for 5% of the measurement period.
L90	The sound level exceeded for 90% of the

	measurement period. For example, L90 (10 min) is the level exceeded for 90% of the measurement time of 10 minutes.
L95	The sound level exceeded for 95% of the measurement period.
Lden	This is a composite of long term leq valued for day, evening and night. It is determined by averaging the L day with the L evening plus a 5 dB penalty and the L night plus a 10 dB penalty.
Leq T, energy time-averaged sound level	A sound level measurement index, which averages all of the sound energy in a period over the measurement time T. For example, Leq $_{10}$ is the average sound level over a 10 minute period.

Lmax This represents the upper value of the sound pressure levels measured in a given period.

Low frequency noise	The definition of low frequency noise can vary, but it is generally accepted to be within the range of 10Hz to 150Hz.
Masking	The process by which the threshold of audibility of one sound is raised by the presence of another (masking) sound.
Mechanical Noise	Noise emitted by a wind turbine from machinery usually within the nacelle.

m/s	Metres per second.
Night Hours	2300-0700 hours on all days
Noise	Sound that is subjectively judged to be undesired in a given context.
Phase 2 Report	*Wind turbine AM review: Phase 2 report.* 3514482A Issue 3 WSP | Parsons Brinckerhoff, 2016. Department for Business, Energy & Industrial Strategy. A study suggesting a range of decibel penalties by reference to **AM values** for inclusion in planning permissions for wind turbines.
Quiet Waking Hours	1800-2300 hours on all days plus 0700-1800 hours on Sundays and 1300-1800 hours on Saturdays.
Relative noise limit	A noise condition in a planning permission which limits WTN to a certain level above background noise.
SCADA data	SCADA is a computer system with software tools used for controlling and monitoring the wind turbine. It measures *inter alia* windspeed, speed of rotation, blade pitch and decibel level. SCADA data is retained and can be reproduced. The SCADA data for both T1 and T2 was included in the defendant's discovery.

Shadow Flicker	Term used to describe the short-lived effect of shadows cast by rotating blades of wind turbines when the sun passes behind them, which occurs under certain combinations of geographical positions and time of day.
Sound	Energy that is transmitted by pressure waves in air or other materials and is the objective cause of the sensation of hearing. Commonly called noise if it is unwanted.
Sound Frequency	Sound comprises a range of frequencies extending from the very low, such as a rumble of thunder, to high frequencies, such as those generated by a small bell. Allowing for individual variation, the audible range of frequencies for the human ear is generally in the region of 20Hz to 20,000Hz.
Sound Pressure	Sound pressure is usually measured in A-weighted decibels, which are generally denoted as dBA. The decibel scale is logarithmic and not linear in nature. This means that if, for example, two instances of the same sound level occur at the same time and each has a sound level of 30dBA, their combined level will be 33dBA, and not 60dBA.

Spectrogram	A visual representation of the spectrum of frequencies in a signal as it varies with time. In acoustic terms it shows the acoustic frequency content of the raw noise data which is helpful in identifying the main sources of noise and clarifying whether it is wind turbine related.
Spectrum, spectral content	Sounds are typically made up of acoustic energy present in many frequencies of the audible spectrum. The frequency spectrum describes this signal 'content'.
Stable atmospheric conditions	Conditions under which the mixing of layers in the atmosphere is minimised. This leads to a much greater increase in wind speed with height.
Supplemental Guidance Note 5	One of six Supplementary Guidance Notes to the GPG published by the IOA in 2014. *Supplementary Guidance Note 5 on Post Completion Measures* governs the technical aspects of ETSU planning compliance assessments.
Total operational noise (level)	In the context of wind turbine acoustics, this normally refers to the total sound environment considered at a given location. In the present case, total operational noise comprises the wind turbine noise and the background noise.
WEDG 1996	*The Wind Farm Development Guidelines for Planning Authorities* issued by the Department of Local Government in 1996.

WEDG 2006	*The Wind Energy Development Guidelines 2006*, issued by the Department of the Environment, Heritage and Local Government in December, 2006.
WHO 2009	*Night Noise Guidelines for Europe* (2009) ISBN 978 92 890 4173 7
WHO ENGER	*Environmental Noise Guidelines for the European Region* (2018)
Wind Shear	A description of the increase in windspeed with height above ground level.

Introduction

1. The plaintiffs are two couples[1] who claim they have been interfered with, over a substantial period of time, in the use and enjoyment of their homes, at Ballyduff, Enniscorthy County Wexford. The claim is for private nuisance in the form of noise and vibration generated by two nearby wind turbines, owned and operated by the defendant. The plaintiffs also complain of shadow flicker.

2. Ms. Webster and Mr. Rollo ("the Webster Rollos"), own Hill House (HH), and until recently Ms. Carty and Mr. Shorten ("the Carty Shortens") owned Nettlefield (NF). The nearer of the two turbines, Turbine 2, ("T2") is located some 359 m from the Carty Shorten house and some 369 m from the Webster Rollo house and the further turbine, Turbine 1, ("T1") is some 652 m from the Carty Shorten house and some 655 m from the Webster Rollo house. Each of the turbines are 74.5 m in hub height and as they are located on a height, the height difference between the plaintiffs' houses and T1 and T2 respectively is 169 m and 152 m. The relative locations of the turbines and the plaintiffs' houses means that the prevailing south westerly winds blow from the direction of the turbines towards the plaintiffs' houses. It is also common case that because the plaintiffs' houses are located in the lee of a hill (on which the turbines are placed), they are sheltered from the prevailing wind and are in a "wind shadow" (which I understand to mean a location that is generally calm and sheltered).

3. The windfarm was built on foot of a grant of planning permission dated 16th April, 2004. Condition 15 states that noise levels from the turbines when measured at the nearest inhabited house shall not exceed 40dBA (15 minute leq[2]) at a windspeed of 5 m/s and 45dBA (15 minute leq) at a windspeed in excess of 10 m/s. Due to grid connection difficulties, there was a delay in the implementation of this planning permission and the two turbines did not become operational until February 2017.

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[1] Although the Webster Rollos have since separated.

[2] In this judgment, I will in general refer to this as "leq" regardless of the time interval involved. This is primarily to distinguish this measurement from L90.

4. In addition to seeking damages for nuisance and an injunction to prevent nuisance, the plaintiffs maintain that the windfarm is operating otherwise then in compliance with its planning

permission and seek relief pursuant to section 160 of the Planning Development Act, 2000 (as amended).

5. O'Moore J. directed that the trial of the proceedings would proceed in a modular fashion with module 1, which is the subject matter of this judgment, dealing only with the issue of liability and module 2, if required, dealing with the issue of damages and remedy. However, during the course of the trial of module 1, it was agreed that this module would also determine the entitlement or otherwise of the Webster Rollos to damages for personal injuries[3] and that the assessment of the quantum of such damages (if any) would be taken up in module 2.

6. It was expected that module 1 would run for five weeks. However, it is clear that the parties' estimate of the time required to try the numerous factual, technical and legal issues in dispute was utterly unrealistic . It should be noted that this is the first private nuisance claim in relation to WTN that has run to judgment in this jurisdiction, or it appears in the United Kingdom. The only comparable authority cited to me by the parties is a judgment of the Supreme Court of Victoria of New Zealand of 12th March, 2022, *Noel Uren v Bland Hills Wind Farm Pty Ltd* [2022] VSC 145.

7. The trial of module 1 very significantly over-ran its original estimate and was heard over the course of 51 days between 22nd November, 2022 and 6th November, 2023. In total, the plaintiffs called 11 witnesses and the defendant called five witnesses. The combined book of transcripts of the hearing of the proceedings runs to over 6000 pages.

<u>The nature of wind turbine noise ("WTN")</u>

[3] In the form of pure psychological injury.

8. Wind turbine noise ("WTN") typically consists of both aerodynamic noise caused by the interaction of the rotors with the surrounding air and mechanical noise created by the mechanical elements of the turbine. It is the first of these that is in issue here.

9. Wind turbine aerodynamic noise is typically broadband in nature in the sense that it is evenly distributed across the frequency spectrum; but it can exhibit lower frequency content.

Sound with significant lower frequency content is both more intrusive and less effectively attenuated by barriers such as windows, walls and insulation.

10. Although WTN can be constant it usually exhibits period fluctuations in level, the frequency[4] of which is related to the blade passing frequency of the turbine rotors. This volume change is known as amplitude modulation ("AM")[5].

11. Two categories of wind turbine AM have been identified in the literature and guidelines: The first is AM in the mid and upper frequency[6] ranges. The sound which this produces, is that which we commonly associate with windfarms and is best described as a swishing sound. This blade swish, which I will refer to as ("swish AM") is commonly described as *"normal AM".* The second category of AM has a lower frequency sound character and is best described as a "whoomph" or thump sound ("thump AM"). Thump AM is commonly described as *"abnormal AM", "adverse AM"* or *"excessive AM".*

12. In broad terms[7], the extent to which AM fluctuates as the rotors turn is measured by the differential between the peak and the trough of the sound levels – i.e., the peak to trough differential ("the AM value"). If the AM value is high, then the perception will be of a louder sound changing to a quieter sound, and vice versa. This will increase the intrusiveness of the WTN. Conversely, if the AM value is low, then the perception will be of a sound which is more

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[4] Note the two different uses of the word frequency, i.e., to define spectral content and, as here, to describe the temporality of blade passing.

[5] Graphs prepared by one of the plaintiffs' experts derived from the noise monitoring on site which are attached at paras 434 and 435 might be helpful in illustrating AM.

[6] Here "frequency" refers to spectral content.

[7] There are some nuances to this which I will outline below when discussing eh IOA RM.

steady and monotonous. Swish AM and thump AM can each display either high or low AM values.

13. In addition to variations in its spectral content (swish AM/thump AM), and its AM value (high or low values), AM can also exhibit other distinct characteristics such as:

- regular AM with little variation in rhythm.
- erratic AM with no clear periodicity or rhythm which exhibits sudden bursts or isolated peaks of noise and is often accompanied by high AM values.

- Intermittent or variable AM which disappears and returns again, or which fades in and out.

14. Although the plaintiffs complain that the WTN causes an unwelcome general increase in noise levels at their properties, the key feature of their case is that the AM associated with these turbines (but primarily the closest turbine, T2) renders it objectively unreasonable.

Summary of plaintiffs' and defendant's case

Plaintiffs' case

15. In brief, the plaintiffs' case is that whilst the assessment of WTN nuisance is an objective and not a subjective exercise, it is not determined by decibel level alone but by reference to all of the characteristics of the WTN. The assessment is not purely quantitative but also qualitative. Close attention must therefore be paid to all the characteristics of the WTN such as its decibel level, whether there is swish or thump AM, its AM values, the erraticism, impulsivity or variability of its AM and the duration, frequency and timing of the intrusion occasioned thereby.

16. The plaintiffs maintain that even if a windfarm benefits from planning permission, the noise conditions in the permission cannot provide the litmus test for determining whether the WTN constitutes an unreasonable interference with amenity.

17. To demonstrate the features of the WTN complained of in this case, the plaintiffs' experts carried out noise monitoring over extensive periods both externally and internally at HH and NF. The plaintiffs present the results of this noise monitoring in audio recordings and in graphical format. They maintain that, when assessed against relevant quantitative and qualitative criteria, this data supports the contention that the WTN poses a substantial nuisance.

Defendant's case

18. The defendant argues that the noise conditions in the windfarm planning permission comprise a wholly reliable indicator as to what levels of WTN are objectively reasonable at this location. Therefore, because the WTN is said to comply with the conditions in the planning permission, nuisance cannot be established.

19. The defendant argues that the plaintiffs' experts' audio recordings and graphs were not recorded or analysed in accordance with established methodologies. It maintains that the plaintiffs' experts' approach is novel and bespoke and therefore of little assistance to the court.

20. A further overarching argument of the defendant is that the plaintiffs' complaints are subjective only and that the test for nuisance is objective. The defendant relies on three key items of evidence that it submits established that the expectations of an objectively reasonable ordinary person have not been *"exceeded"* in this instance:

i. The evidence of its acoustic experts, to the effect that the noise conditions incorporated into the planning permission for the windfarm comprise a reasonable objective standard in respect of noise emissions.
ii. Evidence said to demonstrate that the windfarm is operating in compliance with the said noise conditions.
iii. The evidence of Ms. McGinn the purchaser/occupier of NF to the effect that in general the WTN is not adversely affecting her enjoyment of the property.

Structure of this judgment

21. At the outset, I will summarise my findings on the issues to be tried in this case. After outlining the legal test for nuisance, I will set out the key factual evidence and then detail the court's site visit. Next, I will provide a brief overview of the expert evidence.

22. To place the arguments of the parties in context, it will then be necessary to review the regulatory framework under which planning authorities set noise conditions for wind farm developments.

23. Moving on to the main body of the judgment, I will first consider the defendant's argument that the noise conditions in the planning permission for this windfarm are binding on the court because they comprise a wholly reliable indicator of what constitutes objectively reasonable WTN at this location. The defendant also contends that the WTN complies with these noise conditions. This means that if this argument were to succeed, it would be dispositive of the claim.

24. Thereafter, I will consider the reliability of evidence of the plaintiffs' experts, including the audio recordings (and associated graphs) derived from their noise monitoring at the plaintiffs' homes. After this, I will consider what criteria ought to best guide this court in the nuisance assessment and then analyse the WTN as against a range of relevant quantitative and qualitative criteria.

25. After making certain findings of fact, I set out my reasons for concluding that nuisance is established in this case.

26. I will then explain why I direct the parties to re-engage in mediation in an attempt to identify appropriate and proportionate mitigation measures. Finally, I will examine the plaintiffs' claim to damages for personal injuries and close by briefly considering the plaintiffs' application pursuant to s. 160 of the Planning and Development Act 2000.

Issues to be tried and summary of the court's findings

27. I set out below the issues for determination together with an overview of my conclusions in relation to each issue. It should be emphasised that this is only a very brief summary of my reasons for those conclusions and that the real analysis thereof is set out in the body of the judgment.

Issue 1: Is the court bound by the noise condition in the planning permission in assessing what is objectively reasonable for the purposes of determining a claim for nuisance? Is the noise condition in the planning permission a wholly reliable indicator of what WTN is reasonable?

No.

Is the permission binding on the court in its nuisance assessment?

The defendant argues that, *as a matter of law*, a permission which specifically regulates the matter complained of – in this instance, WTN – prevents the court from concluding that operation in accordance therewith constitutes a nuisance. The defendant relies upon *Smyth v Railway Procurement Agency and anor* [2010] IEHC 291 (*"Smyth v RPA")* in which Laffoy J. held that, if operated in accordance with the Line B order, the operation of the LUAS would be in accordance with law and could not constitute a nuisance. Effectively, the defendant seeks to equate the legal impact of the Ballyduff planning permission with that of the Line B Order in *Smyth v RPA.* However, the two cannot be equated. This aspect of Laffoy J.'s reasoning is concerned with the defence of statutory authority in respect of a development authorised by legislation. Its logic cannot be read across to a decision made by a planning authority in the form of a single planning permission.

Is the permission a wholly reliable indicator of what WTN is reasonable?

In any event, I am not satisfied that the permission does specifically regulate the matter complained of by the plaintiffs. The Ballyduff permission regulates WTN by way of decibel levels only and cannot establish an objective yardstick for the particular aspects of the WTN complained of by the plaintiffs in this case – the AM.

Neither the Ballyduff permission nor the planning file as a whole reveal any consideration, assessment or regulation of this feature of WTN. The permission cannot therefore be seen as a wholly reliable indicator of what AM values and other AM characteristics are objectively reasonable.

This lacunae in the permission may be contrasted with the evidence in *Smyth v RPA*. The process under consideration in *Smyth v RPA* incorporated a searching and comprehensive investigation, analysis and assessment of all noise aspects of the project. On the evidence therefore, Laffoy J. was satisfied that the noise conditions thereby derived were a wholly reliable indicator as to what the ordinary person whose requirements[8] are objectively reasonable would expect in terms of noise control. Furthermore, I do not accept that in the circumstances of this case the defendant can profit from an argument that the court must show curial deference to the Ballyduff planning permission. Curial deference was urged on the court because, it is said, the Ballyduff permission reflects prevailing standards and expertise pertaining to WTN at the time of the grant of permission (and indeed to date). However, the interpretation of the permission argued for by the defendant does not reflect prevailing planning guidance at the time of the grant of the Ballyduff permission - the 1996 Wind Energy Development Guidelines (WEDG 1996)[9]. Conversely, if the Ballyduff permission is interpreted in harmony with WEDG 1996, then I am far from being satisfied that the WTN complies therewith. Further, contrary to the defendant's argument, the noise limits laid down in the Ballyduff permission do not reflect current expertise on the impact of the relevant characteristics of the WTN complained of here-such as high AM values and thump AM.

<u>Issue 2: Is compliance with the planning permission demonstrated?</u>

2 (a): For the purposes of the nuisance case, which party bears the onus of demonstrating compliance or non-compliance (as the case may be) with the noise condition set out in the planning permission?

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[8] Even if I am wrong in this, I am not in any event satisfied that the defendant has demonstrated that the WTN complies with the noise limits set out in the permission. See para 341 for a summary of why this is so, with the full analysis preceding that.

[9] Which provided that noise levels measured externally at any dwelling house should not exceed 40 dBA Leq as to which see para 184 below.

In the nuisance action, the defendant bears the onus of proving the defence advanced; namely that the WTN complies with the noise condition in the Ballyduff permission when correctly interpreted.

2 (b): What is the correct interpretation of the noise condition in the permission?

There is an ambiguity in the planning permission. It is clear that at a windspeed of 5m/s, WTN may not exceed 40 dBA leq. It is also clear that at windspeeds in excess of 10m/s WTN may not exceed 45 dBA leq. However, the permission does not specify the applicable limit at windspeeds between 5 m/s and 10 m/s.

The correct interpretation of the planning permission is that noise levels from the turbine may not exceed 40 dBA leq at windspeeds between 5 m/s and 10m/s. The higher limit of 45 dBA leq only applies for windspeeds in excess of 10 m/s.

2 (c): What does the compliance data show?

The defendant seeks to demonstrate compliance with the Ballyduff noise condition by reference to noise monitoring conducted at HH, rather than at NF. However, compliance with the noise condition cannot be demonstrated by noise measurements taken at HH because NF is the measurement location designated in the permission.

On the correct interpretation of the noise condition in the Ballyduff permission, compliance is not demonstrated by reference to the NF data because total operational noise- i.e., WTN and background noise - at night-time exceeds 40 dBA leq from windspeeds of 7m/s. Total operational noise also exceeds 45 dBA leq at windspeeds in excess of 9.5 m/s. Although the defendant argues that this is not attributable to WTN, but to other factors, it bears the onus of so demonstrating by refence to background noise studies. No such studies have been tendered to the court.

Even if one overlooked the fact that HH is the incorrect measurement location, there is a paucity of data at HH during night-time at windspeeds in excess of 8m/s such that the HH data could not reliably demonstrate planning compliance. Further, even if one were to overlook this frailty, total operational noise at HH exceeds the limit of 40 dBA leq set in the noise condition at windspeeds in excess of 6m/s. Therefore, in the absence of background noise studies, compliance cannot be demonstrated.

Issue 3: Is the character of the locality to be assessed on a "windfarm basis" or a "no windfarm basis"?

Nuisance is to be assessed by reference to the character of the relevant locality. There is permission for a windfarm at this location. Because of the planning permission, the plaintiffs cannot fairly contend that audible WTN (with some degree of AM) is in and of itself an unreasonable interference. On the other hand, the defendants cannot contend that because WTN is known to occasionally demonstrate certain particularly intrusive characteristics – for example high AM values or thump AM - these characteristics are necessarily part of the locality. WTN which entirely dominates the plaintiffs' sound environment could not have been reasonably anticipated by the grant of permission. Therefore, whilst a windfarm at this location is part of the locality, WTN with the characteristics identified above cannot be said to form part of the locality.

Issue 4: What criteria ought the court consider in the assessment of nuisance?

The methodology developed by the (United Kingdom) Department for Environment, Food and Rural Affairs for the assessment of statutory noise nuisance complaints pertaining to WTN, the *Windfarm Noise Statutory Complaint Methodology, 2011* ("the Defra Guidance") is of considerable assistance in establishing an assessment framework. The Defra Guidance identifies both quantitative and qualitative criteria ("the Defra criteria") to be weighed and assessed with care and professionalism in adjudicating upon statutory WTN nuisance complaints.

Issue 5: Does the court accept that the criticisms advanced by the defendant undermine the reliability of the plaintiffs' acoustic experts' evidence and the data on which same is based?

In general, no.

In so far as concerns the 2017 external NF data, the 2017 internal HH data and the 2021 internal NF and HH data, the court is satisfied that the audio recordings and associated time domain graphs presented by the plaintiffs' experts, MAS Environmental Ltd

("MAS"), reliably present the general noise character at the plaintiffs' homes. The IOA RM published by the Institute of Acoustics for "rating" AM values is not the exclusive permissible method for presenting and analysing AM. In considering AM values and the general impact of AM on site, regard may therefore be had to the MAS audio recordings (and associated graphs) prepared on foot of the 2017 external NF data, the 2017 internal HH data and the 2021 internal NF and HH data.
MAS's calculation of AM values as derived from the time-domain graphs is sufficiently reliable to inform this court's analysis. The AM levels thereby derived will differ by a reasonably modest extent from those likely to be derived over the same time intervals under the IOA RM.

Furthermore, the impression of AM gained from the audio recordings and time domain graphs is confirmed by the IOA RM analysis performed by MAS of the internal 2021 HH and NF data. Although precise AM values cannot be calculated for the HH master bedroom specifically, one can approximate the relevant AM values by reference to the AM values presenting in another room in the same house.

Due to an inadvertent error, the external NF 2021 audio recordings were recorded at façade level rather than in the free field and furthermore a double skinned windshield was not used. I will therefore have no regard to these audio recordings, to the MAS time domain graphs pertaining to these audio recordings or to MAS's purported IOA RM analysis of this data.

Issue 6: Does an analysis under the Defra criteria support the argument that the characteristics of the WTN amount to a substantial interference with the plaintiffs' use and enjoyment of their land? Yes,
for the reasons which follow:

Sensitivity of the complainant
To quote Henchy J. in *Hanrahan v. Merck Sharp Dohme (Ireland) Ltd* [1988] ILRM 629 ("*Hanrahan*") the *"notions and standards of behaviour and responsibility* [of all four plaintiffs] *correspond with those generally pertaining among ordinary people in our society at the present time, who seldom allows his emotions to overbear his reason,*

whose habits are moderate and whose disposition is equable." In short, the plaintiffs are "*ordinary persons with reasonable objective expectations*".

Level of the noise/ loudness

The noise levels presenting, when combined with other features, give rise to significant potential for dominance and unacceptable intrusiveness.

Type of noise

Even on the most conservative analysis, the MAS audio recordings and time domain graphs show that, at the time of measurement, the WTN at the plaintiffs' homes exhibits AM values in excess of 5 or 6dBA. I accept that this is a regular and sustained state of affairs. Regular and sustained peak to trough differentials of 5 or 6 dBA, if audible at a sufficient level will suggest an unreasonable impact. I find that clearly audible AM values of this order (and higher) are a substantial feature of the WTN at the plaintiffs' homes. Indeed, AM values of 10 dBA are regularly present both externally and internally.

Irrespective entirely of its high AM values, the WTN displays considerable intermittency/variability (when the AM disappears and returns again or fades in and out), impulsivity (sudden changes in sound level) and erraticism (i.e., when AM exhibits no clear periodicity or rhythm). These characteristics are particularly evident in light of the high AM values. The WTN also commonly presents as a clear whoomphing sound and exhibits distinct thump AM, both of which are highly variable and unpredictable. This is WTN that an objectively reasonable person should not be expected to tolerate.

Aggravating features - Spectral content of the noise

Whilst lower frequency noise is not the dominant characteristic of this WTN, there is a significant element of audible lower frequency noise which manifests as thump AM.

Characteristics of the neighbourhood

The character of this quiet rural locality includes a permitted windfarm development. However, the characteristics of the neighbourhood do not include WTN which dominates the plaintiffs' sound environment or WTN which displays excessive AM values, thump AM and other particularly attention drawing characteristics.

The exceedance of WTN over background noise

Planning guidance for wind turbines commonly recommends a "relative noise limit" of 5 dBA over background noise for each windspeed bin. The plaintiffs have not proven on the balance of probabilities that the WTN exceeds background noise by in excess of 5 dBA at a range of windspeeds. On the other hand, as a result of the characteristics of its AM, the WTN regularly dominates the plaintiffs' sound environment.

The impact of the noise on basic needs such as sleep

The World Health Organisation Night Noise Guidelines, 2009 and its Environmental Noise Guidelines for the European Region, 2018 are not of particular assistance in deciding whether this WTN is such as to unreasonably impact upon sleep. I find that the WTN displays characteristics of high AM values and thump AM which have a very high potential to disturb sleep. I find as a fact that, particularly when turning at moderate to higher speeds of rotation, the turbine regularly disturbs the plaintiffs' sleep.

How easily the noise can be avoided/ Measures to reduce or modify the noise

The plaintiffs' ability to avoid the WTN externally is extremely limited. Internally, shutting the windows and attempting to mask the noise may assist. However, such measures will often be ineffective to mitigate sleep impacts in particular.

How often the noise occurs and the time of day or night when the noise occurs

I accept the evidence of the plaintiffs' experts and the plaintiffs themselves that the conditions so demonstrated occur commonly and on a sustained basis. I also accept that these unreasonably intrusive conditions are particularly prevalent during the most sensitive times of the day; in the early morning and at night and in the evenings.

Issue 7: What is the response of the defendant and its experts to the plaintiffs' case? Does the evidence of the defendant's experts suggest that the WTN is not a substantial interference with the plaintiffs' use and enjoyment of their land? No. The defendant's experts have provided no persuasive evidence in response to the points discussed in the above analysis. The defendant's experts did not engage in any meaningful way with the characteristics of the WTN as demonstrated on the audio recordings, time domain graphs and spectrograms prepared by MAS which are identified as amounting to unreasonable interference with amenity.

Issue 8: Did the acoustics experts fail to discharge their duties to the court?

No. I do not find that either Mr. Stigwood (one of the plaintiffs' two acoustic experts) or Mr. Carr (one of the defendant's two acoustic experts) failed to discharge their duties as experts to the court. However, the testimony of both these witnesses, displayed less of a sense of balance than one would expect, which inevitably impacts to some degree upon the weight to be afforded to their evidence.

The defendant's second acoustic expert (Mr. O'Reilly) gave evidence only in relation to planning compliance and offered no evidence on the issue of nuisance.

In assessing whether nuisance is present therefore, I have therefore placed considerable weight upon the evidence of the plaintiff's other acoustic expert, Ms. Large, who I find to be a non-partisan and reliable witness.

Issue 9: Does the court accept the plaintiffs' evidence as to the characteristics of the noise and that such characteristics occur commonly and on a sustained basis?

Yes, for the reasons set out above.

Issue 10: Does the court find that the WTN is a substantial interference with the plaintiffs' use and enjoyment of their land? Is liability in nuisance established?

Yes, for the reasons set out above. Two particular features of the WTN render the noise an unreasonable interference. First, there are frequent and sustained periods of WTN with AM values widely acknowledged to be associated with high levels of annoyance. Second, the WTN exhibits thump AM which is a characteristic known to lead to adverse reaction in the community.

I accept that the noise impact demonstrated on the audio recordings (and associated graphs) occurs commonly and for sustained periods. WTN which exhibits these characteristics on a regular and sustained basis is unreasonable and exceptional.

I find that the plaintiffs' complaints are objectively justified in that the WTN interferes with the ordinary comfort and enjoyment of their homes. When it occurs, this interference is a substantial interference.
While the WTN is liable to annoy during the working day, higher prevailing background noise levels and the fact that the occupants are not trying to relax, or sleep means that, objectively speaking it does not in general substantially interfere with the plaintiffs' enjoyment of their property.

On the other hand, I find that the WTN poses a nuisance to the plaintiffs in the evenings and at weekends when one could reasonably expect to be enjoying recreation in the garden and/or peace in one's dwelling.
Demonstrably the WTN also poses a nuisance at night and in the early morning when a quiet environment is at a premium.
The plaintiffs are entitled to damages for unreasonable interference with the enjoyment of their property. The measure of such damages is for module 2. The issue of whether an injunction ought to be granted and if so the terms of such injunction is also for module 2. Likewise, the issue of whether the plaintiffs ought to be confined to damages in lieu of an injunction is for module 2.

I direct the parties, in advance of module 2, to engage in mediation to devise appropriate mitigation measures and if possible, to resolve all outstanding issues between them.

Issue 11: Does the court accept the defendant's submission that the evidence of Ms. McGinn means that nuisance is not made out in this case?

No. Whether or not interference by way of noise is, to quote Henchy J. in *Hanrahan,* "*beyond what an objectively reasonable person should have to put up with*" will depend on the objective nature of the noise and not on the reaction of particular individuals to the noise. Ms. McGinn's reaction to the WTN whilst undoubtedly of relevance to the issues in the case, does not outweigh the other evidence to the effect that objectively speaking, the WTN is intolerable and unreasonable.

Issue 12: Are Mr. Rollo and Ms. Webster entitled to an award of damages for personal injuries in the form of pure psychological injury?

No.

I reject the defendant's submission that the claim to personal injuries must be struck out as being in breach of s. 12 of the Personal Injuries Assessment Board Act 2003. However, I take the view that reasonable foreseeability of pure psychological injury is a precondition to the award of damages for such an injury. In my view, the defendant could not reasonably have foreseen a risk of either personal injury or recognisable psychiatric illness as a consequence of the noise emitted by the turbines. Mr. Rollo may not therefore recover damages for pure psychological injury even though same was caused by the WTN and its consequences.

Issue 13: Is the defendant guilty of negligence?

No. The parameters of the contended for duty of care and the specifics of any breach of such duty have not been identified with sufficient particularity to establish liability in negligence. In my view, therefore, the plaintiffs cannot succeed in a claim for negligence.

Issue 14: Have the plaintiffs made out a case for relief under s. 160?

Although for reasons already explored, I am not satisfied that the defendant has demonstrated that the WTN complies with the noise condition in the planning permission, this issue was not part of the pleaded case. I am not satisfied that the plaintiffs have made out a case of breach of planning permission on any of the grounds pleaded. As such, the present application pursuant to s.160 must fail.

The legal test for the tort of nuisance

28. As observed by Laffoy J. in *Smyth v RPA*, the definitive statement of what is required to establish the tort of private nuisance is to be found in the judgment of the Supreme Court in

Hanrahan. Henchy J. identified the legal basis of the tort in nuisance as follows:-

> *"To provide a basis for the award of damages for the private nuisance relied on, the plaintiffs have to show that they have been interfered with, over a substantial period of time, in the use and enjoyment of their farm, as a result of the way the defendants conducted their operations in the factory..."*

29. Later in the judgment Henchy J. confirmed that:

"The plaintiff is not entitled to insist that his personal nicety of taste or fastidiousness of requirements should be treated as inviolable. The case for damages in nuisance... is made out if the interference is so pronounced and prolonged or repeated that a person of normal or average sensibilities should not be expected to put up with it. It is not necessary that an interference by objectionable smell should be so odious or damaging that it affects the plaintiffs' health. It is enough if it can be said that a reasonable person in the plaintiffs' circumstances should not be expected to tolerate the smell without requiring the defendants to make financial amends."

30. Thus, to succeed in a claim for nuisance, the plaintiff must show interference with the ordinary use, enjoyment and comfort of their property. As I will come to at para 346 below, nuisance is always assessed by reference to the character of the particular locality.

31. The interference with the ordinary use, enjoyment and comfort of the property must be substantial in the sense that it is pronounced and prolonged or repeated. The intrusion must be "*pervasive, persistent, frequent and intolerable*", per Charleton J. describing noise nuisance in *Lanigan & ors v. Barry & ors* [2008] IEHC 29.

32. In *Lanigan v. Barry,* Charleton J. observed that *"There must be a real and definitive infringement on the comfort and convenience of the persons occupying or using the premises or land in order to establish as actionable wrong".* Furthermore, the temporal quality of the alleged problem is of relevance. Close attention must be paid to the timing, duration and impact of the occurrence complained of.

33. Likewise, the frequency of occurrence must be considered. Occasional, temporary or fleeting events cannot in general give rise to a nuisance However, depending upon the nature of the particular interference in issue, there may be no requirement that the nuisance is continuous and unremitting 24 hours a day. Provided the impact occurs with sufficient regularity and frequency, nuisance may be established even though the relevant interference waxes and wanes somewhat. Further, the same level or character of noise that may not be a nuisance during the day can be a nuisance in the evenings if it regularly disturbs rest and relaxation, or at night if it regularly disturbs sleep.

34. In *Hanrahan,* Henchy J. stated:

"...In so far as the nuisance alleged consists of interference with the ordinary comfort and enjoyment of the property of the plaintiff, his evidence must show sensible personal discomfort, including injurious affection of the nerves or senses of such a nature as would materially diminish the comfort and enjoyment of, or cause annoyance to, a reasonable man accustomed to living in the same locality..."

35. Central to the assessment of whether nuisance is made out in a particular case is therefore the notion of the reasonable person, of which Henchy J. stated:

"To my mind the reasonable man connotes a person whose notions and standards of behaviour and responsibility correspond with those generally pertaining among ordinary people in our society at the present time, who seldom allows his emotions to overbear his reason, whose habits are moderate and whose disposition is equable.

It is clear from the authorities on the law of nuisance that what an occupier of land is entitled to as against his neighbour is the comfortable and healthy enjoyment of the land to the degree that would be expected by an ordinary person whose requirements are objectively reasonable in all the particular circumstances. It is difficult to state the law more precisely than that."

36. Later in the judgment to similar effect:

"As I have pointed out earlier in this judgment, by reference to the cited passage from the judgment of Gannon J in Halpin and Ors v Tara Mines Ltd, *where the conduct relied on as constituting a nuisance is said to be an interference with the plaintiffs' comfort in the enjoyment of his property, the test is whether the interference is beyond what an objectively reasonable person should have to put up with in the circumstances of the case.*

37. The court must try to discern what could reasonably be "*expected by an ordinary person whose requirements are objectively reasonable in all the particular circumstances*". The court is concerned with what could reasonably be expected by an ordinary member of society - the putative objectively reasonable person.

38. What amounts to a material or substantial interference is not judged by what the plaintiff (or indeed any other identified individual) subjectively find annoying or inconvenient. As stated by Laffoy J. in *Smyth v RPA* the "*nub of the matter is whether the evidence establishes that the plaintiffs' complaints... [are] objectively justified*"..;

39. Society is entitled to expect that its ordinary members will exhibit a reasonable degree of tolerance, that they will be guided by a "live and let live" ideology. The question is whether making allowances for that, objectively unreasonable interference is established. The primary focus must remain on the objective nature of the interference itself, rather than on the response of the plaintiff (or indeed the response of any other identified individual). The question is whether the *interference* is objectively unreasonable. The court must hold the balance and the assessment is one of degree, applying the common sense of ordinary people.

40. The onus of proof in establishing nuisance is clearly on the plaintiff throughout. Once, however, nuisance is established, *"it is no defence to such a claim, if established, that the activities complained of were carried out with the highest standards of care, skill and supervision and equipment"* (Henchy J. in *Hanrahan*). Unlike a plaintiff who pursues a claim for negligence, it is not necessary to show any breach of duty of care to succeed in a nuisance action.

41. This case concerns the production of renewable energy, which is clearly of vital importance to the society and to everyone who lives in it. Nevertheless, and correctly in my view, the defendant does not argue that this factor carries decisive weight in determining whether nuisance is established[10]. In *Hanrahan*, Henchy J. stated that it is no defence to a nuisance claim, if established, *"that such activities are of great public importance and cannot conveniently be carried out in any other way"*.

42. On the other hand, however, the public interest may be of relevance in the context of remedy. Although a plaintiff who establishes nuisance has a *prima facie* right to an injunction such that the defendant bears the legal burden of demonstrating that damages rather than an injunction is an appropriate remedy, the public interest must inevitably be a factor in the court's

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assessment of an appropriate remedy. At the very least it means that a generalised injunction ought not to be granted where a tailored injunction more suitable to the particular interference held to constitute nuisance is warranted.

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[10] Note that I deal separately below with the legal relationship between a grant of permission and the entitlement to sue for nuisance arising from conduct that is said to be consistent with that permission.

43. This case comes before the court at a time when existing planning guidance regulating, *inter alia*, the noise aspects of wind farm developments in Ireland, the Wind Energy Development Guidelines, 2006 ("WEDG 2006") is presently under review. Whilst draft revised *Wind Energy Development Guidelines* were published in 2019, ("draft WEDG 2019"), these have now been withdrawn. In the absence of clear policy guidance from the government on WTN, the assessment in an individual case is a classic matter of degree on which the court must exercise judgment. As Henchy J. states "*it. is difficult to state the law more precisely than that*".

44. In terms of damages, it appears that the approach of the Irish courts might differ from the courts of England and Wales in awarding damages for personal injuries to a plaintiff who succeeds in nuisance claim. In this case, choosing between these differing approaches would not be decisive. This is because, in my view, lack of foreseeability would in any event, prevent recovery for the particular personal injuries claimed here - pure psychological injury.

45. Finally, before closing out this brief review of the legal test for nuisance, it is convenient to deal with defendant's submission that the claim of the Carty Shortens for private nuisance should fail, *in limine,* because they no longer own, or occupy NF.

46. The defendant correctly submits that it is an essential element of the tort of nuisance that the plaintiff has a right to occupy the land affected and, further, that the plaintiffs have produced no authority for the proposition that a former owner of an interest in land has standing to maintain a claim for damages for historic nuisance even after the land in question has been sold to a third-party

47. The point, however, is that at the time of the institution of these proceedings in 2018, the Carty Shortens were the owners of NF. In my view, they do not lose *locus standi* as a result of having sold the property during the currency of the proceedings. Rather, they retain an entitlement to advance a claim to damages in nuisance for any unreasonable interference with amenity occasioned during the period of their ownership and potentially for diminution in the sale price. Further argument on heads of damage, and quantum of damages, etc. is a matter for module 2.

Factual evidence

Evidence of Ms. Margaret Webster

General impact of turbines

48. HH and NF are situated in a quiet rural valley close to the Sliabh Bhuí mountains in County Wexford. It was put to Ms. Webster that there were other windfarms in the area, the closest of which is "*some two or three kilometres*" away. Ms. Webster's evidence is that, absent the Ballyduff turbines, ambient noise is generally characterised by the sounds of nature. The rear elevations of both HH and NF are sheltered from the prevailing south westerly winds by a high hill on which the turbines are placed.

49. Although the Ballyduff windfarm comprises two turbines, it is the closer turbine, T2 which is the source of complaint. When T2 is shut down for maintenance, one can still hear T1 turning; but it is not intrusive.

50. When they noticed the turbines being erected Ms. Webster and Mr. Rollo were initially optimistic. They assumed that because of their location in a sheltered valley some distance beneath the turbines, HH would be shielded from impact. However, their view is that the opposite is the case; because HH is so sheltered, the wind rarely approaches the house from a direction that would mask the sound of the turbine. Combined with the prevailing low level of other background noise, this substantially increases the impact of the turbines.

51. Ms. Webster's evidence is that the WTN is annoying and ever changing. The noise varies with wind direction and windspeed which dictate blade orientation and speed of rotation respectively. Windspeed is of more obvious influence than wind direction; in general, the faster the rotors turn, the worse the noise. In addition, time of day and weather impact on the intensity of the WTN. The noise is considerably louder at night and in winter. It also varies according to whether there is rain, cloud cover or clear skies. Taking into account atmospheric conditions, the effect of the WTN is more often than not *"very intense"*. Ms. Webster recounts that when the noise and vibrations from the turbine are intense, she experiences a feeling of anxiety and overall unease that she cannot shake off.

52. Ms. Webster's evidence was that, when turning quickly, T2 emits a range of distinctive sounds. In addition to a swishing sound, it emits *whoomph* and *whump* sounds and intermittent louder *thumping* or *whacking* noises. These sounds are often accompanied by disturbing vibration, meaning that she could regularly *"feel"* as well as hear the noise. This is perceived as pressure coming from the air as the blades rotate, which feels like *"a pummelling inside* [her] *body"*. All of this, Ms. Webster states, is a frequent characteristic of the WTN, particularly at night.

53. The noise is highly variable and unpredictable in loudness, intensity and character. It can change from a *thump thump* or a *whump whump* to a kind of *whack whack* noise within minutes or even seconds. The noise can dissipate overnight and then pick up in the morning or the opposite can happen.

54. In cross-examination, Ms. Webster fully accepted that there are periods, perhaps for several days at a time, when the noise is not intrusive. When turning slowly, T2 makes a light whooshing sound which is quite consistent. At times, particularly during the summer, this sound might be barely audible inside the house. However, she stated that, for the most part, particularly in the wintertime, the noise is more rather than less intrusive. As a very broad guess, Ms. Webster estimated that the noise is intrusive 80% of the time.

55. The turbine is audible both outside and inside the house at all times of the day including at night with the windows closed. It is audible in all rooms of the house even in the sitting room which was the furthest room away from the turbine. When the turbine is rotating quickly, the WTN is not merely audible but dominant both inside and outside the house, with the windows open and closed. The sounds of daily activities such as boiling a kettle, using the washing machine or watching television generally mask the WTN. However, without such masking noise, one can hear the WTN in all areas of the house, The WTN frequently intrudes to the extent that Ms. Webster finds it difficult to concentrate or relax. At its worst, and particularly at night, Ms. Webster described a sensation of being able to hear and feel every rotation of the turbine. Ms. Webster accepted that other sounds - such as passing cars or farm machinery- might also occasionally be heard in her bedroom with the window closed. However, such noise ceases at a certain point in the day. By contrast, when it is turning rapidly, the noise and vibrations of the turbine intrude into Ms. Webster's bedroom, even when the window is closed, on a "*24/7*" basis.

56. The HH master bedroom is at the front of the house, but its gable wall faces broadly (if obliquely) towards T2. It was put to Ms. Webster that the defendant's experts would say that it was "*beyond the realm of physics*" that the WTN could be heard in the master bedroom at the front of HH, but the defendant's experts did not give such evidence. Although Mr. Carr did not hear WTN in the master bedroom of HH at the time of his site visit, he only spent between five and ten minutes in the bedroom on this occasion.

57. Ms. Webster's evidence was that the WTN and vibrations pass through the gable wall into the master bedroom. She stated that, in her experience, the WTN was much louder, more annoying and more easily audible than it appeared on the internal audio recordings taken by her experts in HH in 2017 and 2020/2021.

58. Prior to the erection of the turbine, Ms. Webster had slept well. Her evidence is that the WTN causes three different kinds of sleep disturbance. The first is difficulty in falling asleep. Ms. Webster states that there have been countless nights when she can hear the WTN in her bedroom and needs to use music or other background sound to distract attention from this unpleasant sound and aid sleep. This occurs at least ten times a month. Second, when the WTN is at its worst, it can completely wake her up "*bolt upright*". What wakens her is not so much the absolute level of the noise but a change in its character which has a jarring effect, particularly if she is in a light sleep. These sudden awakenings occur ten to fifteen times a year. Third, even when the WTN is lower, there is a general detrimental impact on sleep quality; although she would sleep through the night, Ms. Webster nonetheless wakes exhausted. To mitigate the noise from the turbines, Ms. Webster tried to sleep with the windows closed as often as possible, which particularly, in the summer months can be quite uncomfortable.

59. Ms. Webster also described shadow flicker, which occurs in early spring and late summer, as follows; *"the light on a sunny day would change from the kind of dappling light that occurs when sunlight comes through trees to a full shadow falling suddenly followed by an instant return of light."* This would herald alternate periods of darkening and lightening occurring with great rapidity. Shadow flicker occurs in the valley in front of HH, in their garden and on the walls or floors of rooms in their house. It is very difficult to escape the flicker which is visible even with the curtains drawn. Although shadow flicker would only be inside the house a couple of weeks a year, it is present in the valley and garden for longer periods which is still disconcerting.

Interactions with Mr. Brazil

60. In July 2017, the Webster Rollos alerted the director of the defendant company, Mr. Brazil to their experience of the noise. Initially, Mr. Brazil suggested improving their windows and insulation towards which he would contribute €4,000. The Webster Rollos felt that insulation was a large financial undertaking which would not in any event be effective as against low frequency WTN.

61. On 14th August, 2017, Mr. Brazil and Mr. Conor Brennan attended HH for a meeting with the Webster Rollos and the Carty Shortens. As an alternative to contributing towards the cost of insulation, Mr. Brazil suggested that the plaintiffs sign a *"noise acceptance agreement"* pursuant to which they would receive an annual inflation linked payment of €4,000 per annum for the duration of the planning permission for the turbine. This agreement would be noted on the title deeds of HH (and NF) and would bind all purchasers thereof. A further requirement of the agreement was that Mr. Brazil would have a right of first refusal if their property was ever put on the market.

62. The plaintiffs asked Mr. Brazil if the turbines could be turned off or turned down at night or at weekends. This request was not acceded to.

63. Mr. Brazil also informed the plaintiffs that it would be possible to install a computer programme to turn off the turbines when there was a risk of shadow flicker. However, this proposal was not actioned by the defendant.

64. A few days after the August 2017 meeting, Mr. Rollo telephoned Mr. Brazil to reject the proposal of a noise acceptance agreement, and an initiating letter followed from the plaintiffs' solicitor. It was suggested to Ms. Webster in cross examination that this rejection had been premature as the proposal of €4,000 per annum was *"just opening negotiations"* which could have continued were it not for their solicitor's correspondence. Ms. Webster's response was that they wanted to enjoy living in their house and did not want to be paid to endure the noise.

Impact on the Webster Rollo relationship

65. Ms. Webster's evidence was that after a few years of living with the turbine, her 16 year relationship with Mr. Rollo started to disintegrate. In Ms. Webster's view the pervasive noise and ongoing lack of sleep caused by the WTN was a significant factor in the destruction of the relationship. Her belief is that the WTN brought the couple to the stage where they were both so exhausted, discouraged and low that they could no longer fight for the relationship. Ms

Webster was worried for Mr. Rollo's safety and well-being, and she suffered episodes of panic and tearfulness.

66. By December 2020, it was obvious that Mr. Rollo needed to remove himself from the situation and wait out the legal process. In early 2021, the couple having made the decision to separate in any event, Mr. Rollo moved out of HH. This was clearly a very low point for both Ms. Webster and Mr. Rollo.

Noise diaries

67. Ms. Webster (and for the majority of this time, Mr. Rollo) kept a noise diary from August 2018 to October 2021. This diary chronicles their experience of the WTN, both day and night.

68. The Webster Rollo noise diary records intrusive, unpredictable WTN varying in intensity. In harmony with their oral evidence, the diary describes, whoomphing, thumping, banging, hacking, slapping and whacking sounds. It regularly records that the house vibrates and hums with these sounds which appear to hit the gable wall of the master bedroom and come through the walls and ceilings. The diary very regularly records the couple's inability to have a restful night's sleep and the exhaustion which follows.

69. An intermittent but consistent feature of the diary is that it records the Webster Rollo's relief and gratitude when the turbines are quiescent marred by trepidation of the inevitable recommencement of the noise. The strong impression is of being unable to control one's own private environment which is dominated by the turbine. Ms. Webster encapsulated this in stating that she and Mr. Rollo felt "*at the mercy of whatever way the turbine was going to be acting on a particular day to ensure that it produced a maximum output of energy.*"

70. Ms. Webster was cross-examined at length about entries in the couples' diary. Counsel for the defendant noted that she occasionally records "*I can hear the turbine*" (or words to similar effect) and suggested that she was therefore intolerant of any level of audible WTN, particularly at night. Having reviewed all of the diary entries, it is abundantly clear that Ms. Webster and Mr. Rollo do not equate mere audibility with nuisance. The evidence is that, when turning slowly, the light noise produced by the turbine is not a cause of nuisance even if it can be heard internally. What primarily disturbs Ms. Webster's relaxation and sleep is when the turbine is turning "full tilt". At such times, there is no respite anywhere in the house irrespective of whether the windows are open or closed. Ms. Webster stated: "*I can tell you with honesty and with certainty it wakes me from my sleep*". It was also suggested to Ms. Webster that her diaries were overly dramatic. She accepted that some of her entries focussed on her poor experience but that there were also other more routine entries. This is correct.

71. The primary theme of this cross-examination was by way of a compare and contrast exercise as between (a) particular diary entries, (b) a ten minute extract from the SCADA[11] data recorded at T2 pertaining to the same 24 hour period as the diary entry and (c) the SCADA data at the time of the court's site visit. Counsel noted that Ms. Webster - and indeed all of the plaintiffs - had confirmed that at the time of the court visit, the WTN was not intrusive either externally or internally. It was suggested to Ms.

[11] The SCADA data records windspeed, speed of rotation, blade orientation and power output at ten minute intervals.

Webster that this compare and contrast exercise showed that, even when the SCADA data revealed identical conditions to those then pertaining at the time of the court's visit, the diaries still record high levels of nuisance[12].

72. However, any such exercise will be heavily influenced by the precise segment of SCADA data chosen as a comparator with the relevant diary entry. Given that the plaintiffs' unanimous experience is that the WTN can change in character within a matter of minutes, there is little weight to be attached to a disconnect between an isolated 10-minute segment of SCADA data and the correlating diary entry which seeks to summarise the main features of the WTN over the preceding 24 hour period. It is also important to bear in mind that, often several diary entries might even be completed together in a "clump" after a few days.

73. By way of example, Mr. Rollo's diary entry for 19th August, 2018 reads –"*Awakened by turbine again! Left for work at 5.30 extremely noisy. Turbine quiet late afternoon.*" Counsel for the defendant cross examined Ms. Webster (and not Mr. Rollo who authored the diary entry

in question) by reference only to 10 minutes of SCADA data ending at 5.30 am. This SCADA data shows that windspeed, speed of rotation and wind direction were similar to those pertaining at the time of the court's visit. However, when plaintiffs' counsel re-examined Ms. Webster by reference to the full 24 hour SCADA data it became clear that earlier in the night, both windspeed and speed of rotation were significantly higher (particularly between midnight and 3 am approximately). It was also evident that, as noted by Mr. Rollo, both windspeed and speed of rotation dropped in the late afternoon.

74. The same limitation applies to the cross examination conducted by reference to Mr. Rollo's, dairy entry of 8th September, 2018 which records :"*Kept awake by turbine all night. Noise the same all day.*" The SCADA data for 4 am - on which Ms. Webster was cross examined - shows windspeed and speed of rotation only modestly above levels recorded at the

[12] I have been informed that the 10 m standardised windspeeds at the time of my visit varied between a minimum windspeed of 3m/s and a maximum windspeed of 6.2 m/s with 10 minutes averaging between 4.1 and 4.8 m/s over the time of the visit.

time of the court visit. However, the complete SCADA data for the day in question reveals higher windspeeds and speeds of rotation for the night hours both before and after this particular time. It also records higher windspeeds and speeds of rotation throughout the bulk of the day (particularly from 2.30pm).

75. Ms. Webster also emphasised that in addition to windspeed and speed of rotation , wind direction and weather conditions have a huge impact on how noise and vibration would be experienced. The latter two of these factors are not captured by the SCADA data. She further emphasised that one should not interpret a particular diary entry in isolation. Rather, entries have to be placed in the context of the days that surround them. Several days of lack of sleep tend to wear one down, reduce tolerance and increase frustration levels which might naturally influence diary entries later in the relevant sequence.

76. This in my view is the case for Ms. Webster's diary entry of 3rd December, 2021 which records: "Turbine very loud all day and night. Turing very fast and "aggressive" almost when outside feels like I'm being pummelled by force from turbine if I stand in back yard near driveway". Counsel pressed Ms. Webster on a 10 minute segment of SCADA data captured at 2pm on 3rd December. Such an exercise entirely glosses over the fact that the preceding night's SCADA data - again only put to Ms. Webster in re-examination - shows that windspeed and speed of rotation were indeed high. This dovetails with Ms. Webster's diary entry for 2nd December which records "very loud" noise that night. A different picture however emerges during the day of 3rd December. Although I accept that Ms. Webster's experience of being "pummelled" occurred when she went outside late in the evening (at which stage the wind had picked up), it is fair to say that the SCADA data suggests that during much of the day windspeed and speed of rotation were not high when compared to conditions at the time of the court's visit (indeed they are generally lower). The point, however, is that this entry followed what could fairly be described as a bad week. Ms. Webster describes the WTN during the preceding week as "very noisy", as making "whooshing and clapping" sounds at night and "very distracting". As stated, it is also recorded as "very loud" overnight on 2nd/3rd December. Ms. Webster was not challenged on any of these entries, whether by reference to the SCADA data or otherwise. Ms. Webster also records an earache for the whole of the preceding week which of course will accentuate the impact of WTN (and, I assume of all noise). In reality, the entry for 3rd December, 2021 is probably more consistent with Ms. Webster's experience of the week as a whole than with the specific day it records. The entry also supports the impression of Prof. Kevin Gournay, Chartered Psychologist - who gave evidence on behalf of the plaintiffs - that Ms. Webster's level of tolerance of the WTN is decreasing over time. Overall, I find that the entry for 3rd December, 2021 represents a rare and uncharacteristic occasion on which Ms. Webster allowed her more generalised frustration – most likely accentuated by physical discomfort resulting from persistent earaches - to bleed into a specific diary entry. Whilst I accept Prof. Gournay's view that such increasing sensitivity is not unusual, I have nonetheless been cognisant of it.

77. In my view, the themes pursued in this part of the cross examination ought to have been put to the plaintiffs' experts-which did not occur. This is because, whilst it is clear that windspeed and speed of rotation heavily influence the level and characteristics of WTN, a range of other factors are also highly relevant. Such factors include relatively small changes in wind direction and blade pitch and, as Ms. Webster states, prevailing meteorological conditions. These factor all influence thump AM, which is described as the most intrusive aspect of the WTN at Ballyduff. Demonstrably, Ms. Webster, as a lay witness, is unqualified to explain such matters. Rather, she stated that the diary is intended to be experiential and deferred to experts to explain what factors might influence or explain the characteristics of the WTN which she records in her diary entries.

78. Overall, I find that Ms. Webster's diary entries, like her oral evidence, presented a balanced and truthful account of her experience of the WTN. I make a similar finding in relation Mr Rollo's diary entries up until mid to late 2020[13]. From over three years of diary entries, the defendant pointed to only a handful of diary entries which it contends are inconsistent with the SCADA data. Of these, I find that only one – that of 3rd December, 2021 – can fairly be characterised as inconsistent with the SCADA data for the day on question. Further, this inconsistency pertains to only part of the relevant 24 hour SCADA data and further arises only if one considers the diary entry in isolation from the week of which it forms part. As Ms.

[13] See para 461for an analysis of Mr. Rollo's reaction to the turbine from mid to late 2020.

Webster states: "*We are people living in our home; it is not a scientific experiment, it's our home and we are experiencing this on a continuous basis*". Bearing in mind the quality of other evidence supporting Ms. Webster's account of the overall characteristics of the WTN, I attach very little weight to a frailty in a single diary entry.

Evidence of Mr. Keith Rollo

79. Mr. Rollo has worked as a rigger for many years and is accustomed to heavy machinery and loud noise. The WTN is highly variable and unpredictable. He described it as horrendous during the winter months when its accompanying vibration penetrates the fabric of the building throughout the house. Mr. Rollo shared Ms. Webster's view that the internal audio recordings taken in HH under-represent the general impact of the WTN in the house. This is partly because, as Mr. Stigwood explains, human hearing is directional (in the sense that one is more conscious of a sound from a specific source) and also because the audio recordings could not convey the sense of vibration and pressure that is felt in the house.

80. The impact of the noise affected Mr. Rollo most profoundly through his sleep. At night, the turbine frequently makes a thumping, whacking and slapping noise; like the side of the house was being hit by something. When it was suggested to him that shutting the windows would diminish the sound, Mr. Rollo accepted that the turbine is less noisy with the windows closed. However, although on windy winter nights he would sleep with the windows closed, Mr. Rollo's general preference is to sleep with the windows slightly open. In any event, Mr. Rollo stated that, even with the windows closed, and despite wearing professional noise cancelling headphones, the noise and vibrations caused by the turbine still disturbed his sleep.

Like Ms. Webster, Mr. Rollo's sense is that the noise and vibrations come though the walls of the house. At times, the whole house vibrates with the noise. As a result, all attempts to mask the WTN using both professional noise cancelling headphones and industrial earplugs (which

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he had obtained from work) were unsuccessful because, he could still feel the noise "*through my bones*".

81. When unable to sleep, Mr. Rollo moved to the sitting room because it was at the front of the house and did not have a gable wall facing the turbine. Although the noise intruded, as it did in every room of the house, he would try to sleep with the television on to mask it.

However, Mr. Rollo's sleep pattern remained extremely disrupted, and on many nights, he would get no more than two hours sleep. This meant that he frequently rose feeling exhausted and stressed. This exhaustion was hazardous as Mr. Rollo's job involves working at heights.

82. Mr. Rollo's evidence was that the constant noise and lack of sleep "*broke* [him] *down*". He developed mental health problems and ultimately contemplated suicide. In late 2020, Mr. Rollo's solicitor became concerned and referred him to Prof. Gournay who recommended that he see his General Practitioner, Dr. Ford. Dr. Ford in turn referred Mr. Rollo into a self-harm counselling programme where he attended ten or twelve sessions. After the conclusion of this programme, Mr. Rollo's employer arranged further counselling which concluded very recently.

83. In early 2021, Mr. Rollo accepted that because of the dark thoughts he was having, he had to leave the house urgently. He moved out in March 2021, initially staying with family friends. Mr. Rollo's current residence is about half an hour from HH in an estate in Wexford town.

84. On leaving the house, Mr. Rollo's sleep pattern initially improved but then disimproved again. He is still suffering from depression and continues to take anti-depressant medication.

Evidence of Ms. Joan Carty and Mr. Ross Shorten

85. Ms. Carty and Mr. Shorten owned NF until comparatively recently and sold it to Ms. Maura McGinn in August 2021 (as to which see further below). Ms. Carty described the range of sounds emanating from the turbine, the most difficult and intrusive of which is a loud whomping or thumping sound with associated reverberation and vibration. This loud whomping and thumping noise is very hard to listen to for any period of time and is audible from every room in the house. Mr. Shorten's evidence was to a similar effect; he recounted that the noise, the vibration and the sense of pressure in the air are overpowering and upsetting.

86. The couple's evidence was that as a result of the WTN, and its associated vibrations, it was impossible to sleep in the master bedroom, even with the window closed. The noise intrusion forced them to vacate the master bedroom which is a dormer and move to a somewhat quieter bedroom downstairs. However, the WTN still disturbed their sleep.

87. Because of the WTN, Ms. Carty and Mr. Shorten no longer enjoyed visiting NF. They found the WTN to be extremely intrusive during a 5 day period they spent working on the patio outside their house in August 2017. Even with a music speaker outside to try and mask the WTN (albeit at a volume at which they could still converse), they were disturbed by the whomp whomp sound as the blades cut through the air. Ms. Carty said that after the turbine started turning, she never again sat on the patio to read. In addition, they stopped having guests to the house because they were embarrassed about the noise and intrusion from the turbine.

88. When the couple raised these difficulties with Mr. Brazil, he indicated that he might, in due course, be prepared to buy NF as he had known that it had was previously on the market. He also arranged for monitoring equipment to be installed at NF on the understanding that the results would be furnished to the Carty Shortens. Although Mr. Shorten requested this data both verbally and in writing, it was never furnished.

89. The couple's evidence was that the house was placed on the market in September 2018 and was ultimately sold at a price significantly below its full value, to Ms. McGinn.

90. Two additional witnesses as to fact were called by the plaintiffs.

Evidence of Ms. Maura McGinn

91. The plaintiffs called Ms. Maura McGinn, the current occupant of NF. She purchased NF from the Carty Shortens on 12th April, 2021. Ms. McGinn stated that the WTN was pretty obvious when she viewed the house. She knew that she could not have afforded to buy the house were it not for the presence of the turbines.

92. On her first night in the house, Ms. McGinn was shocked by the WTN which was exceedingly loud and kept her awake. Ms. McGinn was concerned that she made a mistake in purchasing the house and worried that she would be unable to sleep in the master bedroom upstairs. However, Ms. McGinn "persevered" and continues to sleep upstairs.

93. Ms. McGinn does not generally spend the whole week in the house as she works in Dublin a few days a week. When she is going to bed at night, the rhythmic nature of the noise can *"get in on"* her and it can be hard to fall asleep. Alternatively, she might wake to the WTN and then find it more difficult to get back to sleep. As she points out, when you hear the turbine, it is very difficult to un-hear it. Overall, although the turbine can interrupt her sleep, Ms.

McGinn stated she was a good sleeper.

94. The turbine generally makes noise all the time, apart from on very still days. The noise outside is louder and stronger. Inside the noise is much quieter downstairs, but it can definitely be heard upstairs. Ms. McGinn describes the noise as a "*whoomph, whoomph, whoomph kind of noise*".

95. In general, Ms. McGinn is careful not to focus on the noise and tries not to let it bother her. She would be afraid that if she did focus on the WTN for too long, it would start to get in on her.

96. Ms. McGinn is from a large family and lots of people come to visit. She finds herself being quite defensive of the turbine and therefore warns her family about the turbine before they visit. Whenever workmen come to the property, they refer to the turbine and to the noise. Her surveyor recommended that she put in additional insulation for the house. Although she followed this advice, this made no real difference in the noise levels.

97. Under cross-examination, Ms. McGinn confirmed that she did not regret buying the property. Her first night in the property had been a particularly noisy night and her general approach is to try not to pay too much attention to the turbine. She has managed to get used to the noise or has learnt to ignore it such that she conceded[14] that *"it doesn't seem... to be creating a terribly great problem for[her]in [her]enjoyment of the property"*.

Evidence of Ms. Ashley Doran

98. Ms. Ashley Doran lives at Ballyduff. Ms. Doran's house is located 313 metres from the Webster Rollo's house. There is a distance of 601 metres between T2 and Ms. Doran's house and a distance of 808 metres between T1 and Ms. Doran's house.

99. Ms. Doran stated that the turbines make a deep, heavy reverberating noise which she describes as groaning and whomping sounds. Reverberations are experienced both inside and outside the house. The WTN is disturbing and disorientating making it hard to focus or concentrate. On occasion the intensity of the sound and vibration makes her dizzy and queasy. At times, the sound of the turbines hurts her ears. It is difficult to cope with the inconsistency of the WTN which varies from *"quiet"* to *"thunderous"* depending on the meteorological conditions. The WTN disturbs her sleep and Ms. Doran has started sleeping in the room furthest from the turbine. Both she and her husband sleep with earphones which they use to mask the sound of the turbines. Overall, although Ms. Doran's husband, finds the turbine *"a bit annoying"* he manages to put it out of his head and get on with things.

Evidence of Mr. John Brazil

100. Mr. Brazil, who is an experienced developer of on-shore windfarms, and director of the defendant company gave evidence to the following effect. WTN will always be greatest directly downwind. In his view, the higher noise levels on the MAS NF crosswind planning compliance graph[15] was not reflective of WTN but of extraneous noise. Mr. Brazil's view is that the Ballyduff WTN is not abnormal or out of the ordinary as regards either to its noise levels or its AM. In his experience, the AM was of normal "blade

[14] In answer to a question posed by counsel for the defendant.
[15] As to which see para 115 above and para 335 -340 below.

swish" variety. However, he accepted that he had only been on the plaintiffs' properties for very limited periods of time. Mr. Brazil accepted that from time to time, there would inevitably be audible windfarm noise internally at both HH and NF. He maintained however that there would be no real audible noise in the HH master bedroom or that it would be "*very very low*".

101. Mr. Brazil confirmed that although the audio recordings taken by the plaintiffs' experts accurately recorded the sound where the microphones were placed, these were only "snapshots" and would not necessarily be typical of the normal day to day experience of the

windfarm. This assertion was not taken up by the defendant's experts who did not suggest that the audio recordings were unrepresentative of general WTN at the measurement locations.

102. Mr. Brazil accepted that he had not asked his experts to assess the character of the WTN. He had not requested them to either listen to or asses its AM or other characteristics. Rather, he had relied entirely upon the fact that the planning compliance graphs prepared by his experts showed that external noise measurements were compliant with the planning permission and with WEDG 2006. Mr. Brazil also confirmed that if WEDG 2006 had applied at the time of the Ballyduff planning application, planning permission would not have been granted for turbines within 500 metres of an existing house without consent of the householders.

103. Mr. Brazil also indicated that the average capacity factor for the windfarm would be in the mid-30s per cents. This means that most of the time, the wind is insufficient for the turbine to operate at full capacity. Even on a very windy week one would anticipate only a 50% capacity factor.

<u>Site visit</u>

104. As agreed, the court carried out a site visit on 1st December 2022.

105. The plaintiffs' residences are in the lee of a high hill on which the turbines are situate. T2 is clearly visible on a height behind the houses. The dwellings are off a minor road in a quiet and tranquil rural area, which is sparsely populated. The ambient sounds of the locality are those generated in the natural environment such as wind noise, foliage stirring and birdcalls. One could also expect the usual array of domestic sounds from human activities and the sounds of the Webster Rollo's dogs. In addition, although not apparent on the day of the court visit, I gather one encounters the sounds of farm machinery and local traffic. There are no other businesses in the area.

106. At the time of the court's site visit, it was a dry, mild day. One could discern that HH and NF are in a sheltered location almost scooped into the hill. The air was very still close to the plaintiffs' houses. Having said that, bearing in mind the clement day, the wind was generally quite calm even some short distance away from the plaintiffs' houses. Indeed, at the time of my visit, average 10 minute 10 m standardised windspeeds for T2 varied between only

4.1 m/s and 4.8 m/s and T2 was rotating only slowly.

107. The WTN was audible outside and inside both houses including in the master bedroom at NF and in the master bedroom at HH with the windows open (but not with the windows closed). When asked, all four plaintiffs expressed the view that although it was audible both inside and outside their houses, they would not consider the WTN presenting at the time of the court's visit to be intrusive. I am in agreement with this assessment.

<u>Brief Overview of Expert Evidence</u>

Acoustics experts called by parties

108. The plaintiffs called two acoustics experts. Mr. Mike Stigwood, a qualified environmental health officer, is an Environmental Health Consultant and Acoustician and Director of MAS. At the time of reporting, Ms. Large was a Senior Acoustic Consultant at MAS.

109. The defendant also called two acoustic experts. Mr. Shane Carr, a qualified environmental health officer with a post graduate diploma in acoustics and is a Director of Irwin Carr

Consulting. Mr. Brendan O'Reilly is an Acoustic Engineer and Director of Noise and Vibration Consultants Ltd.

110. Although I will now briefly summarise the evidence of the acousticians, I will in due course consider same in more detail as I proceed through my analysis of key issues in the case.

This will unavoidably involve some repetition, which I will attempt to keep to a minimum.

111. Later in this judgment, I will also consider the arguments advanced by each party that the opposing acoustics experts failed in their duty to the court.

Noise data presented by plaintiffs' experts

112. Ms. Large carried out two noise surveys at the plaintiffs' houses between 10th November, 2017 and 15th December, 2017. Monitoring equipment was set up which recorded long term high quality - 100 milli-second audio - internally at HH (on foot of which the "2017 HH internal data"[16] was derived) and externally in the garden / patio area at the rear of NF, (on foot of which "the 2017 NF external data" was derived). The internal HH audio recordings were recorded by a microphone placed in a home office/bedroom on the ground floor at the back of HH. Audio was recorded with the window both open and closed. The external NF audio recordings were recorded with a microphone placed approximately 3.5m away from the house façade-which is an appropriate free field location. Where relevant, I refer to this collectively as

"the MAS 2017 data".

113. The second noise survey was carried out in December 2020 and January 2021. Due to Covid restrictions, neither Ms. Large nor Mr. Stigwood could travel to Ireland and the

[16] In each case, such data consists of audio recordings, time domain graphs of the said audio recordings and spectrograms showing the correlation between the noise and spectral frequency. Where applicable I refer to these graphs collectively together as "the associated graphs" [17] It appears that this only came to light shortly before the trial.

monitoring equipment was sent to Ireland and set up under their instruction by the plaintiffs' solicitor. Audio recordings were recorded internally at HH between 4th December, 2020 and

19th February, 2021 (on foot of which the "2021 HH internal data" was derived) and internally at NF between 22nd February, 2021 and 10th March, 2021 (on foot of which "the 2021 NF internal data" was derived). Finally, there was also an external survey at NF between 10th March, 2021 and 21st May, 2021 (on foot of which "the 2021 NF external data" was derived). The internal HH audio recordings were recorded with a microphone placed in the same home office/bedroom as in 2017. The internal NF audio recordings were recorded with a microphone placed in the master bedroom of NF, which is a dormer at roof level. Once again, the windows were sometimes open and sometimes closed. The external NF audio recordings were recorded with a microphone which, inadvertently, was placed closer to the exterior façade than would be appropriate for free field measurements[17]. It also appears that, again inadvertently, the microphone was not protected with a double skinned windshield. Where relevant, I refer to this collectively as "the MAS 2021 data".

114. The evidence tendered on behalf of plaintiffs as describing or representing the WTN noise at HH and NF was therefore advanced in a number of ways, as follows:

i. The factual evidence of the plaintiffs, Ms. Doran and Ms. McGinn as to their experience of the noise on site

ii. extracts from Webster Rollo diaries,

iii. factual and opinion evidence from Ms. Large and Mr. Stigwood as to their personal experience of the noise on site during their site visits in 2017 and 2021.

iv. (as just described at para 112 and 113 above) long term high quality 100 millisecond audio of the sound taken within the dwellings and in the patio of NF. Approximately 25 of these audio recordings were played to the court ranging in duration form 30 seconds to 10 minutes [17]Certain internal audio recordings were played to the court in a sound studio. These audio recordings were tendered to demonstrate the features of

[17] Disregarding, the 2021 NF external audio recordings, approximately 25 external and internal audio recordings were played to the court. The vast majority of the internal audio recordings played to the Court were recorded with the window slightly ajar.

the WTN such as its dominance, the presence of both swish and thump AM and the erraticism of the AM;

v. 100 millisecond time-domain graphs (i.e., temporal graphs plotting the noise levels against time) presenting the audio recordings at iv above. The MAS reports included approximately 100 of these graphs[18] ranging in duration from 25 seconds to 25 minutes. These graphs were tendered to demonstrate the features of the WTN such as its AM values[19] and the presence of thump AM;

vi. graphs plotting the WTN by frequency spectra (spectrograms) together with graphs comparing the noise on site to permitted levels of low frequency noise. These graphs were tendered to demonstrate the presence and significance of thump AM;

vii. opinion evidence from Ms. Large and Mr. Stigwood and, to a limited extent Mr. Mayer, in respect of all of the aforesaid;

viii. in respect of the AM specifically, Mr. Stigwood prepared further graphs on foot of the MAS 2021 data by way of purported IOA RM analysis. The IOA RM is explained at paras 194 *et seq* below)[20].

ix. Mr. Stigwood also prepared a planning compliance graph in respect of NF demonstrating noise levels in crosswind conditions (at the wind quadrant northwest

through to northeast[21]). I will refer to this as "the MAS NF crosswind planning compliance graph"[23]

Evidence of Ms. Sarah Large and Mr. Mike Stigwood

115. Mr. Stigwood accepted that Mr. O'Reilly's planning compliance graphs demonstrated planning compliance in the downwind direction using the ETSU methodology. By

[18] Ms Large's first report includes approximately 55 separate time domain graphs- approximately 30 external NF graphs, and 25 internal HH graphs (most of which were recorded with the window ajar). Ms Large's second report includes approximately 20 further internal HH time domain graphs (with the window ajar). Mr Stigwood's first report includes approximately 10 further internal HH time domain graphs (with the window ajar) and approximately 20 internal NF time domain graphs (with the window ajar). As stated, I disregard, the 2021 NF external data.

[19] An example of two of these graphs is to be seen at paras 434 and 435 below.

[20] Mr Stigwood's IOA RM graphs of the internal NF and HH data as derived from the noise monitoring on site is attached at para 451.

[21] In this respect, Mr. O'Reilly's planning compliance graphs all relate to directly downwind conditions. [23] This is attached and further discussed at para 335 below.

contrast, his evidence was that the MAS NF crosswind planning compliance graph showed a fairly consistent exceedance of the noise limits in the permission.

116. However, MAS's overall opinion was that planning compliance (and planning guidance generally) was of limited relevance to the nuisance assessment. They view planning control and nuisance as separate frameworks with different aims and objectives. The purpose of the planning system is to regulate the development of land in the public interest. Planning authorities perform their functions by reference to a range of environmental, social, economic and policy considerations. Although they will consider the potential effect of proposed development on the amenity of any neighbouring properties, planning authorities are not obliged to give this factor any particular weight in the assessment. By contrast, MAS state that the impact on amenity will be the key consideration in a nuisance assessment.

117. Ms. Large and Mr. Stigwood consider that the Defra Guidance, which assesses both qualitative criteria (dominance, erraticism, impulsivity and variability etc) and quantitative criteria (decibel level, AM values) provides a more suitable methodology for the assessment of nuisance. In contrast to planning controls which proceed on the basis of external noise measurements only, the Defra Guidance recognises that as most complaints of noise nuisance relate to sleep disturbance, internal monitoring should be undertaken to see whether it corroborates complaints.

118. MAS also contended that *BS 4142:2014-Method for rating and assessing industrial and commercial sound* (BS 4142) provided a useful methodology of assessment of WTN nuisance.

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119. The results of the 2017 and 2021 external and internal noise monitoring were presented and analysed in four separate expert reports prepared by Ms. Large and Mr. Stigwood [22] which were extensively opened in evidence to the court. As stated, Mr. Stigwood also played extracts from the audio recordings to the court.

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[22] MAS reports dated: 27th June, 2018, 12th January 2021, 3rd October, 2022 and 6th November, 2022.

120. Ms. Large and Mr. Stigwood observe that the plaintiffs' houses are in wind shadow and that the area is extremely quiet. In Mr. Stigwood's opinion, absent the windfarm, this would be a *"low noise environment"* as defined in WEDG 2006.

121. In Ms. Large's view, the plaintiffs' noise environment was entirely dominated by the WTN on every day of her lengthy noise survey. Moreover, the period of adverse impact was almost continuous. The WTN causes a stark and significant change in the sound environment which will be perceived as a doubling of the overall loudness, and at times, a quadrupling of the overall loudness. MAS was of the view that WTN exceeds background noise by considerably more than 5 dBA.

122. In Ms. Large's opinion, the impact is further exacerbated by excessive AM values, thump AM and the overall unpredictability of the WTN which means that one cannot predict and plan, adding a further layer of intrusion. MAS's evidence is that the 2017 and 2021 data demonstrates that long periods of high AM value are a very common feature of this WTN. In

Ms. Large's view, the 2017 data shows that the levels of AM frequently modulate by 10 dBA and that AM values in excess of 13 to 15dBA are common. In MAS's view, the audio recordings also demonstrate prominent thump AM. Spectrum analysis confirms the presence of lower frequency noise, which is heard as thump AM, felt as vibration and perceived as a sense of pressure. This is a particular feature of the internal environment in HH. The 2017 and 2021 data also shows that the AM is impulsive (with a pattern of rapid rise and fall), erratic (with no clear periodicity or rhythm) and intermittent/variable (it disappears and returns again or fades in and out). Mr. Stigwood's view was that, due to stable atmospheric conditions enhancing sound propagation, this AM intrusion occurs more during the night.

123. Ms. Large did not apply the IOA RM to her data to "rate" the AM values as, in her view, such an exercise is directed only towards the calculation of a penalty for planning

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purposes. As the IOA RM is a 10 minute averaging method, it tells one nothing about what is happening within each 10 minute segment in terms of spectral frequency or the character of the

WTN. As such, Ms. Large felt that the IOA RM would not tell her anything that had not been already established from her own analysis of the data.

124. Mr. Stigwood accepts that the IOA RM analysis is "*pretty good at giving you certainly a first glance at whether there is an AM problem*". However, it is not the only method of evaluating AM values. Mr. Stigwood maintains that the application of the IOA RM analysis to the 2021 NF external audio recordings yields average AM values of 8 dBA which would attract an average 5dBA penalty pursuant to draft WEDG 2019. Mr. Stigwood also opines that, when a noise nuisance complaint relates to the indoor noise environment, the IOA RM analysis should be applied to internal measurements. In this case, doing so yields similar results to those derived externally.

125. In Ms. Large's view, the sleep disturbance reported by the plaintiffs was consistent with and supported by her noise data and by her own experience of the WTN on site which all demonstrated significant adverse noise impact. The WHO criteria[23] for night-time sleep disturbance (which is based on the Lmax[24] of noise rather than its average decibel level) are exceeded by the WTN. Indeed, due to low background noise and significant lower frequency energy, one would expect sleep impacts at even lower levels.

126. In Ms. Large's view, the WTN, which occurs all day and all night is dominant and oppressive both outside, and within the dwellings. There is no respite from the WTN, and its worst impact often coincides with the most sensitive times of the day. The sound character is highly changeable with multiple attention-drawing characteristics. At a basic level, the ability to be "quiet" in one's own home and undisturbed by unwanted noise is prevented by the operation of the wind farm. The WTN causes annoyance, disturbs sleep and then inhibits recovery by preventing subsequent rest and relaxation.

127. In MAS's view, the 2017 and 2021 data comprises objective evidence to corroborate the plaintiffs' complaints of significant adverse impact on the use and enjoyment of their

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[23] WHO 2009 Night Noise Guidelines for Europe
[24] The maximum AM peaks of noise

dwellings. The WTN exceeds normal boundaries of acceptability and expected intrusion by a substantial margin. When compared to a substantial number of windfarms that she has previously assessed, Ms. Large views the Ballyduff WTN as exceptional. Overall, she viewed the noise intrusion from the Ballyduff turbine as worse than any other case of WTN that she had previously encountered.

Noise data presented by defendant's experts

128. The evidence tendered by the defendant as to the WTN at HH and NF was advanced in the following ways:

i. planning compliance graphs prepared by Mr. O'Reilly at both HH and NF[25]

ii. Mr. Carr's opinion evidence on the HH compliance graphs. Mr. Carr did not address the NF compliance graphs.

iii. the factual evidence of Mr. Carr as to his experience of the noise in the bedroom at HH for a period of 5 to 10 minutes on the day of the joint site inspection.

iv. Comment by Mr. Carr on some of the plaintiffs' experts' evidence.

Evidence of Mr. Shane Carr

129. Mr. Carr observes correctly that all WTN assessments assume that as windspeed increases so too does the background level. In comparing the "turbine on" and "turbine off" scenarios, MAS does not take account of the expected increase in background noise levels associated with windier conditions. MAS is therefore not comparing like with like. Mr. Carr also criticises MAS's failure to correlate its data with windspeeds, wind direction or meteorological conditions.

130. Mr. Carr's view was that the planning condition sets a fixed limit at different windspeeds, namely 40 dBA leq at 5 m/s and 45 dBA leq at 10 m/s. In his view, no noise limit applies between those windspeeds.

[25] Mr. O'Reilly's planning compliance graph for night-time in downwind conditions at both NF and HH are attached at paras 326 and 308 below.

131. Mr. Carr assessed planning compliance by reference to Mr. O'Reilly's HH compliance graphs. In Mr. Carr's view, these show that total operational noise complies with the noise limits in the planning permission in directly downwind conditions. There was therefore no necessity for background noise measurements.

132. Further, Mr. Carr and Mr. O'Reilly (and indeed one of the plaintiffs' experts, Mr. Mayer) all gave evidence that WTN noise would be expected to be at its greatest in this downwind quadrant. In Mr. Carr's view, crosswind conditions are associated with a 2dBA reduction in turbine noise. In Mr. Carr's view therefore, any exceedances of the noise conditions in the planning permissions shown on the MAS NF crosswind planning compliance graph were not caused by turbine noise.

133. Mr. Carr also viewed the WTN as compliant with WEDG 2006. Further, Mr. O'Reilly's HH planning compliance graph for daytime hours showed that measured noise levels at low windspeeds without the windfarm operating, were above 30dBA L90. This was not therefore a *"low noise environment"* as defined in WEDG 2006.

134. Mr. Carr [26] also expressed the view that the measured noise levels at HH complied with the recommended limits set out in draft WEDG 2019. Indeed, he stated that the HH noise levels were so low as to ensure that there was "*sufficient headroom*" to incorporate any penalty for AM that might be imposed by draft WEDG 2019.

135. Mr. Carr's view is that a planning compliance assessment is a key aspect of a nuisance assessment. Both planning regulation and nuisance consider the impact on residential amenity within established frameworks.

[26] The defendant's planning expert, Mr. Lawlor, agreed with Mr. Carr in this regard.

136. By contrast, the MAS analysis is qualitative and *"generic"*. He also criticises the MAS approach as *"novel* "and *"bespoke"*. In Mr. Carr's opinion, MAS failed to rigorously apply any appropriate guidelines to the assessment of nuisance. Whist he noted that the Defra Guidance does not measure nuisance by reference to a particular fixed decibel limit, one must still assess nuisance in accordance with *"some recognised standards or guidance"* (such as the planning permission, WEDG 2006, the IOA RM or draft WEDG 2019).

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137. Under the Defra Guidance, the plaintiffs must, by reference to such guidance show that an established threshold of impact or *"threshold of significance"* is being exceeded. That

"threshold of significance" was not exceeded in this case because, in Mr. Carr's view the overall noise levels at Ballyduff were generally *"very low"*. This was not therefore a borderline or *"critical"* case requiring him to either carry out any further monitoring or to listen and form a view on the character of the noise. In any event, Mr. Carr rejected the view that one should or even could assess nuisance by listening to the noise. This is because various people have various different opinions about what constitutes an unreasonable interference. In essence therefore, whilst he accepted that the audio recordings accurately capture the sound environment where they were situated, Mr. Carr viewed them as of little value in determining whether nuisance was made out.

138. Mr. Carr rejected the relevance of BS 4142 as it applied to industrial noise generally but not specifically to WTN.

139. Mr. Carr's evidence was that MAS had also failed to ensure that their noise measurements were taken in accordance with best practice. Mr. Carr accepted that the MAS 2017 audio recordings (i.e., the HH internal audio recordings and the 2017 NF external audio recordings collected on foot of Ms. Large's noise survey) accurately measured sound levels at the point of the microphones. However, due to sound reflections, the 2017 HH internal audio recordings (and associated graphs) were not necessarily reflective of noise levels in the wider room or in different rooms in the same house.

140. Mr. Carr's most trenchant criticism was reserved for the MAS 2021 data which was recorded by the plaintiffs' solicitor who is not an appropriately qualified "*competent person*". As regards the 2021 NF external audio recordings, good practice requires that that measurements are made in the free field between 3.5 and 20 metres from a dwelling. However, due to inadvertence this did not occur, and the noise was recorded at façade level. As a result, although Mr. Carr accepts that the audio recordings accurately captured the noise environment where the microphones were placed, the use of façade level measurements (instead of free field measurements) increases overall noise levels. Moreover, the 2021 NF external audio recordings were gathered without the use of an appropriate windshield which means that wind contamination cannot be excluded. Mr. Carr noted that MAS had screened that part of the MAS 2021 data that was included in the expert reports and had also screened the audio recordings played to the court. However, he does not accept that this screening is effective to exclude wind contamination because one cannot always hear how wind affects the microphone. Furthermore, Mr. Carr also stated that one cannot take façade measurements where there is a significant low frequency content to the noise.

141. As regards the 2021 NF internal audio recordings and the 2021 HH internal audio recordings, Mr. Carr again contended that the noise levels at the point of the microphone would not necessarily reflect noise levels in other parts of the house.

142. Mr. Carr was extremely critical of MAS's methodology in presenting AM. He stated that the IOA RM defines AM and sets out a strict methodology (in terms of measurement methodologies and postprocessing) for rating AM values. This in turn allows for consistent assessment. By contrast, the MAS approach to calculating AM values (computing the differential between AM peaks and AM troughs on the time domain graphs) exaggerates the level of AM. To explain this, Mr. Carr noted that Mr. Stigwood himself had accepted that the AM values as calculated on foot of the MAS time domain graphs would typically overstate the AM values when compared to those produced by the IAO RM by "*1 to 2 dB*".

143. Mr. Carr noted that Mr. Stigwood also had purported to undertake an IOA RM analysis of the MAS 2021 data discussed above (the 2021 NF external audio recordings and the 2021

HH and NF internal audio recordings). In Mr. Carr's view, this data could not form the basis for a valid IOA RM assessment. This was for several reasons.

144. First the 2021 NF external audio recordings were taken at façade level which distorts AM. Related to this is the criticism that Mr. Carr maintains that one cannot take façade measurements where there is a significant low frequency content to the noise.

145. Second the 2021 NF external audio recordings were captured without the use of an appropriate windshield. In this latter respect, Mr. Carr opined that even if one were to accept that the screening exercise carried out by MAS was adequate to exclude contamination from the specific data included in their reports and from the audio recordings played to the court, this was irrelevant to the IOA RM assessment which was based on a far more extensive cache of data - 6 weeks of continuous data. Mr. Stigwood had not screened this more extensive cache of data for contamination and yet had input it all into the IOA RM analysis.

146. Third, as stated above, Mr. Carr viewed Mr. Stigwood's IOA RM analysis of the 2021 NF and HH internal data as of no value. This was because - in addition to the fact that the monitoring equipment was set up by the plaintiffs' solicitor rather than by MAS - the IOA RM analysis is not intended to be carried out on internal measurements.

<u>Evidence of Mr. Brendan O'Reilly</u>

147. Mr. O'Reilly confined himself to presenting the defendant's evidence in relation to compliance with the planning permission. Mr. O'Reilly's view was that the Defendant was fully compliant on both the HH and NF data. He accepted however that the polynomial line (or trendline) for the NF night-time graph was 43.5 dBA L90, which is above the planning permission limit of 43dBA L90. In Mr. O'Reilly's view this potential exceedance could be fully explained by the noise of the wind in the trees close to the NF measurement location.

148. Mr. O'Reilly also accepted that the MAS NF crosswind planning compliance graph shows an exceedance of total operational noise above the permission limits but stated that "*it had nothing to do with the turbine*" and was more likely noise from wind in the trees. In Mr.

O'Reilly view, contributions from wind were evident on both the daytime and night-time compliance graphs. Although in rural Ireland, the biggest contribution to increased noise levels is the wind in the trees, people are generally habituated to it and therefore never complain about it or even notice it. Mr. O'Reilly accepted that the plaintiffs' properties were in a wind shadow and that the wind environment at hub height was very different to the wind environment at the properties.

Planning experts called by parties.

<u>Evidence of Ms. Ann Mulcrone and Mr. Gavin Lawlor</u>

149. The evidence of the plaintiffs' expert, Ms. Ann Mulcrone, a town planner and former president of the Irish Planning Institute, was restricted to the pleaded allegations of breach of the permission for the purposes of the s. 160 application. I will detail this evidence when considering issue 14 below.

150. Similarly, the evidence of the defendant's expert, Mr. Gavin Lawlor, a town planner recently elected to the Council of the Irish Planning Institute, was largely responsive to the s. 160 application. In addition, in harmony with Mr. Carr, he also expressed the view that the whole purpose of the fixed noise limit in planning permissions is to protect the residential amenity of nearby residents. In essence, such a noise condition is inserted to eliminate nuisance. In his view, the noise limits in the permission carefully balance the acceptable noise and the desired outcome of renewable energy. He stated that the WTN was "*meticulously compliant*" with condition 15. In addition, Mr. Lawlor tendered a similar view to that of Mr. Carr in relation to the interpretation of the planning permission with which I deal with below.

Evidence of Mr. Dietrich Mayer

151. The plaintiffs led evidence from Mr. Dietrich Mayer, a qualified Mechanical and Automotive engineer who now operates as a Wind Energy Consultant advising on the execution of wind development. Although Mr. Mayer clearly has a high degree of practical experience in wind farm developments, I entertain some doubt as to whether he is sufficiently qualified to give expert evidence. I will therefore briefly summarise Mr. Mayer's evidence but will have regard to it for the purposes of context only.

152. Mr. Mayer's view is that bearing in mind their proximity to the plaintiffs' homes and the local topography it ought to have been recognised at the time of the installation of the turbines that there was a significant risk of unacceptable noise and high levels of AM.

153. In their present location, the usual proportionate relationship between noise levels at the receptors and at the rotor tips is distorted due to their respective heights and to the fact that the houses are in a wind shadow.

154. The speed of rotation of the blades is a critical factor for the generation of noise. If windspeeds accelerate steeply, the blade angle will change, and extra noise will be produced because of a disruption of the laminar flow. In gusty conditions the turbine has to exert a lot of control, producing frequent fast pitching activities and associated peaks in noise.

155. Other factors that can increase noise emission are the misalignment of blades and blade pitch. In addition, air inflow turbulence could play a role here because the operation of T1 will create a wave effect in the airflow towards T2 which will cause increased loads and sound emission from T2.

156. The WTN could be reduced by a number of methods. One ought first check that the rotors were clean, undamaged and properly aligned. The turbine rotors could be serrated, or appliances could be added to the blades to reduce the sound power level. One could also, if required, de-rate T2 at certain times and operate it in power reduced mode. As noted in the manufacturer's technical data sheet: *"For a noise sensitive site it is possible to operate the E70 with a reduced rotational speed and a reduced rate of power during the night."* Enercon can also provide a software programme to eliminate shadow flicker at impacted properties.

Evidence on shadow flicker

157. Although this is fundamentally a noise nuisance case, the plaintiffs also complain of nuisance in the form of shadow flicker.

158. By agreement, the parties submitted a shadow flicker report of Jennings O'Donovan & Partners dated 24th May, 2017 prepared by Mr. David Kielty. Mr. Kielty's report, which was based on modelling rather than on-site assessment, found that the plaintiffs' dwellings could potentially experience an impact from shadow flicker as they are within ten rotor diameters of the Ballyduff windfarm. The report shows that the total predicted hours per year of the shadow flicker at HH and
NF on a *"worst case"* scenario is:

NF (34.2 Hours Per Year)
HH (35.6 Hours Per Year)

159. This calculation is based on topography alone and assumes that the sun is always shining and that there is no cloud cover. It also excludes vegetation, forestry, buildings and other man made buildings which in a *"real"* context would screen the flickering effect of the wind turbines. The report states that T2 is the largest contributor to shadow flicker occurrence.

160. The report then finds, by way of a desktop survey, that the actual hours of sunlight at Ballyduff represent 35% of the total hours of daylight and that therefore shadow flicker will only potentially occur for 35% of the predicted worst case time. Reduction factors were therefore applied which produced the following results:

NF (34.2 Hours Per Year) Reduction @ 35% = 12.0 Hours shadow flicker per year
HH (35.6 Hours Per Year) Reduction @ 35% = 12.5 Hours shadow flicker per year

161. The conclusion is as follows: *"Although there is no agreed standard for shadow flicker impact in Ireland, the [WEDG 2006] recommends that shadow flicker at dwellings within 500m of a turbine should not exceed either 30 hours per year or 30 minutes per day."*

162. The report concludes that the Ballyduff Windfarm has the potential to introduce shadow flicker impacts that may exceed this WEDG limit of 30 minutes per day when sunshine occurs. However, the predictions do not take into account weather conditions or the presence of natural features e.g., trees and hedges which will reduce sunlight. The report concludes that the impact of such factors renders it likely that the 30-hour guidance limit is satisfied in practice.

Medical evidence of Prof Kevin Gournay and Dr. Declan Murray

163. As Ms. Webster and Mr. Rollo seek damages for personal injuries, the psychological impact of the WTN was addressed by Prof. Kevin Gournay, Chartered Psychologist and Prof. of the Institute of Psychiatry, Psychology and Neuroscience, Kings College, London - who gave evidence on behalf of the plaintiff - and Dr. Declan Murray consultant psychiatrist of Glebeview Clinic- who gave evidence on behalf of the defendant. Both experts were eminently experienced and qualified and gave evidence in a measured, considered and independent manner.

Medical opinion in respect of Margaret Webster

164. There was a divergence of views as between the medical experts in relation to Ms. Webster. Prof. Gournay's view is that she satisfied the criteria for a recognisable psychiatric illness; a depressive disorder, which he classified as mild to moderate. This resulted from a complex range of synergies; principally anxiety concerning Mr. Rollo together with sleeplessness and irritability caused by the WTN.

165. Dr. Murray's view was that Ms. Webster had not suffered from an identifiable psychiatric disorder. Whilst there is no doubt that the WTN and the disintegration of her relationship with Mr. Rollo had imposed considerable stress on Ms. Webster, she has coped with that stress. Therefore, although Dr. Murray accepted that Ms. Webster experienced sleep difficulties, felt down in herself and had become tense and irritable, his key point is that her reaction was understandable; she succeeded in managing her emotions and reactions. In short, her psychological reaction to the circumstances was not disproportionate. Nor did Dr. Murray view Ms. Webster's symptoms of depressed mood and diminished interest as sufficiently pervasive or prolonged to qualify as a psychiatric injury.

166. With respect for the contrary view of Prof. Gournay, I agree. Ms. Webster has had to tolerate an extremely difficult situation for the past number of years. Overall, however I accept the evidence of Dr. Murray that her reaction to the WTN is not disproportionate to the circumstances that she is experiencing. As such, I also accept his view that Ms. Webster has not suffered from a recognisable psychiatric illness and does not currently so suffer.

Medical opinion in respect of Keith Rollo

167. When Prof. Gournay first examined Mr. Rollo in December 2020 he was extremely concerned for his mental well-being. Mr. Rollo's history was of expressed emotions of hopelessness and helplessness in the face of unremitting WTN and impulsive thoughts of suicide. These red flags for suicide, when juxtaposed with the fact that Mr. Rollo worked at heights, providing him with suicidal means and opportunity, prompted Prof. Gournay to take the extremely unusual step of intervening in the legal proceedings. He informed the plaintiff's solicitor of his concern and strongly suggested that the wind turbine was turned off at night so that Mr. Rollo's chronic sleep disturbance might be mitigated. As I note above, a request to this effect was refused by the defendant.

168. Prof. Gournay diagnosed Mr. Rollo as suffering from a major depressive disorder of at least moderate severity with low mood, sleep disturbance, irritability and anger. Dr. Murray did not substantially disagree.

169. There was some disagreement between Prof. Gournay and Dr. Murray in relation to Mr. Rollo's progress after diagnosis. On this, I find that Mr. Rollo's depression improved significantly after he moved away from the turbine in early 2021. However, in mid-2022, he experienced a recurrence of his symptoms. This recurrence was characterised by anxiety rather than depression and was in the mild to moderate range. Mr. Rollo attributed this recurrence to the upcoming court case which is an entirely reasonable explanation. I accept Dr. Murray's view that Mr. Rollo's depression has now substantially resolved, albeit that some residual symptoms persist at a subclinical level. In addition, Mr. Rollo remains vulnerable to further episodes of depression and anxiety in the future.

170. In terms of causation, Dr. Murray opined that although the windfarm contributed to Mr. Rollo's depression, other potential risk factors mean that it is possible that he could have developed depression in any event. I find that this is improbable as most of the vulnerabilities described were longstanding and yet Mr. Rollo had never before suffered from depression. Mr. Rollo's past history appears to have been of a robust person. He had not previously experienced sleep disturbance or psychiatric symptoms save for a brief transient episode of anxiety.

171. Given the absence of any prior insomnia and the temporal relationship between the operation of the turbine and the onset of Mr. Rollo's sleep disturbance, I conclude that the WTN is the sole cause of this sleep disturbance. Further, in light of the well described relationship between sleep disturbance and depression, I accept Prof. Gournay's view that Mr.

Rollo's depression was entirely reactive to the external stressor posed by the WTN and the resulting long term sleep disturbance.

172. Accordingly, I find on the balance of probabilities that the cause of Mr. Rollo's depression was the WTN and the sleeplessness associated therewith. I am fortified in this view by the fact that the medical records demonstrate significant improvement - no doubt assisted by modalities such as antidepressant medication and counselling - once Mr. Rollo moved away from the turbine.

173. I accept Prof. Gournay's view that the unremitting WTN, his lack of sleep and his depression ultimately affected Mr. Rollo's personality and outlook. I further accept that for a period of time, probably commencing in mid to late 2020 and perhaps continuing for a couple of months after he moved out of HH, this impacted upon Mr. Rollo's overall response to the WTN which was often characterised by obsessive ruminations. I also accept that this personality change was a manifestation of Mr. Rollo's illness and was also therefore precipitated by the WTN.

Planning Guidance in relation to Wind Energy Developments

174. The defendant's primary defence is that it is not open to this Honourable Court to find that the threshold for nuisance impact should be set at a specific level other than the noise limit set out in the planning permission and that because the WTN complies with this noise limit, nuisance is not established. I should consider this argument at the outset because, if accepted, it would be dispositive of the case.

175. Before embarking on this exercise, however, it is necessary to refer to planning guidance on wind turbine developments at the time of the grant of the Ballyduff planning permission. This is important to the interpretation of the Ballyduff planning permission (which, as we shall see is a matter of dispute between the parties). An understanding of the planning framework is also required to assess another aspect of this argument; namely the defendant contends that both the noise limits set in the Ballyduff permission and the WTN which it produces comply with all appropriate planning guidance on WTN at the time of the grant of permission. In addition, an appreciation of more recent planning guidance on wind turbine developments is similarly of relevance as the defendant also argues that both the noise limits set in the Ballyduff permission and the WTN is in compliance with current expertise on WTN[27]. Therefore, in addition to summarising planning guidance at the time of the grant of permission and to date, I will where relevant, highlight how same might be applied to the Ballyduff permission or to the WTN itself. At a later section of this judgment, I deal separately with the Defra Guidance (which is not planning guidance but rather guidance on the assessment of statutory nuisance complaints concerning WTN).

Guidance pre-dating the planning permission

176. The parties opened two key pieces of guidance pre-dating the permission: first, the ETSU-R-97 guidelines, *The Assessment and Rating of Noise from Wind Farms* published by the Department of Trade and Industry in 1996 ("ETSU") and second, WEDG 1996.

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[27] Thus, the defendant argues that "*the permission limits continue to reflect the current combined wisdom and expertise of appropriately qualified experts as to what levels of WTN*" [are reasonable]. It further contends that because the WTN complies with those permission limits, it reflects that current wisdom and expertise and is by definition not unreasonable.

ETSU

177. ETSU sets out a framework for noise levels thought to offer a reasonable degree of protection to windfarm neighbours without placing unreasonable restrictions on windfarm developments. Since its adoption, ETSU has been the primary framework by which planning conditions pertaining to wind farms are set in the United Kingdom. It is also the primary methodology by which planning compliance continues to be assessed in both the United Kingdom and Ireland.

178. ETSU assumes that WTN relative to background noise is likely to be greatest at low windspeeds. However, it acknowledges that assumption does not always hold true for turbines on hillier sites which may experience high winds, whilst the sheltered receptor will experience low levels of wind generated noise.

179. ETSU recommends that noise limits should be set relative to existing background noise at the nearest noise sensitive properties and that the limit should reflect the variation in both the WTN and background noise with windspeed.

180. Ultimately, a combined relative and fixed limit was recommended. In general, WTN would be limited to 5 dBA L90 above the background sound levels (the relative limit) or a value in the range of 35 to 40 dBA L90 (the fixed limit), whichever is greater. In low noise environments, the day-time level of the L90 of the wind farm noise should be limited to an absolute level within the range of 35-40 dBA L90.

181. An absolute night-time limit of 43 dBA L90 was recommended as appropriate to protect sleep. This limit was not felt to offer sufficient protection to external amenity in quiet areas during the day.

182. The ETSU approach applies the noise limit only to WTN and not to total operational noise, which is a combination of WTN and background noise. As it will often be difficult to isolate one from the other, ETSU assumes that if total operational noise is below the relevant noise limit, then no further action is necessary. Conversely, if total operational noise is above the relevant noise limit, then a correction for the influence of the existing background noise should be performed. In such circumstances, compliance cannot be demonstrated without ascertaining background noise.

183. In 2013, the Institute of Acoustics (IOA) released a *Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise* ("GPG") which addressed many technical aspects of ETSU. In 2014, the IOA published six Supplementary Guidance Notes to the GPG, which provided further information on specific aspects of the assessment procedures. For present purposes the most important of these is Supplementary Guidance Note 5 on Post Completion Measures ("Supplementary Guidance Note 5") which governs the technical aspects of ETSU planning compliance assessments.

<u>WEDG 1996</u>

184. WEDG 1996 were the relevant planning guidelines at the time of the grant of planning permission in this case. These provided that noise levels measured externally at any dwelling house should not exceed 40 dBA Leq and that tonal or impulsive qualities in the noise should be avoided. I pause to note that although I find that the noise limits set in the Ballyduff permission are generally in accordance with WEDG 1996, total operational noise is frequently above 40 dBA Leq.

Guidance post-dating the planning permission

<u>WEDG 2006</u>

185. The current assessment framework applying to the grant of planning permission for wind farms is set out in the planning guidelines issued by the Department of the Environment, Heritage and Local Government in December, 2006, WEDG 2006.

186. WEDG 2006 characterises aerodynamic noise from wind turbines as general broadband noise which can display some "character" ("swish"). The possibility of thump AM is not mentioned. Noise limits should be applied to external locations. The chosen measurement index is L90 which is intended to allow reliable measurement without corruption from relatively loud transitory noise events from other sources.

187. In general, significant noise problems are unlikely where the distance from the nearest turbine to any noise sensitive property is more than 500 metres. I pause to note that T2 is of course 359/369 metres from the plaintiffs' dwellings.

188. During the day, WEDG employs a combination of relative and fixed noise limits. The language here is somewhat ambiguous. The guidelines provide for "*a lower fixed limit of 45 dBA or a maximum increase of 5 dBA background noise*" without specifying whether it is intended that the lower or greater of these two limits apply. I accept the defendant's argument that planning authorities are free to choose whichever of these limits is greater. Therefore, save in low noise environments, WEDG 2006 deems it acceptable to set a limit of 45 dBA L90 irrespective of background noise levels.

189. WEDG 2006 notes that during the night the protection of external amenity becomes less important, and the emphasis should be on preventing sleep disturbance. It provides that a fixed limit of 43 dBA will protect sleep inside properties during the night.

190. The defendant argues that the Ballyduff permission complies with the recommendations in WEDG and that the WTN experienced at the plaintiffs' homes also so complies. Strictly speaking, confirming compliance with WEDG requires an assessment of whether or not this is a low noise environment. There is presently no compelling evidence either way on this issue[28]. I will therefore give the defendant the benefit of the doubt and assume that the above noise limits apply.

191. As such, the two noise limits set out in the Ballyduff permission (40 dBA leq and 45 dBA leq), which are either below or equal to the WEDG noise limits (45 L90during the day and 43 L90 during the night) therefore comply with WEDG 2006.

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[28] See para 512 below for an analysis of the parties' respective evidence on background noise levels.

192. The defendant consequently argues that because the Ballyduff WTN complies with the noise limits in the permission. this means *a fortiori*, that the WTN also complies with WEDG 2006.[29] I will accept, for the sake of argument, that this is so.

193. The key point however is that the issue of compliance or otherwise with the WEDG 2006 limits is largely beside the point. This is because, for reasons I will explain in due course, I do not view WEDG 2006 as delineating the parameters of WTN nuisance in this particular case.

Developing understanding of AM and the Institute of Acoustics (IOA) Reference Method (IOA RM)

194. Whilst ETSU and WEDG 2006 continue to be applied in the UK and Ireland respectively, it is now recognised that there is a need to address noise impacts in a more nuanced way.

195. Although the ETSU methodology is intended to absorb any additional impact due to AM into the noise limits it recommends, it does not fully address the potential impact of AM in WTN in at least three respects. First, ETSU understood AM as overwhelmingly of the "swish" variety and no real account is taken of the possibility of AM of a lower frequency character, "thump AM". Second, ETSU primarily contemplates AM values of *"up to"* 3 dBA. Indeed, the ETSU Review[30] points out that on the basis of the comments in ETSU, the value of 3 dBA is sometimes referred to as the 'expected level' of AM. However, it is now apparent that AM can display AM values much greater than this. Third, ETSU assumes that as distance from the turbine increases beyond 50 metres, the rhythmic swishing would become less pronounced, reducing audibility. It is now clear that "thump AM" - compared with "swish AM"- can be discerned at longer ranges and over different wind directions.

[29] For reasons I will detail below, I am of the view that the Ballyduff WTN is not in fact in compliance with the permission because the defendant has misinterpreted the permission limits. That however is not of immediate relevance because, as at this point of my discussion, I am considering whether the defendant is correct in submitting that the Ballyduff WTN complies with the *WEDG* noise limits.

[30] As to which see further para 216 below.

196. Concerns about AM, particularly lower frequency "thump" AM, led to the commissioning of several UK government funded surveys. Ultimately, in 2016, the findings of two parallel AM studies were reported. The first was the IOA led investigation ("the IOA AM report") which states:

> *It is now generally accepted that there are two manifestations of wind turbine AM. An observer close to a wind turbine will experience 'blade swish' because of the directional characteristics of the noise radiated from the trailing edge of the blades as it rotates towards and then away from them. This effect is ... not generally expected to be significant at typical separation distances, at least on relatively level sites. The Renewable AM project... has coined the term 'normal' AM (NAM) for this inherent characteristic of WTN, which has long been recognised and was discussed in ETSUR-97 in 1996 (ETSU, 1996)*

> *In some cases, a form of AM is observed at residential distances from a wind turbine (or turbines). The sound is generally heard as a periodic 'thumping' or 'whoomphing' noise containing relatively low frequencies... The prevalence of this type of modulation is subject to debate. On sites where it has been reported, occurrences appear to be occasional, although they can persist for several hours under some conditions, dependent on atmospheric factors, including windspeed and direction.... The Renewable UK AM report adopted the term 'Other AM' (OAM) for this characteristic. Elsewhere it might be reported as Excessive Amplitude Modulation (EAM).*

197. The purpose of the IOA AM report was to devise a method for measuring and rating AM in WTN. The primary goal was to develop a methodology to be used within the planning regime. I will consider in due course[31] the relevance of the methodology ultimately developed by the IOA for rating AM ("the IOA RM") to the exercise currently being conducted by this court.

198. The second 2016 study, the Phase 2 report, concluded that AM controls were needed at development planning stage and that this was best achieved by means of a suitable penalty scheme whereby, increasing levels of AM would attract a decibel penalty which would be added to the relevant sound power levels for the purposes of fixing decibel limits.

[31] 33 See para 421 *et seq.*

199. In simple terms the combined effect of the IOA RM and the Phase 2 Report is as follows: first, pursuant to the IOA reference, turbine related AM is calculated over ten seconds blocks. This is measured by deducting the L95 (the sound power level exceeded for 95% of the time) from L5 (the sound power level exceeded for 5% of the time). Provided that at least 50% of the ten second blocks contain detectable AM, average AM is logged for that 10 minute period. Thereafter, the AM value for each ten minute period is to be converted to a penalty which is then correlated with the relevant windspeed and incorporated into the decibel limit at the windspeed in question.

<u>Proposed revisions to WEDG 2006</u>

200. In Ireland, the Department of the Environment, Community and Local Government has produced three different draft guidance documents proposing various revisions to WEDG 2006. *Proposed revision to Wind Energy Development Guidelines 2006 – targeted review in relation to noise, proximity and shadow flicker, December 11th, 2013.*

201. On 11th December, 2013, the Department published proposed revisions to WEDG 2006 on which it invited submissions ("the 2013 draft revision"). The 2013 draft revision recognised that distinctive special audible characteristics of WTN including impulsiveness, AM and low frequency presented a challenge. WTN can be influenced by a variety of factors not directly related to distance such as topography, ground cover, windspeed and direction.

202. The 2013 draft revision recommended 40 dBA L90 as an outdoor limit which would apply irrespective of day or night. Exceptions were possible in the case of consent of the windfarm neighbour impacted. I note that total operational noise at NF is in excess of 40 dBA L90 at windspeeds above approximately 8 m/s. Total operational noise at HH is in excess of 40 dBA L90 at windspeeds above approximately 6 m/s.

2017 Preferred draft Approach.

203. In 2017, a preferred draft approach was circulated. The preferred draft approach proposed a relative noise limit of 5 dBA above existing background noise within the range of 35 to 43 dBA L90 with 43 dBA L90 being the maximum noise limit permitted day or night. The noise limit would be further reduced to take account of AM and low frequency noise. I note that total operational noise at NF is in excess of 43 dBA L90 at windspeeds of 9.5 m/s and above.

204. The preferred draft approach provided that shadow flicker would be eradicated in full by technology and appropriate modelling at design stage. It was expected that strategic environmental assessment would be undertaken and that guidelines would be finalised and issued by the first quarter of 2018.

Draft revised Wind Energy Development Guidelines December 2019 ("draft WEDG 2019").

205. Draft WEDG 2019 was issued for public consultation in December 2019 ("draft WEDG 2019"). Their aim was "*to strike a better balance between addressing the concerns of the local communities in relation to wind farm proposals, whilst maintaining Ireland's ability to deliver on its binding energy policy obligations, and ensuring that there is greater, and earlier, community engagement by windfarm developers*".

206. The noise limits in the draft WEDG 2019 were undoubtedly more onerous than the WEDG 2006 and afford a higher level of protection to people who live in the vicinity of any future wind farm developments. The defendant in the present case submits that the WTN complies with draft WEDG 2019. Although I emphasise that WEDG 2019 is draft guidance only and further that it has now been withdrawn, I will nonetheless consider whether the defendant is correct in this argument.

207. Draft WEDG 2019 notes that the principle of a 5 dBA increase above background levels has been regarded as good practice for many years and proposed the adoption of this basic structure subject to a lower limit value of 35 dBA L90 and an upper limit value of 43 dBA L90. Effectively, this imposed a limit of 35 dBA L90 as a default until the 5 dBA above background levels exceeds this and 43 dBA L90 is the maximum noise permitted day or night, regardless of background noise level. Therefore, although the defendant contends that the Ballyduff WTN complies with draft WEDG 2019, compliance cannot be assessed, still less confirmed, absent a background noise study at this site.

208. Draft WEDG 2019 also recognised the particular challenges posed by thump AM. It notes that although the characteristic sound close to a wind turbine could be described by the listener as a regular 'swish' which decreases rapidly with distance, under adverse conditions at a distance of several hundred metres from the turbine, whoomphing or thumping type noise can dominate and cause annoyance at lower levels than noises without such characteristics.

While such AM can occur over extended periods it tends to vary in intensity, adding to the annoyance.

209. Draft WEDG 2019 proposed a rating penalty for certain special audible characteristics (tonal noise and AM) in addition to a fixed threshold for low frequency noise. It was felt that subjective listening tests and direct measurements did not provide a reliable method of quantifying AM for the purposes of applying the penalty scheme. Accordingly, draft WEDG 2019 recommended the application of the IOA RM as an objective and reliable methodology for quantifying AM.

210. Draft WEDG 2019 acknowledged that the setting of a threshold for excessive AM is not straightforward. It notes that available research at that time did not identify a clear level at which the impact of WTN AM becomes "significant" "excessive" or "unacceptable". However, research suggested an onset of perception at an AM value of about 2 dB and above this, rising annoyance with increasing AM values is expected. Moreover, the research highlighted a very strong relationship between annoyance and the overall sound power level - i.e., overall loudness- of the WTN.

211. The penalty scheme proposed in draft WEDG 2019 operates by penalising higher AM values as follows:

- AM with an AM value of less than 3 dB - no penalty
- AM with an AM value of 3dB to 10 dB - sliding scale of penalties ranging from 3 to 5 dB
- AM with an AM value of more than 10 dB - 5 dB penalty.

212. Draft WEDG 2019 recommended using only night-time measurements to isolate WTN from other potential noise sources. Draft WEDG 2019 noted that AM has been shown to occur in both downwind and crosswind conditions and that where a complaint relates to AM noise all wind directions associated with AM should be included in determining the rated noise level.

I pause here to note that the defendant's compliance data only relates to one wind direction: directly downwind.

213. In any event, total operational noise at NF is in excess of 43 dBA L90 at windspeeds above 9.5 m/s. If therefore the Ballyduff WTN attracts any AM penalty, then total operational noise would exceed the recommended maximum noise limit in draft WEDG 2019. The plaintiffs' experts have purported to perform an IOA RM analysis which is said to suggest an AM penalty of 5 dB. For various reasons, I accept the defendant's argument[32] that the plaintiffs' IOA RM cannot be relied upon to calculate likely penalties under draft WEDG 2019.

214. I deal separately at para 471 below with the defendant's expert's contention that the WTN would comply with the recommended limits in draft WEDG 2019 regardless of any character penalty that could be applied. Suffice it to say for the moment that, as the defendant has not even attempted to estimate background noise or to calculate what penalties might apply, I am at a loss to see how it can confidently contend that the WTN complies with draft WEDG 2019.

215. Draft WEDG 2019 also recommended that shadow flicker would not to be tolerated at all. It notes that shadow flicker can easily be prevented through the installation of sensor-based switches / control mechanisms.

ETSU Review

216. The Department of Business, Energy and Industrial Strategy in the UK commissioned a review of ETSU, which was completed in October 2022 and published in February of 2023 ("the ETSU Review"). The primary aim of the ETSU Review was to make a recommendation on whether, in view of United Kingdom government policies on noise and Net Zero, and available evidence, ETSU required updating. The ETSU Review concludes that current regulation in relation to the potential impact of AM in particular should be reviewed and updated. Although, unsurprisingly, its recommendations have not yet been actioned, the ETSU Review provides a helpful objective overview of how the science has moved on since ETSU.

217. The ETSU Review observes that the need for official guidance on the control of AM in wind turbine sound was the single most common theme arising in its review. AM annoyance is influenced by both the AM values and the spectral frequency of the WTN. Increased annoyance

[32] The defendant's argument is set out at para 143 above.

is associated with thump AM, which propagates further, and is more effective at transmitting through structures. The ETSU Review notes that AM values for thump AM can be greater than for swish AM. It also notes that there is strong evidence demonstrating that thump AM is more prevalent at night, due to atmospheric conditions. Although thump AM is difficult to predict, it can potentially be mitigated by control of the blade pitch angle.

218. The ETSU Review concluded that AM is secondary to the overall sound level in determining subjective responses, and that the added impact of AM can be quantified as a change in the equivalent sound level. For planning purposes, the ETSU Review therefore favours a methodology similar to that recommended by draft WEDG 2019 - i.e., the use of IoA RM to rate AM combined with a decibel penalty system for AM.

219. In summary, in so far as relevant, my view in respect of the application of all the above planning guidelines to the Ballyduff windfarm is as follows:

220. I am satisfied that the noise limits set in the Ballyduff permission comply broadly with WEDG 1996. These noise limits also broadly comply with WEDG 2006. However, as the permission does not purport to relate the noise limits to background noise or to regulate AM, the permission does not "comply" with draft WEDG 2019. In other words, the permission does not reflect draft WEDG 2019.

221. I am not satisfied on the balance of probabilities that the WTN on site complies with WEDG 1996. I accept for the sake of argument that the WTN complies with WEDG 2006. Although the defendant maintains that the WTN also complied with the recommendations in draft WEDG 2019, this has not been demonstrated. Clearly, in the absence of a background noise assessment and a fully compliant IOA RM assessment of possible AM penalties, one cannot be satisfied one way or the other on whether the WTN complies with draft WEDG 2019. In any event, as draft WEDG 2019 has now been withdrawn this is not in my view an issue which I have to determine.

<u>Relevance of planning permission-two potential zones of relevance of the permission</u>

222. The grant of planning permission for a particular use is of potential relevance to a nuisance claim in two distinct ways.

223. First, the grant of planning permission (and its terms and conditions) may permit the very intrusion (for example, noise) which is alleged by the plaintiff to constitute a nuisance. In the present case, the question is the extent, if any, to which the planning permission (or the noise condition specified therein) can be relied on as a defence to this nuisance claim.

224. Second, as stated at para 30 above, nuisance is always assessed by reference to the character of the particular locality. The grant of permission for the development impugned may authorise the use of the defendant's property for certain purposes potentially changing the character of the locality. In the present case, the question is whether the plaintiffs' locality should be seen as including the defendant's windfarm at Ballyduff.

Issue 1: is the court bound by the noise condition in the planning permission in assessing what is objectively reasonable for the purposes of determining a claim for nuisance? Is the noise condition in the planning permission a wholly reliable indicator of what WTN is reasonable for the purposes of determining a claim for nuisance?

The defendant's argument

225. In *Cork County Council v. Slattery Pre Cast Concrete Ltd* [2008] IEHC 291, Clarke J. observed:

> *"It is, of course, the case that the mere fact that a party operates in accordance with a valid planning permission does not give that party the right to commit a civil wrong to neighbouring properties. Therefore, the mere fact that [the defendant] might operate in accordance with a valid planning permission does not, of itself, preclude the possibility that there might nonetheless be a nuisance actionable at the suit of neighbouring property owners."*

226. The defendant does not dispute that as a matter of common law and statute,[33]planning permission cannot deprive a property owner of a right to object to what would otherwise be a nuisance. The grant of planning permission for a particular development does not mean that the development is lawful, but that a bar to the use imposed by the planning law in the public interest has been removed.

[33] Section 34 (13) of the Planning and Development Act 2000 provides that a person shall not be entitled solely by reason of a planning permission to carry out any development.

227. Notwithstanding this, the defendant nonetheless argues that the court is *"bound"* by the terms and conditions of the planning permission in assessing what is objectively reasonable for the purposes of this nuisance claim. This argument was advanced in a number of different ways which I will consider below.

228. In its oral submissions the defendant argued that the court was bound to accept and apply the noise limits in the planning permission as a wholly reliable indicator of what the ordinary person would expect in terms of noise control. Although purporting to accept that planning permission cannot *per se* provide a defence to nuisance, it was argued that *as a matter of law*, a permission which specifically regulates the matter complained of – in this instance, noise – prevents the court from concluding that operation in accordance therewith constituted a nuisance. That, it was said[34] was *"the end of the matter"*.

229. The defendants' closing written submissions were more nuanced and argued that the planning permission is *"a key item of evidence"* establishing that the expectations of an objectively reasonable person had not been *"exceeded"* in this instance. The permission noise limits therefore comprise <u>evidence</u> of a *"reasonable objective standard"*.

230. Finally, the defendant argues that the noise limits in the permission ought to benefit from curial deference.

231. The defendant maintains that *Smyth v. Railway Procurement Agency* is binding authority in support of these arguments. It is therefore necessary to consider *Smyth v. RPA* in considerable detail.

Smyth v. RPA

[34] Quoting from para 34.9 of *Smyth v RPA,* as to which see para 252 below.

232. The plaintiffs' ("the Smyths") case was that the newly established Green Line LUAS light railway system operated by the defendant ("RPA") caused them a noise nuisance. They sought an order directing the RPA to erect an appropriate acoustic barrier together with damages for nuisance, negligence and breach of statutory duty.

233. Supported by several of their neighbours, the Smyths maintained that the noise of the trams had an adverse impact on the amenity of their back gardens (which backed on to the LUAS tracks); that it was difficult to hold a normal conversation in the garden; that the noise of the trams was very intrusive in the kitchen, dining area and living areas of their house and that the noise impact in the bedrooms at the rear of the house (which were roughly level with the tracks) was such as to cause serious sleep disturbance which was their single greatest complaint. The Smyths experienced difficulty getting to sleep and were obliged to close their bedroom windows and ultimately to move out of their master bedroom at the back of the house.

234. An understanding of the statutory context and process underlying the development of the Green Line, a major public infrastructural project, is crucial to appreciating the approach

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taken by Laffoy J. in *Smyth v RPA to* (1) the legal effect of the Line B Order pursuant to which the LUAS was established; and (2) the consequent ascertainment of the appropriate objective standard to apply to the Smyths' nuisance complaint.

235. The Transport (Dublin Light Rail) Act 1996 ("the 1996 Act") enabled the Minister for Public Enterprise ("the Minister") by order to authorise the construction and operation of the light rail. The statutory process required that the application to the Minister was accompanied by an Environmental Impact Statement ("EIS") including detailed forecasting on noise emissions. The EIS included detailed analysis of the likely noise impacts on an area by area basis. The likely exceedance of the noise of the trams over the background noise was rated into three categories: "*slight*", "*moderate*" and "*significant*". Where necessary, mitigation measures in the form of acoustic screening were proposed for certain areas.

236. The application was published and any persons likely to be affected had a statutory entitlement to make submissions to the Minister. The Minister was mandated to appoint an inspector to conduct a public inquiry and submit a report of the resulting findings and recommendations. All affected landowners and occupiers and other interested parties were entitled to appear at the inquiry.

237. Judge Sean O'Leary ("the inspector") was appointed as inspector to conduct the inquiry which proceeded in three stages considering first, the *prima facie* need for the light rail, secondly whether the scheme was practicable, viable and safe and thirdly the impact of the Green Line on local communities. The issue of noise and vibration was a key issue to the third stage. The inspector heard evidence from an acoustic engineering consultant who had contributed to the sections of the EIS on noise. The inspector considered the area by area analysis conducted by this expert, commended the objectivity of his evidence and ultimately concluded that if operated in accordance with the noise conditions set out in the EIS, the noise and vibration impacts of the LUAS would be "*slight*". The inspector recommended the inclusion of detailed noise conditions in the Line B order together with general conditions in relation to monitoring noise emissions.

238. S.I. No. 280/1999- Transport (Dublin Light Rail) Act, 1996 (Line B – St. Stephen's Green to Sandyford Industrial Estate Light Railway) Order, 1999 ("the Line B Order") promulgated in September 1999- expressly authorised the construction and operation of the Green Line and as recommended by the inspector, included a condition (condition 28) obliging

RPA's predecessor ("NPS") to agree daytime and night-time limits at each relevant location with the appropriate local authority. Condition 28 further required that; in default of agreement, such matters would be determined by the Minister.

239. Two particular findings assist in understanding the significance of *Smyth v. RPA* to the issues at hand. First, Laffoy J. found that - as NPS had not in fact sought to agree or have such limits determined, condition 28 had not been complied with. Second, the court found, as a fact, that the LUAS operated in accordance with the conditions set out in the EIS and also within the more exacting limits published by the National Roads Authority in October 2004.

240. The courts' reasoning in *Smyth v. RPA* has two primary components.

First component of court's reasoning in *Smyth v RPA* - possible application of the defence of statutory authority

241. First, Laffoy J. determined that if the Green Line had been operated in strict accordance with the Line B Order, then that would be a complete answer to the claim in nuisance. In such circumstances the defendants would be operating the Green Line in accordance with the law and there could be no question of the perpetration of a civil wrong. Thus, at para. 3.7, Laffoy J. states:

"The real issue, the liability of the defendants for noise generated by the operation of the Green Line, is primarily determined by what the Acts of the Oireachtas and the secondary legislation under which the defendants operate the Green Line authorise them to do."

242. Paragraph 32.10 is to broadly similar effect:

"The defendant is a statutory body, which by virtue of (the 1996 Act) has power to operate the Green Line in accordance with the terms of the Line B Order. If, as a matter of the proper construction of the Line B Order, the defendants are entitled to operate the Green Line at the rear line of No. 3 in the manner in which they are operating it, they are operating it in accordance with law, that is to say, in accordance with an Act of the Oireachtas and the secondary legislation made under it, both of which enjoy the presumption of constitutionality and that is a complete answer to the plaintiffs' claim. Alternatively, if the defendants are not operating the Green Line at that location in accordance with the terms of the Line B Order, the ordinary principles of common law apply in the defence to the plaintiffs' claim for nuisance."
(Emphasis added)

243. Counsel for the defendant invoked the language of para 32.10 and submitted that, *"at a high level"* its logic provided a *"complete answer"* to the plaintiff's claim in the present case. This aspect of the defendant's approach is somewhat contradictory. On the one hand it accepts that these passages in *Smyth v. RPA* concern the defence of statutory authorisation and cannot be read across to a grant of planning permission. On the other hand, it relies upon para 32.10 (and similar passages) to argue that because the planning permission for the Ballyduff turbines sets specific noise limits (with which it is asserted it complies), this provides a complete defence to a claim in nuisance in a manner equivalent to that provided by the Line B Order.

244. This cannot be correct. This component of Laffoy J.'s reasoning concerns an argument based on the defence of statutory authority. *Smyth v. RPA* does not support an argument that compliance with specific noise limits in a planning permission is necessarily a complete answer to a claim for noise nuisance. There is a difference between development specifically authorised by legislation and development on foot of a decision made by a planning authority in the form of a single planning permission. Indeed, it is relevant to note that although she reviews Irish and England & Wales authorities in relation to the impact of planning decisions on nuisance, Laffoy J. ultimately considered these authorities to be of "*little relevance*" to the case before her.

Second component of court's reasoning in *Smyth v. RPA*-"*wholly reliable indicator*" **245.** The second component of Laffoy J.'s reasoning – pithily framed in the concluding sentence of para 32.10 (see above) - was that because the Line B Order had not in fact been strictly complied with (due to non-compliance with condition 28), the ordinary principles of common law applied in assessing the claim to nuisance. As the present case does not concern the defence of statutory authority, it is this second component which is of direct relevance.

246. Laffoy J. observed that the kernel of the plaintiffs' case was that the Green Line subjected them to serious noise nuisance, including sleep disturbance. Laffoy J. accepted the *bona fides* of the Smyths and concluded that there was no doubt on the evidence that they subjectively perceived that the operation of the Green Line interfered with the ordinary comfort and enjoyment of their home. However, the existence of nuisance is established by applying an objective standard. The defendant emphasises to this court that, in determining what that objective standard was, Laffoy J. adopted the noise conditions set out in the Line B Order itself.
247. The crucial passage of the judgment upon which the defendant places most reliance appears at para. 34.2:

> *"Even though the Line B Order has not been strictly complied with in the operation of the Green Line by the defendants since 2004, because of non-compliance with condition 28, the process which led to the making of the Line B Order in accordance with the Act of 1996, and its outcome, in my view, is a wholly*

> <u>reliable indicator</u> *as to what the ordinary person whose requirements are objectively reasonable would expect in terms of noise control and noise mitigation in the operation of the Green Line.*
>
> *"Every person who was likely to be affected by the operation of the Green Line had a statutory entitlement to make submissions to the Minister and to attend at the public inquiry conducted pursuant to the Act of 1996 and to make submissions,* inter alia, *on the proposals in the EIS in relation to noise and to noise mitigation. The question of noise was addressed at the public hearings and in the Inspector's report. He took cognisance of the views of the members of the public who appeared and made representations. On the basis that the projected noise levels identified in the EIS would be observed, and subject to compliance with conditions in relation to specific areas, and the general condition in relation to monitoring and fixing day-time and night-time limits, the Inspector found that the noise aspects of the project appeared to be satisfactory. There has been no challenge to that finding.*
>
> *...Therefore, I consider that I am entitled to treat the inspector's finding* [that the noise aspects of the project as set out in the EIS was satisfactory] *as the starting point of identifying the yardstick in applying the objective test. But for the fact that it has not been fully implemented, as conditioned into the Line B Order by (the NPS), it would be conclusive."*(Emphasis added)

248. Here, Laffoy J. is not solely concerned with the defence of statutory authority but with the common law principles governing the tort of private nuisance. The learned judge considered that the noise conditions in the EIS and the Line B Order were a proxy for the objective test of what is reasonable. She was satisfied that the inspector's finding in relation to the noise levels predicted in the EIS were a "*wholly reliable indicator*" as to what the ordinary person whose requirements are objectively reasonable would expect in terms of noise control. Therefore, operation of the Green Line within the noise levels predicted in the EIS – which were conditioned in the Line B Order - did not infringe the comfortable and healthy enjoyment expected by an ordinary person whose requirements are objectively reasonable in the particular circumstances. Laffoy J. therefore held that the Smyths had not established nuisance.

<u>The proposition of law contended for by this defendant</u>

249. This defendant effectively seeks to substitute the words "*the 2004 planning permission*" for the words *"the process which led to the making of the Line B Order in accordance with the Act of 1996"* in para. 34.2 of Laffoy J.'s judgment. Counsel opened this particular passage to the court and stated, *"we say exactly the same thing pertains* *here.* "- in other words that the limits in the permission are, as a matter of law, a wholly reliable indicator of what is objectively reasonable in terms of noise.

250. However, this aspect of Laffoy J.'s finding in *Smyth v. RPA* was based on the evidence before her. Weight is placed on the statutory genesis of the process culminating in the Line B Order. Weight is also placed on the robustness of the process, the evident depth of the consideration of the noise impacts complained of and the need for acoustic barriers. All this provides the context for Laffoy J.'s finding that the noise limits were *"a wholly reliable indicator"*.

251. This is evident from the very passage relied upon by this defendant (para. 34.2) in which Laffoy J. highlighted the following pertinent aspects of the statutory process and the resulting noise conditions: (a) every person who was likely to be affected by the operation of the Green Line had a statutory entitlement to make submissions; (b) such a person had a statutory entitlement to attend at the public inquiry and to make submissions *inter alia* on the proposals in the EIS in relation to noise limits and mitigation; (c) the question of noise was addressed at the public hearings and in the inspector's report; (d) the inspector took cognisance of the views of the members of the public who made representations; (e) the inspector determined that on the basis of the projected noise levels and mitigation measures identified in the EIS the noise impact of the project would be satisfactory and (f) there had been no challenge to that finding.

These factors permitted the court to treat the inspector's finding as the yardstick to be applied in determining the objective test.

252. It cannot be gainsaid that the process under consideration in *Smyth v. RPA* was not only of statutory origin; it also incorporated a searching and comprehensive investigation, analysis and assessment of all noise aspects of the project. The relevance of these considerations to

Laffoy J.'s finding is further evident at para. 34.9. Laffoy J. stated that if the NPS had complied with condition 28 and if the daytime and night-time limits set had accommodated the level of noise complained of by the Smyths then "... *that would have been the end of the matter.*" She continued:

257. The report prepared by the planning authority's planner ("the planners report") of 22nd January, 2004 noted that the proposed site was in an elevated rural area which might prove suitable for a windfarm. Whilst the planning authority had not yet formally adopted a wind strategy for the locality, the draft strategy identified certain areas in north Wexford where windfarms could be encouraged and the proposed Ballyduff turbines were in one such designated area. In contrast to the inspector's highly specific, area by area consideration of the likely noise impacts of the Green Line, the planner's report contains no assessment – formal or otherwise - of the likely levels of background noise or of the potential impacts of WTN (or shadow flicker) on residential amenity.

258. On 16th April, 2004, the planning authority granted permission for a period of 20 years duration. Condition 15 provided that noise levels from the proposed development when measured at the nearest inhabited house shall not exceed 40 dBA leq and 45 dBA leq at windspeeds of 5m/s and in excess of 10 m/s respectively. Beyond stating that the noise limits set out in condition 15 were "*In the interests of residential amenity and the proper planning and development*", the rationale for the selected noise limits is not elucidated. Although I believe the noise limits broadly reflect the limit of 40 dBA leq generally recommended in WEDG 1996, there is no express reference to that guidance.

259. As the grant of permission was not appealed, there was no consideration by An Bord Pleanála – or its inspectors – of the anticipated noise impacts.

260. Therefore, whilst it goes without saying that the permission is a "*planning consent ... given after due process for a development*" (in the words of Charleton J. in *Lanigan v Barry*,), the process is not comparable to the process held by Laffoy J. in *Smyth v. RPA* to establish a wholly reliable indicator of what is reasonable in terms of noise impacts.

<u>Planning permission does not fully regulate the matter complained of</u>

261. In any event, even if the specific noise limits set out in the planning permission were a wholly reliable indicator of what is objectively reasonable in this locality in terms of absolute noise levels, this would not assist the defendant for two important reasons.

"The defendants would be operating the Green Line in accordance with the law and there could be no question of the perpetration of a civil wrong on the plaintiffs. Where, in pursuance of a statutory process of the type formerly provided for in the Act of 1996, and now provided for in the Act of 2001, standards are established for permitted environmental effects and impacts of the construction and operation of a major public infrastructure, such as a public transport system, those are the standards by reference to which the statutory undertaker is authorised and required to act. In such circumstances, it is not open to an occupier of property in the vicinity of the infrastructure to contend that some other standard should be applied. In this case, in my view, as a matter of law, it was not open to the plaintiffs to contend that the Green Line must be operated in accordance with the WHO guidelines or the BS Code requirements so as to avoid committing a nuisance."(Emphasis added)

253. This finding of the court was on the evidence before it. The statement of principle expressed in this passage may not simply be applied to a totally distinguishable process such as a grant of planning permission for a single windfarm, particularly where (as will be further discussed below) that process does not reveal detailed consideration of the impact of WTN. In short, the above passage does not support the proposition of law advanced by this defendant.

Key item of evidence/ wholly reliable indicator of what noise is reasonable?

254. The defendant also relies upon *Smyth v. RPA* to argue that the planning permission is "*a key item of evidence*" establishing that the expectations of an objectively reasonable person "*have not been exceeded*".

255. However, there is no comparison between the statutory process culminating in the Line B Order and that culminating in the granting of Ballyduff planning permission and, in particular, the adoption therein of the condition 15 noise limits.

256. The process leading to the grant of permission in this case was as follows. On 25th November 2003, the defendant applied to Wexford County Council ("the planning authority") for planning permission. The application includes no specific information on expected noise emissions. In contrast to the large number of submissions considered by the inspector prior to the making of the Line B Order, although duly advertised, no submissions were made by any effected landowners in relation to the Ballyduff application generally or in relation to the anticipated noise aspects specifically.

262. First, the Ballyduff permission essentially regulates WTN decibel levels only. Although the ETSU approach takes into account blade swish and absorbs a certain level of AM into the recommended noise limits, AM values were then anticipated to be in the order of 3 dBA and of the swish variety. The ETSU methodology - upon which both the Ballyduff planning permission and WEDG 2006 is based - cannot therefore establish a yardstick for the particular aspects of the WTN complained of by the plaintiffs in this case, high AM values, thump AM and the intrusion and dominance that accompanies those features. Neither the Ballyduff permission nor the planning file as a whole reveal any consideration, assessment or regulation of these features of WTN. How then can the permission comprise a wholly reliable indicator of whether the noise characteristics complained of here - high AM values and thump AM etc - are objectively reasonable?

263. Second, for reasons which I will explain below, compliance with the noise limits in the Ballyduff planning permission is not in any event demonstrated. Therefore, even if a grant of planning permission were to provide an absolute defence to a private nuisance action or to provide a wholly reliable indicator of what WTN must be considered reasonable at this location, it could not on the facts provide a defence in this case.

264. In short, I find that neither as a matter of law nor fact is the permission a wholly reliable indicator of what is objectively reasonable at this locality in terms of WTN.

<u>The condition 28 argument</u>

265. The defendant makes a related argument that if a development benefits from planning permission, but that permission does not fully regulate aspects of the noise complained of (AM, particularly, thump AM), then the court must (a) attempt to ascertain whether, and if so, how the planning authority might have regulated this impact had it directed its mind to it and (b) proceed accordingly.

266. This argument is based on a specific aspect of *Smyth v. RPA*. At 34.2, Laffoy J. stated:

> *"However, in light of what I consider to be the proper construction of the Line B Order and in particular, condition 28, it is necessary to consider what day-time and night-time limits would have been agreed to, or determined, if the (NPA) had complied with condition 28 prior to the commencement of operation of the Green Line in 2004 and to consider whether the operation of the Green Line at the rear of No. 3 would have come within those limits"*

267. In other words, having determined that the RPA had not complied fully with the terms of the Line B Order by failing to set specific daytime and night-time limits, Laffoy J. turned to consider as a matter of probability what daytime and night-time limits might have been agreed or determined had condition 28 been complied with.

268. The defendant gears off this logic to argue that as a matter of law this court is confined to considering "*what…*[AM] *limits…would have been … determined"*, by the planning authority at the time of the grant of permission in 2004.

269. However, this misses the rationale for Laffoy J.'s approach to the condition 28 issue. Consideration of what daytime and night-time limits might have been set under the Line B Order was relevant for two reasons. First, because, correctly construed, this is what condition 28 required. The exercise was therefore performed to simulate what would have occurred had the statutory process been correctly complied with. Second, such consideration was relevant in light of the court's finding that, for reasons I have already explored, the noise limits which would have been set in accordance with the statutory process (and all it entailed) were themselves a wholly reliable indicator - a conclusive yardstick - for what was objectively reasonable. This aspect of the *Smyth* case is in my view *sui generis.*

270. I therefore cannot accept the defendant's submission. The court is not bound by the approach that the planning authority might have taken in relation to AM in 2004. At that time, this feature of WTN was, to put the matter neutrally, incompletely understood.

<u>Curial deference</u>

271. In *Kelly v Simpson* [2008] IEHC 374, Charleton J. noted that:

"The effect of a planning decision can be that what would have been a nuisance because of the intrusion on the quiet, comfort and enjoyment of those occupying the area, as it was prior to the lawful grant of a development through planning permission, may be changed into something which those living in the area will simply have to tolerate … Those who are elected to fulfil the role of the local planning authority can be hoped to take a longer term view as to how the development of their area could best be effected through fitting in housing and industry within an appropriate setting and without ruining the economic draw of an area."

272. The defendant in the case before me accepts that the granting of planning permission does not create an immunity from being sued for nuisance. It nonetheless contends that very significant weight must be attached to the views of the planning authority. When asked to identify an authority in support of this proposition, the defendant points to a passage from *Lawrence & Anor v Fen Tigers Ltd & Ors* [2014] 2 All ER 622, in which the Supreme Court accepted that there are circumstances in which the terms of a planning permission will be relevant in a nuisance case, with Lord Neuberger stating as follows at paragraph 96:

"However, there will be occasions when the terms of a planning permission could be of some relevance in a nuisance case. Thus, the fact that the planning authority takes the view that noisy activity is acceptable after 8.30 am, or if it is limited to a certain decibel level, in a particular locality, may be of real value, at least as a starting point as Lord Carnwath says in para 218 below, in a case where the claimant is contending that the activity gives rise to a nuisance if it starts before 9.30 am, or is at or below the permitted decibel level. While the decision whether the activity causes a nuisance to the claimant is not for the planning authority but for the court, the existence and terms of the permission are not irrelevant as a matter of law, but in many cases they will be of little, or even no, evidential value, and in other cases rather more."

273. This passage is hardly a ringing endorsement of the proposition for which the defendant contends - i.e., that the court is bound to accept the planning conditions as a wholly reliable indicator of what is reasonable in terms of noise impact.

274. In a slightly different argument, the defendant contends that the planning permission is a *"pre-baked"* determination of what is reasonable. It is argued that an assessment of what

WTN a reasonable person would be prepared to put up with at this location is *"hardwired into the process"* leading to the grant of permission.

275. This, the defendant asserts is evidenced by the fact that the noise limits in the Ballyduff permission reflect and incorporate (a) planning guidance at the time of the grant of permission, (b) the practice of planning authorities and An Bord Pleanála at the time of the grant of permission (c) current planning guidelines, i.e., WEDG 2006 and (d) current expert scientific knowledge both nationally and internationally in relation to the regulation of windfarm noise.

276. I cannot agree.

(a) Planning guidance at the time of the grant of permission

As I explain below at para 285 *et seq*, as the defendant interprets the Ballyduff permission, the noise limits do not in fact reflect or comply with WEDG 1996 which was the applicable planning guidance at the time of the grant of permission[35]. Conversely, as I will also explain at para 301 *et seq* below, if the Ballyduff permission is interpreted in accordance with the

applicable noise limits in WEDG 1996, then total operation noise exceeds the condition 15 noise limits.

(b) the practice of planning authorities and An Bord Pleanála at the time of the grant of permission

Planning practice at the time of the grant of permission was by no means homogenous. Mr. Lawlor furnished the court with 28 different planning decisions taken by a range of planning authorities and by An Bord Pleanála as representing planning practice roughly contemporaneous with the grant of the Ballyduff permission. Approximately half of these planning permissions applied a 5 dB penalty to WTN if the noise contained *inter alia* distinct impulses such as bangs, clicks, clatters or thumps or if the noise was irregular enough in character to attract attention. Clearly therefore, even at the time of the grant of permission, certain planning authorities and An Bord Pleanála were attempting to regulate and limit precisely the kind of characteristics of which the plaintiffs here complain. In light of this I find it difficult to see how the defendant can maintain that a planning permission which sets only an absolute decibel limit and effectively ignores AM reflects planning practice at the time of the grant of permission. (c) Current planning guidelines, i.e., WEDG 2006 and

(d) current expert scientific knowledge both nationally and internationally in relation to the regulation of windfarm noise

[35] WEDG 1996 provides that noise levels measured externally at any dwelling house should not exceed 40 dBA Leq and yet the defendant argues that the planning permission permits noise levels of 45 dBA Leq for all windspeeds over 5 m/s.

Although I accept for the sake of argument that the noise limits in the Ballyduff permission and indeed the WTN itself comply with WEDG 2006, I cannot accept the defendant's submission that *"the permission limits continue to reflect the current combined wisdom and expertise of appropriately qualified experts as to what levels of WTN would and would not be objectively reasonable"*. Although the defendant contends that the permission complies with draft WEDG 2019, a comparison would not support this proposition. The essential methodology of draft WEDG 2019 sets maximum decibel limits by reference to background noise and penalises "excessive" AM. Demonstrably a permission which permits noise emissions up to 43 dBA L90 without regard to either background noise or possible AM impact does not reflect draft WEDG 2019.

Conclusion on issue 1

277. Depending upon the evidence, the court may in a nuisance action place considerable weight on the terms of a planning permission. The fact that the planning authority takes the view that a particular noise is acceptable at a particular locality, may be highly relevant. However, there is a spectrum of relevance depending upon the circumstances. At one end of the spectrum are cases where there is no assessment at all of the matter complained of. Such planning permissions are likely to be of no relevance in a nuisance case. At the other end of the spectrum are cases where the particular aspect of the development complained of is the subject of detailed conditions reflecting modern guidance and best practice. Such permissions (and the planning guidance on which they are based) are likely to constitute a strong indicator of what is objectively reasonable. At the mid-point will be cases where, for example the planning permission is opaque in its rationale, where the science in the area has moved on since the grant of permission or where the particular matter complained is incompletely regulated by the permission. Such permission is certainly not irrelevant to the nuisance assessment; but, in a WTN case, it can only assist on those aspects of the WTN which it purports to regulate.

278. I find that, at best, the Ballyduff planning permission is at this mid spectrum point. The permission regulates only one aspect of the WTN, the absolute decibel limit. The basis for the decibel limit chosen is unclear. Scientific knowledge and best practice now establish that significant elements of the noise impact are not regulated by the permission.

279. Indeed, the defendant's argument that the noise limits set out in the permission are paramount is particularly weak here. Although the planning permission was granted in 2004, it was not implemented until 2017 due to grid connection difficulties. If the permission had been implemented in April 2004, the turbines would be de-commissioned in the next few months. When such a long hiatus ensues between grant and implementation of a permission, there will always be a risk that evolution in scientific knowledge and amenity standards will bear down on the operation of the development.

<u>Issue 2: Is compliance with the planning permission demonstrated?</u>

Issue 2 (a): For the purposes of the nuisance case, which party bears the onus of demonstrating compliance or non-compliance (as the case may be) with the noise limits in the planning permission?

280. An unusual feature of this case is that, although the planning permission is a key piece of evidence, neither party had apparently adverted to an obvious ambiguity in the noise condition in the planning permission.

281. Condition 15 states:

"15. Noise levels from the proposed development when measured at the nearest inhabited house shall not exceed 40dBA (15 minute leq)[36] at a windspeed of 5 metres per second and 45dBA (15 minute leq)[37] at a windspeed in excess of 10 metres per second. Measures shall be made in accordance with I.S.O. Recommendations R1996/1 'Acoustics – Description and Measurement of Environmental Noise. Part 1 : Basic qualities and procedures…'

282. It is clear that at a windspeed of 5 m/s, WTN may not exceed 40 dBA leq. It is also clear that at windspeeds in excess of 10 m/s, WTN may not exceed 45 dBA leq. However, the permission does not specify the applicable limit at windspeeds between 5 m/s and 10 m/s. There is therefore an ambiguity in the permission. Moreover, the resolution of this ambiguity impacts on whether or not the defendant has demonstrated that the WTN complies with condition 15.

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[36] For brevity, 40dBA leq

[37] For brevity, 45dBA leq

283. The defendant suggests that the resolution of this ambiguity is not a justiciable issue in the context of the nuisance case because the plaintiffs have not pleaded any specific breach of the condition at windspeeds between 5 m/s and 10 m/s. I am satisfied that in the nuisance action, the defendant bears the onus of proving the defence advanced; namely that the WTN complies with the permission, correctly interpreted.

284. As it was therefore apparent that this ambiguity in the permission had to be resolved, I re-listed the matter and heard legal submissions from both parties on the interpretation of the permission. Although I take the view that the interpretation of a planning permission is primarily a legal matter for the court and does not turn on factual or expert evidence, I also afforded the parties an opportunity to call such further evidence as they deemed necessary

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either relating to or arising from this issue. The defendant re-called its acoustician, Mr. Carr, and its planning expert, Mr. Lawlor, who both gave evidence on the interpretation of condition 15. The defendant did not call further evidence to demonstrate that the WTN complied with the permission as interpreted by its counsel in argument or as interpreted by the testimony of its experts (which were quite different). Nor did the defendant call evidence on whether the WTN complied with the permission limits as interpreted by the plaintiffs. The plaintiffs did not consider it necessary to call any further evidence concerning the interpretation of the permission or relating to whether the WTN complied with the permission limits.

Issue 2(b): What is the correct interpretation of the noise limits in the permission?

285. As noted in Simons on Planning Law, 3rd Ed'n (Browne) at 1-141: Planning permission enures for the benefit of the land, and all persons who may be interested. A planning permission is therefore to be construed objectively, with the words given their ordinary and natural meaning, as would be understood by members of the public without legal training, as well as by developers and their agents. It appears that there are four alternative constructions of condition 15.

I. The interpretation urged upon the court by the defendant's experts Mr. Carr and Mr. Lawlor is that condition 15 sets only two defined limits; namely a limit of 40 dBA leq at 5 m/s and a limit of 45dBA leq at 10 m/s. If the WTN complies with these two specific limits, then that is the end of the matter. The defendant's experts therefore maintain that there is no noise limit at windspeeds between 5 m/s and 10 m/s. I pause to note that this was not the interpretation urged by counsel for the defendant in legal submissions to the court.[38]

Mr. Carr argued that this interpretation is in compliance with WEDG 2006 which permits WTN of up to 45 dBA L90 without apparent reference to windspeed. However, any suggestion that one should interpret the permission by reference to WEDG 2006 is entirely incorrect. No evidence has been given that these guidelines were available, even in draft form at the time of the grant of this permission in April 2004. Indeed, even if they had been published in draft form, they could not inform the interpretation of the permission until formally adopted.

By contrast, whilst extrinsic evidence may not generally be admitted in the interpretation of a planning permission, as the present permission is ambiguous, regard may be had to WEDG 1996 which provides the policy context referable to the determination of the planning permission. WEDG 1996 proceed on the assumption that WTN is most perceptible at lower windspeeds because of lower background noise. As such, it is all the more difficult to discern a valid rationale for apparently imposing a noise limit at 5 m/s and at 10 m/s but imposing no limit between 5 m/s and 10 m/s. Where appropriate, a planning permission is to be given a purposive interpretation to achieve its objective. The interpretation contended for by the defendant's experts would rob condition 15 of much of its utility. The turbine reaches maximum power output at approximately 9 m/s and, on the interpretation contended for, would at that point be subject to <u>no</u> noise limit.

As WEDG 1996 viewed WTN as being most impactful at lower windspeeds, this suggests that the intent of condition 15 was to control noise levels at low as well as at high windspeeds. Members of the public will give a planning permission a common sense interpretation, not a technical interpretation. It is in my view most unlikely that ordinary and reasonably informed members of the public without legal training would favour an interpretation which would permit the turbine to reach its natural maximum power out-put with <u>no</u> applicable noise limit.

[38] 40 See part III below.

The defendant's experts stated that as wind rises, so too does speed of rotation and consequently WTN. They therefore argue that, by definition, if WTN is no greater than 45 dBA leq at windspeeds of, or in excess of, 10 m/s, then compliance with that limit at lower windspeeds can be assumed. Conversely, if WTN were to rise to e.g., 50 dBA leq at a windspeed of 7 m/s, then it would necessarily also be significantly higher than 45 dBA leq at a windspeed of 10 m/s. Hence, they argue, it is necessary only to measure compliance at these two specified levels.

This ignores the fact that the turbine might require to be de-rated and operated in a constrained mode in order to secure compliance with the permission noise limits Indeed, it is common case that noise emissions for this model of turbine are predicted to climb by 14 dBA leq between cut in speed (which is slightly below 5m/s) and maximum power output (at approximately 9 m/s). If WTN is already or close to 40 dBA leq at comparatively low windspeeds (between 5 m/s and 10 m/s) then an increase of 14 dBA leq would bring WTN at maximum power output at 9m/s to a level substantially in excess of the 45 dBA leq permission limit. In short, even if compliant at 5m/s and/or 10 m/s, unconstrained, WTN might considerably exceed the condition 15 limits at windspeeds of 6m/s, 7m/s, 8m/s and 9m/s.

Therefore, one cannot comfortably assume that simply measuring noise emissions at 5 and 10m/s will necessarily protect residential amenity from WTN at these intermediate windspeeds. On the contrary, ensuring compliance at all windspeeds might require operational constraints and such operational constraint must be benchmarked against some noise limit. I therefore take the view that there must therefore be <u>some noise</u> limit between 5 m/s and 10 m/s. The question is: what is that nose limit? There are three candidates.

II. One might conceivably interpret the permission as providing that WTN may not exceed 40 dBA leq at 5 m/s and 45 dBA leq for all windspeeds above that. In a moment of refreshing harmony, neither party contended that this was the correct interpretation. I agree. This is a most unlikely interpretation as the permission specifically uses the words *"in excess of 10 metres per second"*, in permitting noise of 45 dBA leq. To interpret the permission as permitting noise of 45 dBA leq at windspeeds between 5 m/s and 10m/s would be to wholly ignore the words *"in excess of 10 metres per second"*.

III. The interpretation urged upon the court in the defendant's legal submissions[39] is that the noise limit permits WTN to increase incrementally between 5 m/s and 10 m/s, such that the noise is limited to 40 dBA leq between 5 m/s and 6 m/s, 41 dBA leq between 6 and 7 m/s, 42 dBA leq 15 between 7 and 8 m/s, 43 dBA leq 15 between 8 and 9m/s, and 44 dBA leq 15 between 9 and 10 m/s. This interpretation would require the court to insert detailed text into the condition to govern these intermediate windspeeds. If such a sliding scale of noise limits was the intended meaning, one would expect the permission to specify the interval windspeeds and corresponding noise limits. One would at the very least expect the condition to reference the principle of a sliding scale.

IV. The interpretation for which the plaintiff contends is that noise levels may not exceed 40 dBA leq at windspeeds of between 5 m/s and 10m/s and that the higher limit of 45 dBA leq only applies for windspeeds in excess of 10 m/s.

WEDG 1996 provides that generally noise levels measured externally at any dwelling house should not exceed 40 dBA leq. As the condition 15 limit of 45dBA leq is considerably in excess of this generally applicable limit, there is little reason to assume it should be engaged at lower windspeeds.

Rather, it is reasonable to interpret the condition as reflecting the assumption that because background noise is lower at low windspeeds, this is when the impact of WTN is greatest. It is reasonable to assume that the permission means just what it says and is intended to restrict noise levels to the generally recommended limit of 40 dBA leq until windspeeds were comparatively high - in excess of 10m/s - at which point an uplifted limit of 45 dBA leq was judged acceptable.

I note that Mr. Carr indicated that he would not expect WTN to be as high as 40 dBA leq at the cut in speed of 4 m/s or 5 m/s. This is consistent with an interpretation pursuant to which the noise levels are permitted to gradually rise from a low base at cut in speed to 40 dBA leq at 10 m/s, but not beyond that until windspeeds exceed 10 m/s. A natural gradual ramp up of WTN with windspeed to 40 dBA leq is thus catered for.

[39] Albeit not supported by the defendant's experts.

286. In short, it is my view that, logically, some noise limit must apply at windspeeds between 5 m/s and 10m/s. Both the specific wording of the condition and the policy context drive me to the conclusion that the relevant permission limit between 5 m/s and 10 m/s is 40 dBA leq.

287. I emphasise that I do not purport to interpret any planning permission other than the one now before me. In particular, if similar wording were to appear in a windfarm permission granted after WEDG 2006, then this might affect matters. WEDG 2006 permits noise levels up to 43 dBA L90 (45 dBA leq) and 45 dBA L90 (47 dBA leq) for night-time and daytime, respectively. With reference to these guidelines, therefore, the argument that the permission is intended to limit WTN generally to 40 dBA leq would be significantly weaker.

Technical approach to assessment of compliance with planning compliance

<u>ETSU approach</u>

288. I accept the defendant's argument that although not expressed as such, condition 15 is an ETSU derived limit. The defendant's approach was therefore to assume that if the total operational noise is below the level set in condition 15, planning compliance may definitively be concluded. I accept that this approach complies with ETSU.

289. I also accept the defendant's contention that in accordance with standard practice, the GPG and Supplementary Guidance Note 5 govern the technical aspects of compliance (windspeed calculation, sound measurement, data collection, data filtering etc). [40]

290. Technical aspects of compliance are also referred to in condition 15 itself which states that measurements shall be made in accordance with ISO 1996-1, "*Description and measurement of environmental noise*" (ISO 1996). ISO 1996 comprises 3 parts. Part 1, which does not deal with measurements *per se* but rather with "*Basic quantities and procedures*", and cross - refers to Part 2; "*Acquisition of data pertinent to land use*" ("ISO 1996-2"). ISO 19962 which includes recommendations on measurement

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[40] As we will see, the GPG/ Supplementary Guidance Note 5 are of particular relevance to the impact of wind direction on noise levels at the plaintiffs' houses in assessing planning compliance ("directionality").

methodologies has been updated twice since 1996; in 2007 and 2017 ("ISO 1996-2, 2017") respectively. As the parties agree that it would not be standard practice to apply these later editions to a planning compliance assessment, I will apply the 1996 version.

291. The application of the following principles in assessing planning compliance are, to a greater or lesser extent in dispute. On each such contest, I prefer the defendant's approach.

L90

292. In measuring noise levels, the defendant's expert, Mr. O'Reilly used the L90 rather than the Leq metric specified in condition 15. The plaintiffs object on the basis that the L90 metric will have a smoothing effect on intermittent noise sources and will therefore fail to represent AM. Further, as L90, is a measure of the sound power level exceeded 90% of the time, it will of necessity be lower than the leq sound power level. Its use, however, is standard practice in the ETSU methodology which uses a conversion metric of plus 2 dBA as between L90 and

Leq. The defendant's expert adopts this approach which I accept as an entirely legitimate approach.

10 or 15 minute leq?

293. Condition 15 sets the noise limits by reference to 15-minute leq intervals. However, I accept that, because the SCADA data is recorded in 10-minute intervals, it was appropriate to assess compliance by reference to 10 minute intervals.

Windspeed

294. Because windspeed varies with turbine hub height (which differs from turbine to turbine), setting noise limits by reference to hub height windspeed would result in inconsistency. A formula was therefore developed pursuant to which, irrespective of the hub height of the turbine, windspeed is extrapolated down to a 10 metre height using a standard wind shear profile. This enables sound emissions from turbines of different physical heights to be compared and regulated. The GPG states that unless otherwise stated, reference to windspeed is to the 10-metre standardised windspeed.

295. The defendant's planning compliance evidence and argument was presented as against both standardised 10 metre height windspeed and hub height windspeeds (without contending for either one or the other). As argued by the defendant I apply the GPG in other contexts. In the interests of consistency therefore, I will proceed on the assumption that compliance is also to be assessed as against standardised 10 metre height windspeed.

296. As I understand it, the standard practice for plotting windspeeds is that bins are centred on integer windspeeds with a width of 1 m/s. For example, the 5 m/s bin would include all data at windspeeds of 4.5 to 5.5 m/s etc. When applied to this permission, this would mean that condition 15 permits WTN of 40 dBA leq for windspeeds of 4.5 m/s to 9.5 m/s and 45 dBA leq for windspeeds in excess of 9.5 m/s.

<u>Filtering</u>

297. To minimise the effects of extraneous noise sources, ETSU recommends that measurements are taken during quiet waking hours (1800-2300 hours on all days plus 07001800 hours on Sundays and 1300-1800 hours on Saturdays) and night hours (2300 to 0700).

The defendant's compliance data is therefore limited to these times.

298. I accept the view of both parties that planning compliance should be assessed primarily by reference to night-time data. Mr. O'Reilly has filtered out all night-time data between the hours of 4am to 7am to exclude elevated noise levels due to extraneous bird song during the dawn chorus. Mr. Stigwood is critical of this approach which excludes over a third of time data irrespective of the fact that the dawn chorus lasts for a comparatively short time.

299. Mr. Carr accepts that a more nuanced approach to filtering the dawn chorus might have been more appropriate, particularly because at higher windspeeds (i.e., at the right hand side of the graph) one would not expect the dawn chorus to have an appreciable impact on overall noise levels. However, having considered the GPG and Supplemental Guidance Note 5, I am satisfied that Mr. O'Reilly's approach is consistent with the ETSU methodology and I accept its validity.

300. Supplementary Guidance Note 5 provides that compliance measurements should be undertaken in downwind conditions unless there is a specific requirement to measure in other wind directions (such as complaints during cross wind conditions), and that all data except that corresponding to such conditions should be filtered out. Mr O'Reilly took this approach and filtered out all wind directions other than directly downwind of the turbine. Mr. Stigwood disputes the validity of this and maintains that the worst case noise prorogation conditions at this site actually occur in crosswind conditions. For reasons I will explain, I accept the validity of the defendant's approach as being more consistent with Supplementary Guidance Note 5.

Issue 2 (c): What does the compliance data show? - Evidence tendered on planning compliance

301. Mr. O'Reilly carried out noise monitoring at NF from 18th May 2017 to 15th June 2017. His evidence is that the noise monitoring equipment was placed on a terrace in the back garden approximately 17 m from the house at a height approximately level with the eves of the house. Mr. O'Reilly prepared two charts on foot of this monitoring and informed Mr. Brazil that the noise levels complied with the planning permission.

302. A month or so later Mr. O'Reilly was instructed to carry out monitoring at HH which he found strange. Mr. O'Reilly proceeded to conduct monitoring at HH between 6th August to 4th September, 2017. His evidence is that the noise monitoring equipment was placed on a bag of sand in the patio at the back of the house 4.5 metres from the façade of HH, and 2.1 metres from the "end of" an adjacent garage door. Mr. O'Reilly informed Mr. Brazil that this monitoring also demonstrated planning compliance. He was, however instructed to hold off from writing a compliance report.

303. It was not until January 2021 that Mr. O'Reilly was instructed to write a compliance report. He was requested to present the HH data only. In the meantime, the NF noise monitoring data (referred to immediately above) appears to have gone missing and was only recovered from Mr. O'Reilly's computer in December 2022.

HH planning compliance data

304. The primary data advanced by the defendant was in the form of compliance graphs in respect of HH showing WTN in downwind conditions.

Incorrect measurement location

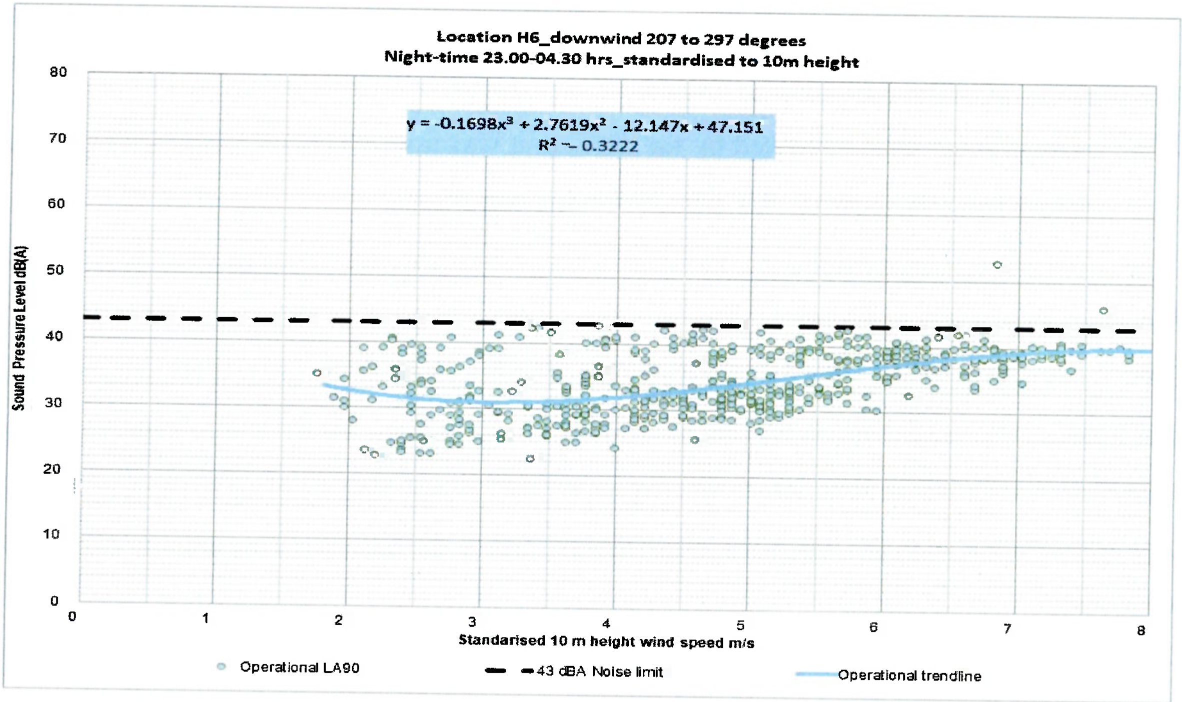
305. Condition 15 requires the measurement of noise levels at the nearest inhabited house. The nearest inhabited house is NF and not HH. Although as I say, Mr. O' Reilly took compliance measurements at NF in June 2017, for reasons which are not entirely clear to me, only the HH data was referenced in the defendant's experts' reports as the basis for the planning compliance assessment.

306. The defendant argues that as the two houses are only ten metres apart, it is unlikely that there is a substantial difference between their respective compliance levels. However, the data derived from HH and NF is quite different both as regards total operational noise and as regards the background sound levels they suggest.

307. As this was the approach taken by the defendant, I will consider the HH compliance data first. Having done so, I will turn to consider the NF compliance data.

Incorrect interpretation of condition 15

308. Mr. O'Reilly produced a number of graphs in which he presents total operational noise at HH during the period of his monitoring. The downwind HH night hours compliance graph (with the dawn chorus removed) is below.



309. Each data point represents a ten-minute period of noise measurements on the L90 metric. Each data point is therefore an average of the L90 noise levels (i.e., the noise level exceeded for 90% of the time during the 10-minute measurement period). In the graph below, these data points are then plotted as against windspeeds (standardised to 10 m), and a trend line is derived. This trend line represents an average of the data points which themselves represents the lowest 10% of the noise levels obtained. The trend line is then compared to the permission limits. In order to compare this data, which was on the LA 90 metric with the Leq metric used in the planning permission, Mr. O'Reilly applied a 2 dBA correction. He therefore assumed that the condition 15 limits of 40 dBA leq at a windspeed of 5 m/s and 43 dBA leq was 38 dBA L90 and the condition 15 limits at a windspeed in excess of 10 m/s was 43 dBA L90.

310. The above HH compliance graph demonstrates that the trend line is below 38 dBA L90 (40 Leq 10) at 5m/s and below 43 dBA L90 (45 Leq 10) at 8 m/s during quiet waking hours.

Mr. O'Reilly therefore interpreted this graph as demonstrating compliance and the plaintiffs' expert did not demur in this particular respect.

311. However, neither expert had adverted to the ambiguity in condition 15. I have determined that, correctly interpreted, condition 15 limits WTN to 40 dBA leq between

5 m/s and 10 m/s. Although neither party's experts therefore tendered on this precise basis, the data speaks for itself. It suggests that total operational noise at HH is in excess of 40 dBA leq for windspeeds in excess of 6 m/s.

312. Total operational noise above the permission limits does not of course establish planning non-compliance as the noise limit applies only to WTN and not to total operational noise. However, if total operational noise exceeds the noise limit, then the developer must ascertain and deduct background noise levels from total operational noise. The defendant has not carried out this exercise. Therefore, whilst non-compliance with the permission has not been conclusively demonstrated, nor has compliance been demonstrated[41].

Insufficient data

313. There is no data at moderate to high windspeeds on the HH night-time graph. Mr. O'Reilly stated that the NF data is far more complete, robust and overall "*better data*" than the HH data. Mr. O'Reilly had been happy with the NF data and expressed surprise that he had been asked to prepare a second set of readings. As such, it is hard to fathom the defendant's focus on the HH data to the complete exclusion of the NF data.

314. There is no noise data at HH during night hours at windspeeds above 8 m/s. It is not possible to reliably assess compliance at 8 m/s (which includes all data in 7.5 to 8.5 windspeed bin) as there are no data points between 8 and 8.5 m/s. Indeed, there are apparently only 5 valid data points between 7.5 m/s and 8 m/s. Compliance at night may therefore only be assessed up to 7 m/s (which includes all data in the 6.5 m/s to 7.5 m/s windspeed bin). For the same reason one cannot assess compliance at windspeeds of 9, 10, 11, 12 etc m/s.

315. Mr. Carr's response to this problem was to rely upon the data collected during quiet waking hours which shows that total operational noise increased from 39.5 dBA L90 at windspeeds of 7m/s to 42.4 dBA L90 at 9 m/s. Mr. Carr suggests that one could assume

[41] I deal separately below with whether a façade level deduction may be made in light of the measurement location.

the same increase at night-time thereby combatting the paucity of data above 8m/s at night. With respect, this is to urge a rather *à la carte* approach to compliance assessment. I have been referred to no guidance which would permit of such an approach.

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316. On the contrary, the GPG requires that compliance data reflect either likely worst case noise conditions or the conditions complained of by the complainant (or both). Supplementary Guidance Note 5 provides that it will usually be necessary to carry out noise monitoring for around 1 month to obtain the necessary range of windspeeds and wind directions to ensure that noise limits are being met for worst case downwind propagation conditions.

317. As the plaintiffs' greatest complaints are at higher windspeeds, the absence of data at moderate to higher windspeeds, there is no assessment of the potential worst case WTN. Further, whilst they also complain of noise intrusion during the day, the plaintiff's primary complaint is of noise disturbing their sleep at night. Reliance on the quiet waking hours data at HH cannot fill the lacunae in the monitoring data.

318. This is no mere matter of detail. Although windspeeds during Mr. O'Reilly's monitoring were considerably lower, higher windspeeds are by no means unusual at this location. Mr. Carr prepared two tables of indicative windspeeds which show that windspeeds in excess of 7 m/s occurred 60% of the time during the MAS 2017 monitoring period and 35% of the time during the MAS 2021 monitoring period. Planning compliance clearly could not be established without including these windspeeds in the compliance data.

319. In addition, the inability to assess compliance at windspeeds in excess of 8 m/s means that even if I were to accept the defendant's expert's interpretation of the permission (which would require compliance testing at only 5 m/s and 10 m/s) compliance could still not be demonstrated. Nor, in the absence of data at the relevant windspeeds could compliance with the "sliding scale" interpretation contended for by counsel for the defendant be demonstrated.

Incorrect positioning for façade deduction

320. ETSU and Supplementary Guidance Note 5 require the placement of a microphone at a free field location, which as per ISO 1996-2 is at least 3.5 metres from the façade of a building. Mr. O'Reilly's report states that he positioned the microphone 4.5 metres from the façade of HH, and 2.1 metres from the *"end of"* an adjacent garage door. The measurements are neither free field measurements nor façade measurements, but a hybrid of both.

321. ISO 1996-2 states *"Note:-if measurements are made 1 to 2 m in front of the façade of a building...an approximation to the incident sound level may be obtained by subtracting 3dB from the measured value".* Mr. O'Reilly relies on proximity to the garage door to make a deduction of *"at least 2 dBA"* from the measured values. There are two difficulties with this.

322. First, I am unconvinced of the robustness of these measurements insofar as concerns the location of his microphone. It was put to Mr. O'Reilly in cross-examination that his measurements were inaccurate, and that the monitoring equipment had in fact been placed 8.8 metres rather than 4.5 metres from the house façade. He freely conceded that this could be the case as he had only *"stepped out"* rather than measured distance to the house. This means that the reported measurements contains at least one significant inaccuracy, potentially almost doubling the distance from the house façade. It was also put to Mr. O'Reilly that he had also underestimated the distance from the microphone to the garage door. Mr. O'Reilly denied this and said that he had measured this distance with a tape measure. However, Mr. O'Reilly did not recall the site visits and did not take contemporaneous notes of same. As such, I must doubt the accuracy of a measurement first committed to paper several years after his site visit. This is not a reliable basis for claiming a 2 to 3 dB deduction in the measured sound levels.

323. Second, a façade deduction is dependent upon the angle of incidence as between the microphone and the façade. ISO 1996-2 applies this deduction to the measurements taken *"in front"* of the façade. In this case, the angle of incidence as between the microphone, the turbine and the contended for façade (the "garage door") is entirely unspecified. Mr. O'Reilly's report states that the microphone was positioned 2.1 metres from *"the end"* of the garage door, which does not suggest that it was perpendicular to the door. Indeed, nor do the photographs taken by Mr. O'Reilly of the monitoring equipment *in situ* so suggest.

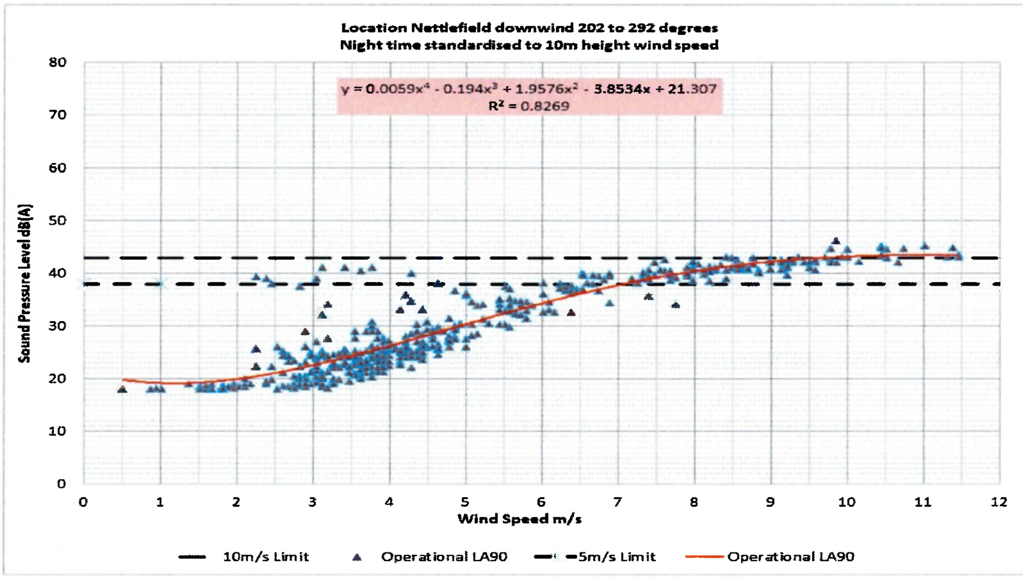
324. The onus is on the defendant to demonstrate planning compliance. In the absence of reliable measurements of both the distance to the façade and the angle of incidence, this is an exercise in conjecture. Whilst it is therefore perfectly possible (and indeed is likely) that some deduction should apply, one cannot without more know what that deduction should be.

325. In any event, this issue is largely academic as it appears unlikely that a 2-3dB reduction would bring total operational noise between 5 m/s and 10 m/s into compliance with the permission limit of 40 dBA leq.

<u>NF planning compliance data.</u>

326. On foot of his noise monitoring in May/June 2017, Mr. O'Reilly prepared downwind NF planning compliance graphs. However, these were not referenced in either Mr. O'Reilly's expert report or in Mr. Carr's reports. Further, no evidence was tendered in relation to the NF compliance data by the defendant's primary acoustics expert Mr. Carr over the course of his 7 days of evidence to the court. This data was only first introduced by Mr. O'Reilly on day 47 of the trial. In addition, notwithstanding repeated requests over a period of over five years the NF data was not at any stage furnished to the Carty-Shortens or to their solicitor. Furthermore, the NF data was not, (as the defendant accepts it ought to have been) included in the defendant's affidavit of discovery. In fact, the continued existence of the NF data only came to light in December 2022 during the course of the trial. It was first furnished to the plaintiffs on day 24 of the trial.

The downwind NF night hours compliance graph (with the dawn chorus removed) is below:



327. The NF graphs show that total operational noise exceeds the permission limit of 40 dBA leq at windspeeds between 7 m/s and 10 m/s. At a windspeed of 9m/s, it exceeds the limit by perhaps as much as 4 dB.

328. In addition, Mr. O'Reilly accepted that the NF graphs demonstrate that total operational noise at night exceeds even the 45 dBA leq limit in the permission from windspeeds of 9.5 m/s. As such, total operational noise exceeds the upper permission limit of 45 dBA leq even under the interpretation favoured by the defendant's experts whereby compliance is assessed only at 5 m/s and at 10 m/s.

329. For a number of reasons, the defendant argues that this exceedance is not attributable to WTN but to wind noise.

330. First, it emphasises that the turbine reaches maximum power levels at 9 m/s and that one would not therefore expect WTN levels to increase beyond 9 m/s. As such, it is argued that the exceedance of total operational noise over 45dBA leq at windspeeds in excess of 9 m/s cannot be WTN and must be background noise, specifically wind noise. Although I have been furnished with thousands of pages of guidance, not one document suggests that one could safely make this assumption.

331. Second, the defendant argues that these measurements were taken 17 m from NF and thus closer to the turbine. However, ETSU permits noise monitoring to be carried out some distance from a residence and states: *"In order to ensure that measurements of wind turbine noise are not influenced by reflections off buildings the microphone should* *be positioned at least 10m away from the façade"*. Indeed, Mr. Carr states that the GPG permits measurements between 3.5 and 20 m from a dwelling. Given the distance from the turbine to NF - 369 m - I fail to see how this additional distance could make an appreciable difference to the level of WTN.

332. Third, the defendant submits that the NF noise levels are elevated because they were taken at a height approximately level with the roof of NF. Yet, no effort has been made by the defendant to calculate what the impact of the additional height may be. Moreover, I have been referred to no guidance which would permit of an unspecified reduction in noise levels by reason of height.

333. Finally, the defendant suggests that because the monitoring equipment was placed 17 m back from the house and thus closer to the tree line, the increased noise levels can be explained by wind in the trees. Mr. Stigwood rejects the suggestion that such noise could have an appreciable impact on the noise levels recorded on Mr. O'Reilly's compliance graphs. His view is that although not as sheltered as the house, the monitoring location chosen is still sheltered. There is therefore a conflict of views on this issue upon which the court has entirely insufficient evidence to adjudicate.

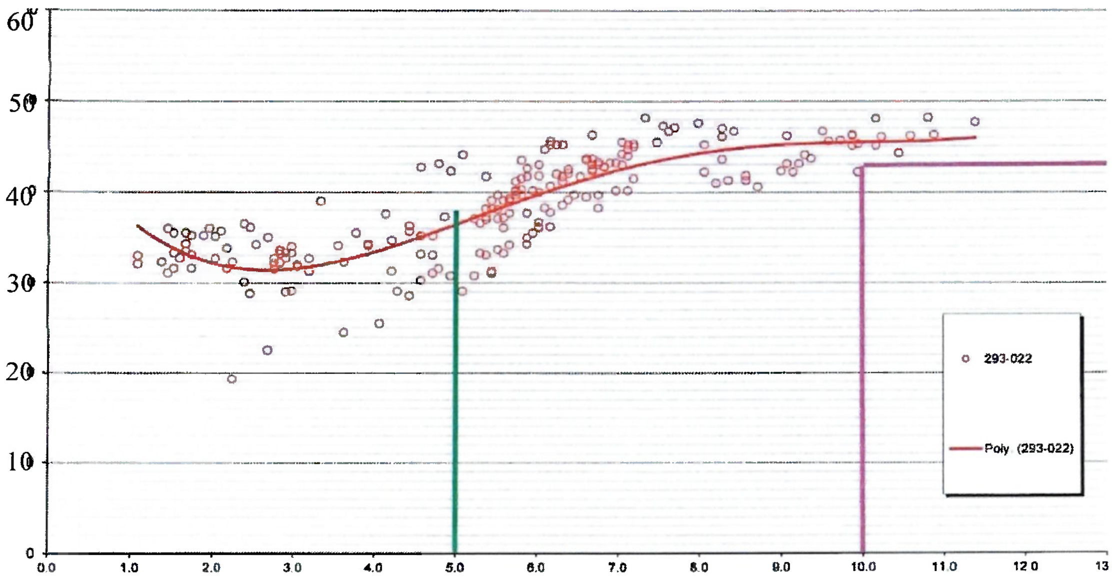
334. The point, however, is that I do not need to decide upon the merits of any of the defendant's above arguments. ETSU is crystal clear. If total operational noise is in excess of the relevant permission limit, then it is for the defendant to ascertain background noise levels at the relevant measurement location and deduct same from total operational noise. The defendant has made no effort to do this. Accordingly, whilst it may be that background noise levels are a substantial contributor to the noise levels appearing on Mr. O'Reilly's NF graphs, the present state of the evidence means that compliance is not demonstrated.

Wind Direction - the MAS NF crosswind planning compliance graph

335. The key to compliance monitoring is to ensure that the compliance testing is carried out under worst case conditions. According to the GPG, this is generally assumed to be downwind unless there are complaints in other wind directions. Mr. O'Reilly therefore presented compliance data only for downwind conditions and the other three quadrants were filtered out.

336. As referenced above, the defendant did not discover the NF monitoring data until midtrial. When this data was finally made available, Mr. Stigwood interrogated it and formed the view that the worst case of WTN (in terms of absolute dBA or sound power level) apparently applied in crosswind and not downwind conditions.

The MAS NF crosswind planning compliance graph is below.



13.

337. Mr Stigwood contends that this graph demonstrates that total operational noise exceeds the permission limits. Because the NF data was not made available until well into the trial, the purported non-compliance demonstrated in crosswind conditions could not have been pleaded.

338. I will admit this evidence and will, accordingly consider whether it impacts upon planning compliance.

339. The defendant contends, with some merit, that it would be extremely unusual if worst case noise propagation were to occur in crosswind conditions. It argues that the higher readings in crosswind conditions at NF are not attributable to WTN but to the fact that wind coming from this direction would be incident upon the treeline located to the west of the plaintiffs' house. This could be a perfectly coherent explanation for the elevated levels[42]. On the other hand, if the elevated levels were attributable to wind noise one would expect the noise to continue to climb as the wind increases. This however is not what the graph shows. Rather the noise increases up to 10 or 11m/s and then levels off. Mr Stigwood therefore argues that it is more likely that these elevated levels reflect WTN which levels off when maximum power output is reached at 9m/s approximately.

340. However, I accept the defendant's argument that compliance measurements need only be undertaken in downwind conditions unless there is a specific requirement to measure in other wind directions such as complaints during cross wind conditions. Overall, the evidence is not particularly consistent with complaints in cross wind conditions. As such, compliance monitoring in cross wind conditions was not required. I will therefore place no reliance upon the MAS NF crosswind planning compliance graph.

Summary and conclusions in relation to planning compliance.

341. In summary, it does not seem to me that the defendant's data demonstrates compliance with the planning permission for the following reasons:

a) Compliance cannot be demonstrated by reference to the HH compliance data because NF is the appropriate measurement location. Further, there is a paucity of night hours HH compliance data at all windspeeds above 8m/s. One cannot be confident that worst case WTN has been assessed.

b) Although this issue is largely academic due to point a) above, I am not satisfied on the balance of probabilities that Mr. O'Reilly correctly positioned the measuring equipment - either as regards distance from the façade or angle of incidence - to capture façade level measurements, I do not accept therefore that it is appropriate to deduct 3 dB from the HH measurements.

[42] The Good Practice Guidelines acknowledge that in rural or semi-rural areas noise generated by wind in the trees is generally a dominant noise source at higher windspeeds and therefore proximity of the monitoring location to trees and vegetation and the type of such vegetation may be significant.

c) In any event, on the correct interpretation of condition 15, the HH night hours compliance graph shows that total operational noise exceeds the limits set out in the permission at windspeeds above 6 m/s.

d) Furthermore, the inability to assess night hours compliance at HH at windspeeds in excess of 8 m/s means that even if I were to accept the defendant's experts' interpretation of the permission (which would require compliance testing only at 5 m/s and 10 m/s) compliance could still not be demonstrated in the absence of data at 10 m/s.

e) Compliance at HH has therefore not been demonstrated.

f) NF is the closest inhabited house and the NF data is more complete and therefore robust. For that reason, compliance ought to have been adjudged by reference to the night hours NF compliance data.

g) The NF monitoring was not carried out at façade level and no façade deduction is indicated from the noise levels measured.

h) On the correct interpretation of condition 15 total operational noise as shown on the NF night hours compliance graph exceeds the limits set out in the permission at windspeeds above 7m/s.

i) Total night hours operational noise at NF also exceeds 45 dBA leq at windspeeds in excess of 9.5 m/s. Therefore, even if I were to accept the defendant's experts' interpretation of the permission (which would require compliance testing only at 5 m/s and 10m/s) compliance could still not be demonstrated.

j) Although the defendant argues that any exceedance of total operational noise over 45 dBA leq at NF is attributable to background noise/wind noise, the onus is on the defendant to so demonstrate by refence to background noise studies. No such evidence has been tendered to the court.

k) In addition, although the defendant contends that this exceedance may be due to monitoring height, it bears the onus of so demonstrating. No such robust evidence has been tendered to the court.

l) Compliance at NF has therefore not been demonstrated.

342. In the case of HH total operational noise exceeds 40 dBA leq between 6 m/s and 10 m/s by approximately 2 dBA. The exceedance at NF - which is the correct property for compliance testing - is greater, perhaps up to 4 or 5 dBA. An exceedance of this order is potentially a material deviation from the noise limits in condition 15.

343. I accept that on the defendant's experts' interpretation of the permission, the exceedance of total operational noise over 45 dBA leq at 9.5 m/s and above is marginal, perhaps no more than a decibel overall. However, this is largely beside the point as I do not accept that this is the correct interpretation of the planning permission. Moreover, the defendant's chosen defence to this action is to maintain that the planning permission is the appropriate metric for assessing nuisance. In contrast to the plaintiffs, who argue that the test for nuisance is both quantitative and qualitative, the defendant argues that the test is purely quantitative and that the WTN is "*meticulously compliant*"[43] with the permission limits. Whilst I reject the argument that the nuisance assessment is exclusively quantitative, it could only ever carry weight if meticulous compliance is in fact demonstrated. Mr. Carr's evidence was that he would regularly advise wind farm developers in adopting mitigatory strategies to bring down WTN by a decibel or two to ensure compliance. There is no suggestion therefore that relatively modest exceedance would not be viewed by the planning authority as non-compliance or would not require the adoption of mitigation measures. Therefore, even if the interpretation that the defendant's experts place on the planning permission is correct, I would not be disposed to hold that compliance is demonstrated.

344. In short, I do not accept the defendant's arguments on Issue 1 or Issue 2.

345. The defendant's arguments are not therefore dispositive of this case, and I will now turn to the key question of whether nuisance is established on the evidence.

Issue 3: is the character of the locality to be assessed on a "windfarm" or "no windfarm" basis?

346. The character of locality is an important factor in any nuisance assessment. Here also a dispute arises as to the relevance of the planning permission.

[43] In the words of the defendant's planning expert, Mr. Lawlor.

347. The plaintiffs and their experts present the locality as a quiet rural location *simpliciter.* To assess nuisance, they therefore compare the current scenario to a "no turbine" scenario.

348. The defendant argues that the planning permission defines the character of the locality, which is therefore presented as a rural location with a windfarm at reasonably close proximity with all that that entails.

349. Should one assess the character of the locality with or without the Ballyduff windfarm?

350. In general, the Irish courts have tended to afford weight to the decisions of the planning authorities in determining the character and nature of the locality. In *Lanigan v. Barry*, Charleton J. considered the relevance of planning permission in determining whether an actionable nuisance had occurred. At para. 22 of the judgment, Charleton J. stated:-

"In considering the issue as to the amenity of an area, regard should be had to its immediate history and its character prior to the commencement of the activity complained off. The character of a neighbourhood may, however, change. This may be due to economic deprivation or to the development within the area of enterprises and structures which change its character. In that regard, the wider question as to how an area is to develop is to be determined in accordance with the Planning and Development Act, 2000. The legislation is an example of the application of democratic principle to the important question as to how the area in which a citizen lives, or carries on his or her business, may change. ... Were the legal mechanism of the scrutiny of planning permission not to exist and were it not the case that notice must now be given in a direct manner through what is in effect an advertisement as to what may happen at the site of a proposed development, then persons might feel aggrieved at being taken by surprise when a factory, set of apartments or some house extensions, suddenly spring up beside them. The legal mechanism is there, however, to allow participation in decisions which may affect the environment, the value of property and the nature of such quiet and comfort as may be the settled expectation of people in any particular area. <u>Therefore, where planning consent is given after due process for a development, including a change of use, the issue as to what is a nuisance will be determined according to the character of that neighbourhood as authorised by relevant planning permissions and as declared by the development plan</u>."(Emphasis added).

351. In *Gillingham Borough Council v. Medway (Chatham) Dock Company Ltd* [1992] 3 All ER 923 at 934 Buckley J. had noted that Parliament had set up a statutory framework and delegated the task of balancing the interests of the community against those of individuals to the local planning authority. The right to object, the provision for appeals and enquiries and the added safeguard of judicial review applied but, ultimately, a planning authority could, through its development plans and decisions, alter the character of a neighbourhood rendering innocent activities which, prior to that change, would have been an actionable nuisance.

352. In *Lanigan v. Barry,* Charleton J. quoted these passages which in his view emphasised the primacy of the planning process in setting local standards of amenity.

"24. This does not mean that a nuisance is authorised by a planning permission granted in accordance with the development plan of a local authority. On the contrary, people retain their rights but according to the standard, judged against the nature of the locality, that the law sets.

25. All of this emphasises the primacy of the planning process in setting local standards of amenity. That process can not be ignored or flaunted or undermined by deception. The standard of amenity that is reasonably to be expected by people living in an area can change as an area is lawfully developed. The nature of businesses suitable for an area can also change as an area is developed by lawful means. Unless the business activity be regarded as unduly sensitive, and therefore unsuitable for the character of an area in which it is situated, no one is entitled to use a planning permission to destroy the business of a neighbour" (Emphasis added).

353. In *Smyth v. RPA*, Laffoy J. also referred to the then recent English authority in *Watson v. Croft* [2008] 3 All ER 1171 in which the Court of Appeal restated the basic principle that a grant of planning permission does not affect the property rights of third parties but that the implementation of that planning permission may so alter the nature and character of the locality as to shift the standard of reasonable user which governs the question of nuisance or not.

354. I accept the defendant's submission that, as a matter of law and fact, part of the character of the locality where the plaintiffs' homes are located is that there is planning permission for a windfarm. I also accept that this inevitably brings with it some degree of visual and aural intrusion - some degree of aerodynamic noise and some AM - which the plaintiffs would be expected to tolerate. However, in the words of Charleton J, "*this does not mean that a nuisance is authorised by [the] planning permission. On the contrary,* [the plaintiffs] *retain their rights but according to the standard, judged against the nature of the locality, as including a windfarm.*"

355. Here the plaintiffs do not base their claim to nuisance on the mere presence of the turbines in a quiet, rural area. Nor does their evidence suggest any objection to some aerodynamic noise or some swish AM of the kind one would usually expect.

356. On the other hand, no reasonable person could reasonably have expected that this permission had authorised WTN which regularly dominates the soundscape and exhibits AM and other characteristics rendering it unreasonably difficult to work, or uncomfortable to relax or sleep. Although the character of the locality includes a windfarm, it is still the case that depending upon the level of intrusion and on its duration and frequency, the WTN associated therewith might be such that ordinary people could not reasonably be expected to tolerate it without mitigation, without compensation, or possibly at all. Whilst the plaintiffs cannot expect their location to be as peaceful as if there was no windfarm, they can nonetheless expect that noise intrusion from the permitted windfarm will not be unreasonable.

357. The court's assessment here must be reasonably exacting. Because of the planning permission, the plaintiffs cannot fairly contend that audible WTN is by definition an unreasonable interference. On the other hand, the defendant cannot say that because (particularly in more recent times) WTN is known to occasionally demonstrate certain particularly intrusive characteristics - for example prominent or thump AM - the grant of planning permission means that the plaintiffs have no remedy if these characteristics present themselves in a manner that is unreasonable in all the circumstances. WTN of this latter nature could not have reasonably been anticipated on foot of the Ballyduff planning permission and is not therefore part and parcel of this locality.

Conclusion on issues 1, 2 and 3

358. In the circumstances of this case, the Ballyduff planning permission does not dictate the boundaries of actionable nuisance. While the decision of the planning authority grants planning permission at a general level for a windfarm at this location, it does not purport to address or regulate the key aspects of the WTN which are complained of here - AM with high AM values and low frequency characteristics.

359. Whilst a windfarm is part of this neighbourhood, this does not mean that the plaintiffs should be expected to tolerate any and all noise nuisance that goes with that use. All that the planning permission can be said to authorise is WTN of a particular decibel level whereas this case is not about the decibel level of the noise but rather its character. It cannot be therefore said that the characteristics complained of are authorised by the planning permission and must be seen as part of the locality.

360. Furthermore, it has not been demonstrated that the WTN is within the noise limits specified in the permission in any event. Therefore, even if this case revolved around decibel levels only, I could not be satisfied that the permission authorises WTN at the level that presently pertains or that WTN at these levels is part of the character of the locality.

<u>Issue 4: What criteria ought the court consider in the assessment of nuisance?</u>

Defendant's argument-the line in the sand

361. The defendant correctly submits that the question of whether the WTN is an objectively unreasonable interference with the plaintiffs' amenity cannot be determined by reference to the plaintiffs' subjective evidence. It further argues that the plaintiffs have made no attempt to establish what their requirements are or, how they can be regarded as objectively reasonable.

362. Thus, the plaintiffs have failed to:

- identify by way of the ETSU methodology the decibel level beyond which noise becomes objectively unreasonable and poses a nuisance or;
- identify, in a manner analogous to the draft WEDG 2019 methodology, the precise parameters pursuant to which noise of a particular decibel level combined with a particular level of AM becomes objectively unreasonable and poses a nuisance.

363. In short, the plaintiffs have not identified a line in the sand, a line of acceptability. Unless and until such a line is identified and applied, it is said that the court cannot assess the matter. Irrespective of how the WTN is experienced by the plaintiffs, this line must determine the outcome of the case. However, the defendant's attempt to identify what the line should be are in my view unconvincing.[44]

364. The primary "line" identified by the defendant and its experts is of course the planning permission. For all the reasons explained above, I find that the line cannot be supplied by condition 15 (with which in any event compliance has not been demonstrated) as it does not regulate what is said to be the most intrusive aspects of the Ballyduff WTN, namely AM, particularly thump AM.

365. Nor, for the same reason, can the line be supplied by WEDG 2006 (with which, for the sake of argument, I accept the WTN complies). WEDG 2006 does not provide the court with any yardstick - objective or otherwise - against which to assess what AM values or what degree of thump AM is objectively reasonable.

366. Similarly, although the defendant places huge reliance on IOA RM, that methodology is not intended to capture the subjective annoyance response and does not purport to be a yardstick for nuisance. The IOA RM cannot tell one what the noise sounds like. Crucially, the defendant's experts do not contend that the IOA RM differentiates between swish and thump AM. Despite Mr Carr's very heavy reliance upon it, the IOA RM is not a "recognised standard"" capable of assessing the <u>impact</u> of AM, and thump AM in particular. The only yardstick of which I have been informed for identifying and assessing the impact of thump AM is the qualitative yardstick advanced by the plaintiffs' expert; to record, listen and analyse the WTN and to correlate same with spectral frequencies by means of a spectrogram.

367. Even leaving these difficulties aside, the IOA RM is not in any case "self-executing". The IOA RM only assists in establishing a "line" if it is used to rate AM values per windspeed on foot of which one then calculates a penalty and then incorporates that penalty into a defined decibel limit. In other words, the IOA RM could only even provide a yardstick for objectively reasonable noise if deployed in a manner analogous to the draft WEDG 2019 methodology.

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[44] As I note above in my summary of the expert's evidence, Mr Carr's opinion was that nuisance must be assessed in accordance with *"some recognised standards or guidance"*. In this respect, Mr. Carr relied primarily on the planning permission and WEDG 2006, but also mentioned draft WEDG 2019 with which he asserted the WTN complied. He also relied heavily on the IOA RM.

368. Yet the defendant and its experts do not see this logic through. Although it maintains that it complies with draft WEDG 2019, the defendant also distances itself from that guidance. The defendant emphasises that although consideration was being given in draft WEDG 2019 to changing the basis of regulation from that set out in WEDG 2006 – principally to bring down maximum noise limits from 45 dBA L90 to the 43 dBA L90 or 5 dBA over background and to reflect a penalty for AM - this draft guidance has not been brought forward. The defendant's uncontradicted evidence is that the present practice of planning authorities is to fix permission noise limits for wind farms in accordance with WEDG 2006 - i.e., by reference to fixed decibel limits only with no penalty for AM.

369. The defendant therefore argues that because this is the present practice of local authorities, the court ought to adopt a similar approach in its assessment of nuisance in this case. I do not agree. The issue is not whether or not WEDG 2006 remains the current regulatory framework for windfarms in this country or indeed whether the Ballyduff WTN complies therewith. Neither WEDG nor present planning practice can determine the matter at hand because they do not reflect current expert scientific knowledge on WTN. Current expert scientific knowledge at least informs more recent publications such as draft WEDG 2019 and the ETSU Review (although of course the first of these has been withdrawn and the second has yet to be formally adopted). Unlike these more recent publications, WEDG 2006 does not even consider the extent to which those aspects of the WTN which are the source of complaint in this case may be said to be objectively reasonable.

370. The fact that AM and thump AM remain to be regulated does not mean that the court should ignore these characteristics. I fail to see how it can credibly be said that merely because an acknowledged problem has not been regulated in the planning sphere the court should now ignore the problem in the context of a nuisance action.

371. This review of WEDG 2006 is clearly a difficult and long-drawn-out process and the same is evidently the position in the UK. In and of itself this demonstrates just how complex and multifactorial the impact of WTN can be.

372. This ongoing evolution reveals the fallacy of a related argument advanced by the defendant; namely that the plaintiffs must demonstrate non-compliance with WEDG 2006 and that the failure to do so effectively means that nuisance is not established. The plaintiffs do not rely upon non-compliance with current planning guidance as establishing nuisance. They argue - correctly in my view - that existing planning guidance effectively (WEDG 2006) is not responsive to the issues complained of - AM, thump AM etc.

373. I think it is fair to conclude that the current direction of travel in wind energy planning guidance is towards setting decibel limits combined with a penalty for character such as AM together with limits on low frequency noise. However, the recommended decibel levels in draft WEDG 2019 might go up or they might go down. The suggested penalties for AM might also go up or they might go down. The permitted exceedance over background noise might go up or it might go down. Likewise, the current low frequency curve may be adjusted.

374. Draft WEDG 2019 is perhaps a reasonably up to date indicator (2019) of what might have been considered appropriate in terms of WTN, AM, low frequency noise etc. However, it is no more than that. Draft WEDG 2019 has since been withdrawn. I therefore criticise neither party for failing to carry out a formal assessment of the Ballyduff WTN as against these draft guidelines. I do, however criticise the defendant's casual assertion that it complies with draft
WEDG 2019 (indeed with "*headroom*") when there is little credible basis for this view.[45]

375. I should say that this court would place very considerable weight upon up-to-date, scientifically robust planning guidelines on wind energy developments which advised on the particular decibel level at which WTN, when combined with AM of a particular

[45] I explain this further at para 206 *et seq* above and 471 below.

nature, is considered an acceptable interference with amenity. If responsive to the particular aspect of the noise complained of, such guidance would be highly persuasive in a nuisance action. A plaintiff who sought to argue that such guidance did not represent a reliable – if not a wholly reliable – indicator of what is objectively reasonable would, in my view, bear a heavy onus. However, no such guidance currently exists; planning guidance in this jurisdiction (and elsewhere) can fairly be described as flux and cannot identify the line of acceptability.

376. This raises a further principled objection to the notion that the plaintiffs must identify a line in the sand upon which this court must rule. Although the defendant does not overtly request a line to be drawn for every windfarm, this would seem to be the terminus of its argument.

377. Yet, there is currently a government policy in evolution in relation to the wind energy development which one would expect to consider at least some of the crucial components of this line in the sand. WEDG 2006 is in the course of review. It would in my view represent a wholly unwarranted intrusion on the executive function for the court to attempt to draw the line of acceptability for windfarm noise. Not only does the court have no jurisdiction to do this, but it also lacks the expertise to even attempt this task.

378. In short, neither the parties' experts nor the court can or should attempt to set a line of acceptability for the community as to what constitutes unacceptable windfarm noise. That is not the purpose of this litigation.

The Defra criteria

379. Ms. Large and Mr. Stigwood identified BS 4214, *Methods for rating and assessing industrial and commercial sound* and the Defra Guidance as the methodologies of most assistance to the court in the assessment of WTN nuisance.

380. I accept the defendant's contention that BS 4142 applies to the assessment of industrial and commercial sound generally and that it is not appropriate to apply it when there is other more specific guidance on windfarms, such as the Defra Guidance.

381. I accept that the Defra Guidance is of considerable assistance. Although the Defra Guidance relates to complaints of (United Kingdom) statutory noise nuisance and not to private nuisance, it is a *"recognised standard or guidance"* on the assessment of WTN nuisance. The Defra Guidance provides a helpful framework under which to analyse the various elements of a WTN nuisance complaint.

382. Whilst not necessarily subscribing to the Defra Guidance to the same extent as the plaintiffs' experts, Mr. Carr referred to it in his direct evidence. In particular he referred on several occasions to the following passage:

> *"Because there are no fixed decibel levels and noise index based standards that act as thresholds for the onset or as a definitive test for Statutory Nuisance, the primary uses of noise measurement will be establishing the intensity of the noise complained of and whether an established threshold of impact is being exceeded as an indicator of impact; and to assist in deciding if the complainant is being more than ordinarily sensitive. Consequently, the choice of noise index will depend on what guideline, standard or limit value is used to assist in making this judgment or articulating the reasons for a decision".*

383. Mr. Carr argues that this means that the plaintiffs must demonstrate that a threshold of impact or "*threshold of significance*" has been exceeded before they can establish nuisance. At a broad level, I accept that this is so. The courts will not entertain claims for minor annoyances and the interference with the use of the plaintiffs' land must exceed a minimum level of seriousness to justify the law's intervention.

384. However, I do not accept that this "*threshold of significance*" is determined by decibel level alone, by the noise limits in condition 15 or indeed by WEDG 2006. Sound levels which can be measured by a sound level metre or other measuring system describe only the amount of energy in a sound but do not provide any other information about its qualities. Therefore, as the Defra Guidance makes clear, noise measurement are helpful but not determinative. The

Defra Guidance states that the assessment must be made *"in the context of the specific complaints made and the circumstances of each case, there is no one size fits all approach that can be applied in all situations; instead, a bespoke investigation is required in each case"*. Ironically, one of the criticisms Mr. Carr levels at the MAS assessment methodology is just that - that it is, in his words, *"bespoke"*.

385. The criteria identified by the Defra Guidance as relevant to the "*bespoke investigation*" - together with certain other pertinent considerations identified by the plaintiffs' experts - which purely for the sake of brevity I will refer to collectively as "the Defra criteria"- are as follows:

- sensitivity of the complainant.
- the level of WTN;
- the type of noise – e.g., the prevailing AM value and the variability, regularity and predictability of the noise;
- whether any aggravating characteristics are present in the WTN - the spectral content of the WTN and whether thump AM is present;
- the characteristics of the neighbourhood where the WTN occurs;
- the exceedance of WTN over background noise;
- the impact of the WTN on basic needs such as sleep;
- how easily the WTN can be avoided and what measures could reduce or modify the WTN;
- the time of day or night when the WTN occurs; the duration and how often the WTN occurs.

386. The above factors reflect the fact that human hearing is obligatory in the sense that our brains are constantly analysing and interpreting sound. Human responses to sound therefore combine both physiological and psychological responses. Noise is related to human response and is routinely described as unwanted sound or sound that is considered undesirable or disruptive. The difference between a sound and a noise is dependent on a number of objective and subjective variables. This all means that the characteristics of a given sound can have a considerable influence on our reactions. I accept Ms. Large's evidence that constant sound with minor change to volume, frequency or character can be easily accustomed to. By contrast, sound characteristics that attract attention and render the sound more discernible are generally considered to increase annoyance. Negative responses are therefore associated with variable, unpredictable sounds and with unexpected changes in loudness such as impulsivity, erraticism and intermittency. Assessment of noise nuisance must consider all of these variables.

387. I also note that the Defra criteria are quite similar to those listed by the EPA in *EPA NG4: Environmental Protection Agency Office of Environmental Enforcement (OEE) Guidance Note for Noise: Licence Applications, Surveys and Assessments in Relation to Scheduled Activities* ("EPA NG4") [46]. Although this guidance, unlike the Defra Guidance, is not windfarm specific, it can only be seen as an endorsement of the view that both quantitative and qualitative factors must be weighed and assessed with care and professionalism in each case.

388. It is my view, that a robust assessment of a windfarm noise private nuisance complaint cannot be conducted without reference to factors such as the Defra criteria.

Issue 5: Do the criticisms advanced by the defendant undermine the reliability of the plaintiffs' experts' evidence - and the data on which it is based - on nuisance?

389. Before assessing the evidence presented in this case as against the Defra criteria, it is first necessary to consider the reliability of the audio recordings (and the associated graphs) which the plaintiffs' experts placed before the court. In particular, it is necessary to determine whether the various criticisms levelled at this evidence by the defendant and its expert, Mr. Carr, mean that the court ought not to treat this evidence as reliable or probative in determining whether nuisance is made out.

Purpose of the plaintiffs' audio recordings and the associated graphs

390. Both parties agreed that the court should hear the MAS audio recordings and consider the associated graphs. However, the defendant contends that this data is relevant for "context" only. Beyond that, it is said, the court ought to pay it no further regard.

391. Mr. Carr contended that the MAS approach of presenting such data to the court was novel and bespoke and would not be considered best practice.

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[46] 48 This notes that the potential impact of noise is dependent on a wide range of factors such as:

• *The subjective loudness/the measured sound pressure level;*

392. By contrast, Mr. Stigwood states that no other existing methodology allows one to appreciate the complainant's noise environment. He states that the same audio/graphical presentation method has been adopted both by MAS and by opposing experts in every wind farm nuisance case in which he has been involved.

393. Mr. Stigwood used a barking dog analogy to illustrate the drawbacks of relying solely upon average decibel levels to assess nuisance. The leq 10 of a barking dog over a ten-minute period tells one nothing about the character or intermittency of the barking. One loud bark might produce the same average decibel level average as ten lower barks. Yet, a single bark might disturb for ten seconds whereas ten lower barks would pose considerably greater disturbance. Further, as L90 considers only the level exceeded 90% of the time, neither the single loud bark nor the ten lower barks would alter the L90 decibel level.

394. I accept that both the L90, and to a lesser extent the 10 or 15 minute leq averages, are relatively insensitive to rapid fluctuations in noise level such as AM. A complaint centred on the changing character and nature of AM cannot be analysed by average decibel level alone pursuant to either the L90 or leq metric. Moreover, WTN can present at higher or lower frequencies giving rise to swish and thump AM respectively. Yet, these cannot be distinguished using either L90 or leq.

395. Because the plaintiffs complain of high AM values, it would undoubtedly have been of considerable assistance if either party had performed a long term assessment of external AM values at NF or HH in strict accordance with the IOA RM. This however had not been achieved.[47] On the other hand, the defendant has not contended that the IOA RM can differentiate between the impact of swish and thump AM, which is one of the plaintiffs' crucial complaints. The plaintiffs also complain of other features which the IOA RM is not designed to capture or assess - such as erraticism, impulsivity, variability/intermittency and general unpredictability of the AM.

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[47] Indeed, MAS had intended to conduct a formal IOA RM analysis on foot of the 2021 NF external data. For reasons I will explain, however, this data is not sufficiently robust to provide a valid basis for IOA RM analysis.

396. Any robust noise nuisance investigation must engage with the complaint actually made. It simply cannot be credibly argued that - an assessment of whether these plaintiffs' subjective complaints are objectively justified - requires no more than a comparison with the noise limits set out in the planning permission and in WEDG 2006.

397. Indeed, it appears that even a planning compliance investigation often involves actually listening to the noise, Supplementary Guidance note 5 advises:

Irrespective of the requirement to carry out tonal analysis, it may be useful to carry out audio recordings for 2 minute samples in every 10 minute interval in all cases to allow for subjective evaluation of any noise effects and particularly of any time histories produced to assist with any discussions about the acoustic character of the noise...., It should be noted that a subjective assessment of this nature would normally be carried out with regard to a diary of complaints or certain wind conditions that have been found to correlate with complaints since listening to all data would usually be impractical.

398. In short, the nuisance assessment requires an engagement with and an evaluation of the plaintiffs' complaints in light of all of the evidence which tends to either corroborate or undermine those complaints. In my view the audio recordings of the WTN and the associated graphs are important components of this evidence.

399. I emphasise that the exercise undertaken by MAS is not simply to assess nuisance by listening to the WTN. Rather, the plaintiff's evidence places the features of the WTN - such as its AM values and the presence of thump AM - in context. MAS estimate general AM values on site in a manner that enables one to compare these values to guidance (such as the Phase 2

Report and draft WEDG 2019) which identify AM values at which annoyance is known to

occur. MAS does not merely identify thump AM on the audio recordings. It correlates the WTN by using spectrograms to confirm the presence of lower frequency sound energy manifesting as audible thump AM. Although Mr. Carr is no doubt correct in stating that various people have various different opinions about what constitutes an unreasonable interference; it is unfair for him to imply that MAS simply played the audio recordings of the WTN to the court and then said, "*isn't this awful?*".

Contamination/Differentiation

400. The defendant submits that the audio recordings might be contaminated by ambient noise, principally wind noise.

401. Mr. Stigwood and Ms. Large did not subjectively listen to the several months of audio recordings collected at both residences. However, Mr. Stigwood did listen to and screen - both aurally and visually (including by spectral correlation) - the audio recordings played to the court and forming the basis for the associated graphs presented in the MAS reports. Therefore, the data presented to the court, and to which I have had regard, has been screened by MAS.

402. Mr. Stigwood was confident that he could discriminate as between ambient sounds and WTN. After listening to almost 25 such recordings (excluding the 2021 NF external audio recordings), I accept that this is generally the case for both the external and internal audio recordings. When AM is present - as it was on virtually every single recording - the WTN is rhythmic in nature, albeit highly changeable and unpredictable. It rises and falls, often quite sharply, every couple of moments. It also disappears and returns again, fading in and out. This noise is distinctive and quite unlike wind or other extraneous noise. Wind gusts, birdsong, footsteps, etc can in the main be separately identified and discerned.

403. The defendant was furnished with all of the audio recordings and the associated graphs well in advance of the trial and has had a full opportunity to review the material. It was suggested to Mr. Stigwood in cross-examination that Mr. Carr would assert that "*many of the recordings*" included wind noise in addition to WTN. In fact, this evidence was not given by Mr. Carr who identified extraneous noise in only a handful of recordings. In each case, the extraneous noise was either entirely obvious or had already been highlighted by Mr. Stigwood in his graphs or oral evidence.

404. Furthermore, as Ms. Large and Mr. Stigwood note, different noise sources carry different frequencies. Therefore, spectrum analysis by means of a spectrogram informs one of the source of the noise and identifies - and thus assists in the exclusion, if necessary – of extraneous noise, such as wind gusts and birdsong.

405. Mr. Stigwood stated that in order for wind noise to play a significant role in the general character or loudness of the sound environment presented on the audio recordings, it would have to be of a nature and at a level far in excess of that which he would consider normal. No convincing evidence was given to contradict this.

406. In this regard, I note that it is not disputed that Ms. Large correctly set up and calibrated the monitoring equipment and used a double skinned windshield to protect the microphone from wind noise when capturing the 2017 external NF audio recordings.

407. The 2021 MAS data was set up by the plaintiff's solicitor under the instruction of MAS. Inadvertently, the microphone was not fitted with a double skinned windshield. However, for internal recordings (the 2017 internal HH audio recordings and the 2021 internal NF and HH internal audio recordings) I consider this to be of minor importance. As Mr. Stigwood points out, the room in which the recording equipment was placed effectively serves as a windshield; internal audio recordings will only be materially affected by wind over the microphone when there is a through wind inside the room. This in turn requires windows or doors to be wide open on both sides of room; these were not the conditions of measurement.

408. Therefore, save during stormy periods, which were clearly identified to the court, I find that wind noise does not contribute substantially to the sound environment on the 2017 internal HH audio recordings or the 2021 internal NF and HH internal audio recordings played to the court (and in the graphs presented in the MAS reports). I am satisfied that extraneous noise can be - or had been - separately identified and does not distort one's aural appreciation of the impact of the WTN on the audio recordings or one's interpretation of the associated graphs.

409. I accept the opinion of Mr. Carr that the position is different in respect of the 2021 NF external data which, as I say, was gathered without a double skinned windshield. I accept that wind contamination cannot confidently be excluded. I also accept that placing the monitoring equipment too close to the exterior façade will tend to increase noise levels by up to 3 dB, which also has the potential to distort AM values. Mr. Carr's related criticism that one cannot take façade measurements where there is a significant low frequency content to the noise, was not put to Mr. Stigwood, which reduces its weight. However, in light of the first two difficulties just discussed, I have in any event entirely disregarded the 2021 NF external data (the audio recordings and all associated graphs) in all of my consideration.

Are the audio recordings selected for playback and analysis representative of the WTN on site?

410. Clearly, MAS did not record the plaintiffs' entire soundscape for the last seven years. Equally, it would not be possible to present to the court all of the audio recordings as this spans several months of monitoring. MAS therefore selected only certain audio recordings (and the associated graphs) on which to focus in their reports and only a subset of these were played to the court. No doubt the recordings (and the associated graphs) chosen were those adjudged to best represent the different features of the WTN complained of by the plaintiffs. Indeed, this is made clear by Mr. Stigwood in his report of October 2022.

411. However, this is really the only practical way to present the audio recordings (and the associated graphs) of the WTN to the court. Crucially, the defendant's expert made no suggestion that the audio recordings selected were unrepresentative of the features of the WTN of which the plaintiffs complain. Mr. Carr has listened to all of the audio recordings referred to in the MAS reports (and has presumably examined all of the associated graphs) and did not contend that those chosen for presentation to the court were unrepresentative of the audio recordings (and the associated graphs) as a whole.

412. Mr. Carr accepted that the audio recordings (and associated graphs) accurately captured and represented the sound environment at the positions where the microphones were placed. He was present in court throughout the presentation and analysis of the audio recordings (and the associated graphs) and did not demur from the opinions expressed by the plaintiffs' experts as to the identified features of the WTN. He did not suggest that the various features identified by MAS occurred only rarely or usually on the audio recordings. There is no suggestion that these features were "outliers". Rather, Mr. Carr's view was that, having "*dipped in and out*" of the full suite of MAS audio recordings, (taken over several months), the general picture was broadly similar.

413. In short, therefore, the court can, and indeed should, have regard to the 2017 external NF data, to the 2017 internal HH data and to the 2021 internal HH and NF data, all of which together are representative of the character of the WTN.

Issues arising in relation to internal audio recordings

414. Although Mr. Carr accepted that the internal audio recordings accurately capture the sound at the location where the microphone was positioned, allowance must be made for *"room modes."* Noise measurements within buildings can be inconsistent due to the influence of room acoustics such as acoustic reflections from surfaces and absorption from soft furnishings, carpets and beds etc. This can create different sound fields resulting in potential over or underestimation of the typical exposure in the room.

415. The defendant contends that to counteract the impact of room modes ISO 1996-2, 2017 recommends the use of several different recording devices at various locations throughout the room rather than via a single microphone. I am concerned that this objection was not adequately put to Mr. Stigwood.

416. I note that ISO 1996-2, 2017 applies to all environmental noise sources such as road and rail noise, aircraft and industrial noise. Unlike the Defra Guidance therefore, ISO 1996-2,

2017 is not WTN specific. Ms. Large and Mr. Stigwood's evidence was that all internal measurements complied fully with the Defra Guidance which states that the effects of sound reflections and absorption can be appropriately managed by positioning the microphone at least 0.5m from any sound reflecting vertical room surface or sound absorbing objects such as items of furniture or curtains etc.

417. I accept that, for present purposes, this is an adequate response to the issue of room modes. This is particularly the case as the plaintiffs' primary complaint does not relate to noise levels *per se* but to noise character.

418. The plaintiffs' experts do not contend that the audio recordings played to the court precisely replicates WTN noise levels at every point in the room or indeed in every room in the house. Rather they are intended to convey an impression of the plaintiffs' sound experience and to demonstrate and corroborate the features of the WTN of which the plaintiffs complain.

I am satisfied that the internal audio recordings are more than adequate for that purpose.

419. The defendant also submits that because the 2021 HH and NF internal monitoring was set up by the plaintiffs' solicitor, rather than by experts, it ought to be disregarded. This, in my view, would be a wholly disproportionate response to the minor criticisms advanced by the defendant, such as for example, the position of the microphone flex. I can see no point of real substance here, and I will therefore have regard to this data.

Criticisms of the plaintiffs' experts' presentation and analysis of the AM on site

420. Ms. Large and Mr. Stigwood presented and analysed the AM on site by reference to the audio recordings and associated time domain graphs. Their opinion was supplemented by their own experience on site. In Ms. Large's opinion, the AM on site is substantial and excessive.

Mr. Stigwood's view is to similar effect. He states that there sustained periods of AM of the highest levels of modulation variation that he has ever seen occur commonly. His view is that this AM *"impacts on residential amenity in a manner and form rarely found so excessive"*.

421. The defendant advances several interrelated criticisms of the plaintiffs' experts' presentation and analysis of the AM on site:

a. AM may only be presented or analysed through the application of the IOA RM;
b. The MAS presentation and analysis of AM by way of audio recordings and time domain graphs is unreliable and ought to be disregarded in any nuisance assessment.
c. The MAS presentation and analysis of AM by way of audio recordings and time domain graphs exaggerates AM.

422. Separately, Mr. Stigwood also sought to the apply the IOA RM to the 2021 MAS data and to present the results of that analysis. The defendant advances two interrelated criticisms of Mr. Stigwood's IOA RM analysis of the AM on site

d. The 2021 MAS data is unreliable and the IOA RM cannot be reliably applied thereto either to derive a penalty or at all.

e. The 2021 NF external data is unreliable and the IOA RM cannot be reliably applied thereto either to derive a penalty or at all.

f. The 2021 NF and 2021 HH internal data is unreliable and the IOA RM cannot be reliably applied thereto either to derive a penalty or at all.

423. I will consider these points in turn.

<u>(a) Exclusivity of the IOA RM in nuisance investigations</u>

424. The defendant's attitude towards the IOA RM is somewhat contradictory. On the one hand, the defendant contends that the only acceptable method for demonstrating AM to the court is via the IOA RM. Yet, despite acknowledging that "*this case is all about AM*", the defendant has not itself carried out an IOA RM assessment of the AM on site.

425. Ms. Large and Mr. Stigwood both accept that the IOA RM can provide useful information tending to confirm the level of AM present in the audio recordings (as depicted on the associated time domain graphs). However, in their view, the IOA RM provides no more than an overall impression of the extent and regularity of such impact. They reject the position that it is mandatory to apply the IOA RM to an AM complaint in a nuisance case and point out a number of drawbacks to the methodology (none of which were in substance disputed by the defendant's experts):

- The IOA RM depicts average AM values in a specific ten minute period as a point on a graph but tells one nothing about the quality of the AM during the period. It may not identify many features of AM said to be most intrusive in this case such as erraticism and impulsivity. Crucially, it is not contended by the defendant that the IOA RM can discriminate between swish and thump AM.
- The IOA RM produces a single value for a 10-minute period. It is not apt to fully represent AM that is variable or intermittent -i.e., AM that disappears and returns again or fades in and out - which is one of the plaintiffs' main complaints. Purely by way of example, if a particular ten minute period has five 60-second blocks of high AM value interspersed by five 60-second blocks of low AM value, the IOA RM will derive an AM value which is the approximate average of the AM depicted over the entire period.

Alternating high and low AM, which can be extremely intrusive, is not accommodated by the IOA RM. The same lacunae might equally result from the requirement of the IOA RM that at least 50% of the 10-second blocks in the relevant 10-minute period contain detectable AM before even being included in the analysis.

- The IOA RM can produce both false negatives and false positives. As above, periods of substantial AM can, be smoothed out by the averaging effect. False positives, such as dogs barking, or cars backfiring cannot be recognised and filtered out because the IOA method is effectively automated.

426. The IOA AM report states that its primary goal is to develop a methodology which can be used within the planning regime. It also states that consideration could be given to its use within the (United Kingdom) statutory nuisance regime as well. The IOA RM has several merits and provides an objective benchmark for rating AM. However, the report emphasises that it is possible for AM to be evaluated in different ways, including subjectively. It states that noise nuisance investigations, for example, need not be limited to any particular method of assessing WTN and would often involve many other factors such as the time of day and the character of the neighbourhood. Furthermore, factors such as the duration and frequency of occurrence may be relevant in determining subjective responses. Therefore, the report acknowledges that the availability of the IOA RM does not preclude other assessments being made.

427. I therefore reject as ill-founded the defendant's argument as to exclusivity of the IOA RM in nuisance investigations. In considering the impact and level of AM on site, it is appropriate to have regard to the MAS audio recordings and associated time domain graphs even though these are not, and do not purport to be, presented by way of an IOA RM analysis.

428. Having said that, the IOA RM analysis, in contradistinction to the audio recordings and time domain graphs (which cover short periods only) is apt to demonstrate AM values over more extended time periods. However, in the present case such a more consistent picture is demonstrated by Mr. Stigwood's IOA RM analysis of the 2021 internal HH and NF data on which I comment below.

<u>(b) can audio recordings and time domain graphs be used to present/assess the AM on site?</u>

429. The defendant also criticises the use by MAS of time domain graphs to present and assess AM in this case. The IOA AM report considers their use as follows:

> <u>The use of the time-domain method</u>
>
> Most respondents agreed that a time-domain method, based on examination of a time-series plot to determine the typical, average, or maximum peak-to-trough values, is very suitable for the assessment of short-term 'clean' WTN data with minimal corruption by other ambient noise. The method has the benefit of relative simplicity. However, the strong majority view was that it was not suitable for rigorous assessment of AM, especially when there was significant noise from other sources, because it was unable to discriminate between fluctuations in noise levels resulting from wind turbine AM and those resulting from variations in other ambient noise. Significant subjective (visual or aural) screening is required to overcome this fundamental deficiency, which is considered to be impracticable for the analysis of longterm data (perhaps covering periods of weeks or months)...
>
> **AMWG comments**
>
> There is some benefit in having a simple method of assessing AM, for example for the purpose of forming an initial conclusion about the validity of a noise complaint...
>
> Any output from such a method would be open to question unless accompanied by time histories which demonstrated (on subjective judgement) the presence of clear AM with no significant contribution from other ambient noise, or using tools such as autocorrelation spectra. However the AMWG does not consider that the method is a robust basis for an assessment metric which may be adopted in a planning condition. Wind turbine AM, where it occurs, is an intermittent occurrence. The assessment of AM on a particular site would generally involve long-term measurements to establish the frequency and duration of occurrence and the particular wind conditions. Reliance on a time-domain method only, which may appear more direct to non-specialists, is not considered to be practicable or robust, because unlike a frequency-domain method, it is unable to detect WTN AM on the basis of its distinctive periodicity and therefore requires significant subjective 'filtering'.

430. The concern of the IOA was that the time domain method would require significant subjective (visual or aural) screening to discriminate between fluctuations in noise levels resulting from wind turbine AM and those resulting from variations in other ambient noise. Therefore, the output would be open to question unless accompanied by time histories which demonstrated (on subjective judgement) the presence of clear AM with no significant contribution from other ambient noise, or using tools such as autocorrelation spectra.

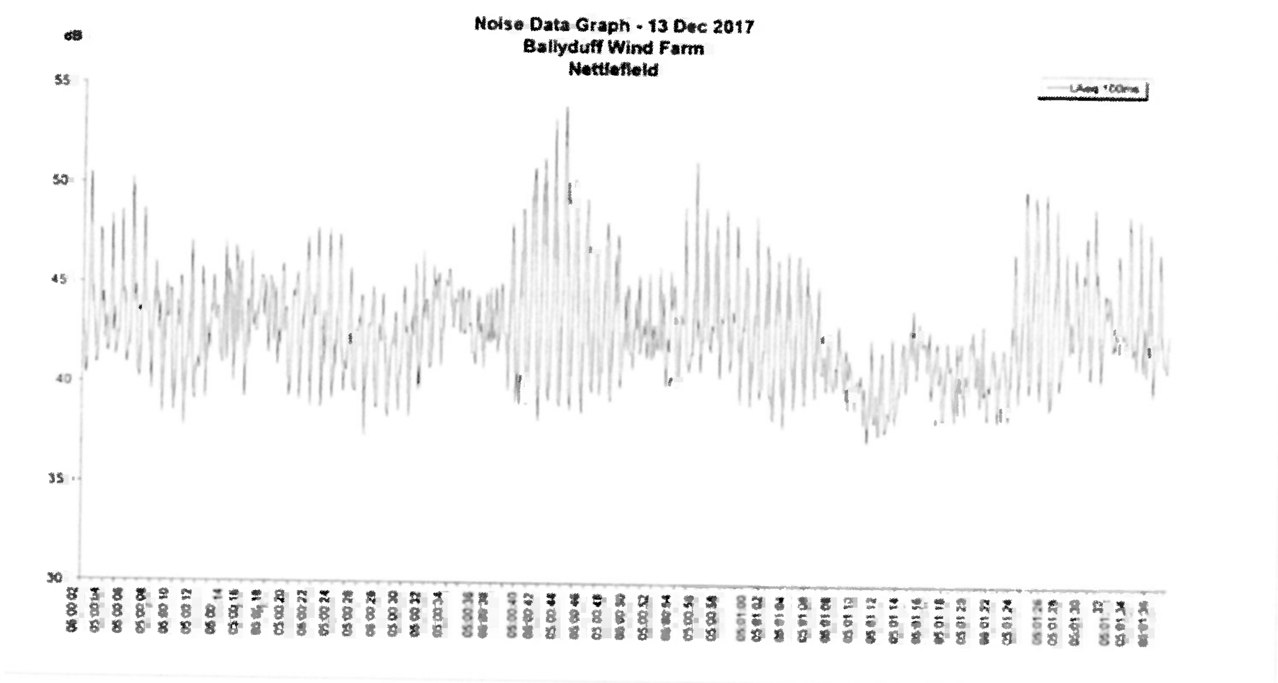
431. This is in substance the exercise carried out by MAS in relation to the audio recordings and time domain graphs it presents.

432. Further, the time domain data demonstrates consistency between the AM values typically presenting at both properties over both periods of monitoring. In my view, this consistency strongly supports the proposition that, overall, MAS's method of presenting and calculating AM values is reliable.

433. With the exception of the 2021 NF external data, I therefore find that the MAS time domain data is sufficiently robust to reliably demonstrate the features of wind turbine AM and to calculate AM values over the periods presented in the graphs[48].

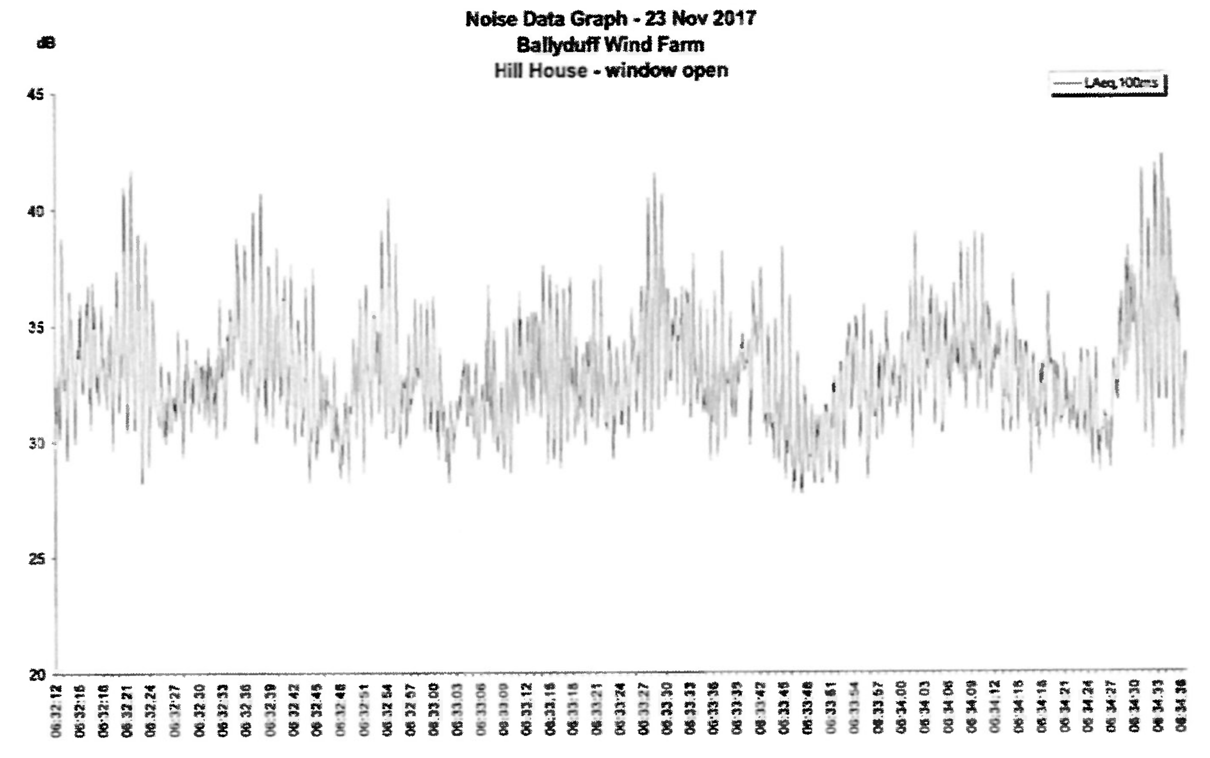
434. Purely for illustrative purposes, I attach below one of Ms. Large's time domain graphs demonstrating the AM externally at NF on 13th December, 2017 at 05.00.

Figure 26: Amplitude modulation -Nettlefield - 13/12/2017 05:00



[48] I deal separately below with the far more extensive data used as an input to Mr. Stigwood's IOA RM analysis.

435. I also attach one of Ms. Large's time domain graphs demonstrating the AM internally at HH (with the window open) on 23 November, 2017 at 06.32.



(c) Do time domain graphs exaggerate AM?

436. Ms. Large and Mr. Stigwood have computed AM values by calculating the differential between the highest peak and lowest trough sound levels in any particular modulation. The defendant states that this may overstate the AM when compared to the IOA RM. This is because the IOA RM calculates AM values by subtracting the L95 from the L5 over the relevant 10 second and 10 minute periods. Mr. Carr emphasises that Mr. Stigwood's report acknowledges that IOA RM derived values *"will typically understate AM peak to trough values…*(when compared with the time domain method) *by 1-2 dBA".* Mr. Carr did not however contend that the likely divergence as between the two methodologies would be any greater than this.

437. Although not calculated over specific 10-second or 10-minute intervals, I accept that the plaintiff's experts' calculation of average or typical AM values as derived from the totality of the time-domain graphs is sufficiently reliable to inform this court's analysis.

(d) Use of 2021 MAS for IOA RM analysis

438. As stated, the plaintiffs' experts' calculation of AM value is derived from their time domain graphs. These graphs represent specific time intervals only. Although the defendant's experts did not contend that the audio recordings and time domain graphs were unrepresentative of the WTN generally, more extensive data would have been of value in assessing long term average AM values at a range of windspeeds. Further, although I reject the proposition that the IOA RM is the exclusive methodology for presenting and analysing AM in general or AM values in particular, one would nonetheless reasonably expect that, in a case which is *"all about AM"*, the plaintiffs' experts (and indeed the defendant's experts) would have formally applied the IOA RM in this case.

439. Indeed, it is clear that Mr. Stigwood set out to perform just such an exercise and to apply the IOA RM to the six weeks of data gathered on foot of the 2021 monitoring. To that end, his October 2022 report presents three IOA RM graphs: first, an IOA RM graph prepared on foot of the 2021 NF external audio recordings; second, an IOA RM graph prepared on foot of the 2021 NF internal audio recordings and third an IOA RM graph prepared on foot of the 2021 HH internal audio recordings. Each such graph plots the average 10-minute AM value over the relevant six weeks as calculated in accordance with the IOA RM. However, for different reasons which I will now explain, none of these three graphs is prepared in full compliance with the IOA RM methodology.

(e) Use of 2021 NF external data for IOA RM analysis

440. Mr. Stigwood's opinion is that the IOA RM analysis of the 2021 NF external audio recordings suggests that average AM values over the six weeks of data were in the order of 8 dBA and would incur an AM penalty of 5 dB under draft WEDG 2019.

441. Mr. Carr indicated that he was unable to stress test this conclusion because he could not discern how the data had been post-processed and analysed by Mr. Stigwood. It is hard to give this much credence. The defendant has had Mr. Stigwood's report and all of the underlying data for some time and could have performed its own IOA RM analysis.

442. However, I accept that due to the absence of a double skinned windshield and because the external NF 2021 audio was recorded at façade level, it cannot form the basis of a valid IOA RM analysis, and I do not accept it for that purpose. I consider immediately below the IOA RM analysis of the 2021 NF and HH internal audio recordings.

(f) use of 2021 NF internal and 2021 HH internal data for IOA RM analysis

443. The defendant correctly observes that the plaintiff's most serious complaints concern indoor noise particularly at night. It nonetheless objects to MAS's presentation of an internal IOA RM analysis.

444. The IOA AM report considers the usefulness, for its purposes, of internal measurements.

> **Is it appropriate to measure AM outdoors in free-field?**
>
> This question generated considerable discussion. Most respondents observed that complaints regarding AM often concerned indoor noise, particularly at night. It could therefore be thought logical to measure noise inside dwellings. Furthermore experience suggests that there is a variable 'transfer function' between indoor and outdoor perception of AM and in some cases, higher levels of AM may be detected indoors than outdoors. However, most respondents accepted the difficulties in measuring noise inside, including the influence of room modes and the resulting spatial variations in noise level, as well as the influence of domestic noise sources…
>
> For the purposes of defining and applying a method for rating AM, most thought that measuring indoors presented too many practical difficulties and outdoor measurements were strongly preferred. Measuring outside is also consistent with most other environmental noise assessment procedures. It was suggested by some that additional indoor measurements would be appropriate if complaints related specifically to noise indoors.
>
> **AMWG comments**
>
> The working group's objective is to define a metric that can be used reliably within the planning system, and external measurements are the only practicable option. For specific complaint or nuisance measurements, investigators are of course free to make internal measurements and assessments in connection with the specific issues. Indoor measurements are problematic for a variety of reasons including, access difficulties, corruption by other sources, and room modes which could result in different responses in different positions in the room. These factors can cause a large variation in noise levels which can affect reproducibility. It is considered unnecessary to account for all of these factors when wind turbine AM can be measured reliably outdoors.

445. Ultimately, therefore, the IOA AM report concludes that as the objective of the working group is to define a metric that can be used reliably within the planning system, external measures were the only practical option. This is entirely logical as it would not be possible for a planning noise condition to be set by reference to internal measurements at specific houses. However, the IOA AM report also acknowledges that for a specific complaint or for nuisance measurements investigators are free to take internal measurements.

446. In considering the robustness of the IOA RM analysis of the internal data, two specific issues arise.

447. First, unlike the other data presented to the court, MAS has not subjectively screened the six weeks of 2021 internal NF and HH data input into the IOA RM for contamination from domestic sources. However, I note that the Carty-Shortens moved out of the master bedroom at NF bedroom in July 2017. Even at the time of the 2017 MAS data collection[49] the master bedroom was therefore unoccupied. Moreover, at the time of collection of the 2021 MAS data[50] the whole house was unoccupied. This tends to mitigate if not exclude many potential sources of domestic contamination which might otherwise undermine the analysis of long term internal data under the IOA RM.

448. The position is different in relation to HH which was occupied during all monitoring periods. As there may be undetected contamination from domestic sources, the IOA RM of this data is less robust. However, as there is no suggestion that there is a significant difference between the AM or the AM values experienced as between the two properties, the 2021 NF internal data may be seen as a fair proxy for the AM values experienced internally at HH.

449. Second, as the IOA points out room modes could result in different responses in different positions in the room. This would be an obvious problem if one was using the

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[49] Note: the 2017 MAS data was not used for the IOA RM analysis but for the analysis of AM values using the time domain method.
[50] Note: this was the data used for the IOA RM analysis [53]
See para 416 above.

data collected to calculate potential AM penalties for the purposes of a planning condition. This requires consistency and ease of replication as between different affected dwellings. However, as room modes have been adequately dealt with by compliance with the recommendations in the Defra Guidance,[53] there can be no objection to the use of the internal data to derive a general picture of AM values at the two properties.

450. I accept therefore that the IOA RM analysis of the 2021 NF internal data is sufficiently robust. Whilst therefore strictly speaking it is not a "formal" IOA RM analysis (because the IOA RM is only formally applicable to external free field data), it is nonetheless evidence of weight.

451. As such, I accept the opinion of Ms. Large and Mr. Stigwood that the impression of AM gained from the audio recordings and time domain graphs is confirmed by the IOA RM analysis of the internal data. I attach Mr. Stigwood's internal IOA RM analysis pertaining to both NF and HH for the time period 4th December, 2020 - 18th February, 2021 below.

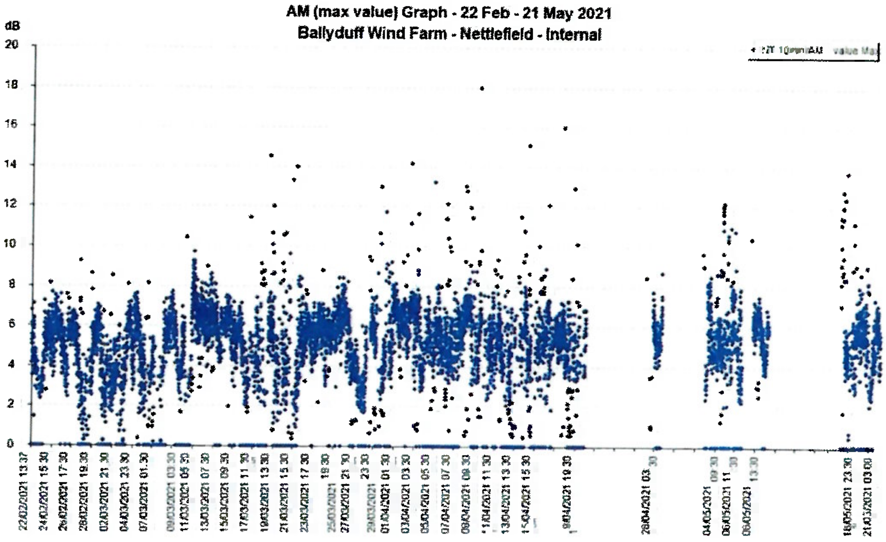
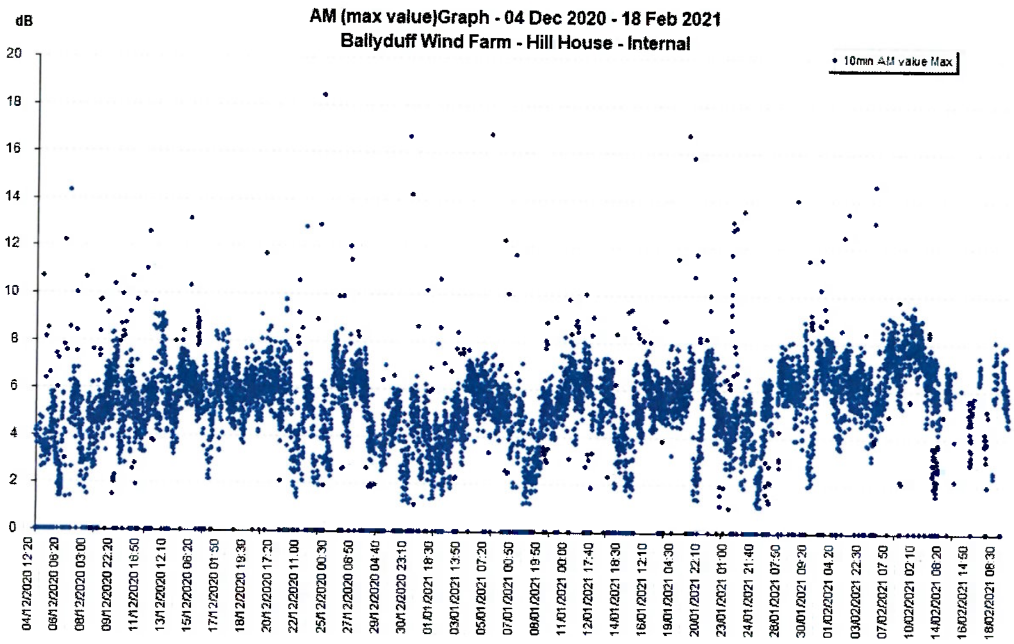


Figure 36: Summary of IoA AM analysis – Nettlefield - Internal



Absence of measurements in HH bedroom

452. In general, measurement errors can occur when a room is occupied at the time of noise monitoring. In NF, the master bedroom was unoccupied, and monitoring was conducted without difficulty. However, HH has been in continuous occupation. Further, due to the WTN, Ms. Webster finds the master bedroom is the only room where she can sleep in. It would clearly not have been practical or reasonable to require her to vacate this room for an extended period of time to facilitate monitoring. Internal monitoring was therefore conducted in a home office situated downstairs at the back of the house facing the turbine. The master bedroom is on the other side of the house and faces the valley.

453. The defendant's legal submissions argue that Ms. Webster and Mr. Rollo have not made out a case in nuisance because there are no noise measurements or internal audio recordings from the master bedroom at HH.

454. Ms. Large's evidence was that an internal noise assessment is an assessment of the house in general. The intent is to find a location that is reasonably representative of the noise impact at that dwelling rather than to place a microphone in every single room. Ms. Large's view was that the home office where the microphone was placed was representative of the noise level in all of the rooms at the rear of the dwelling, upstairs and downstairs. Whilst she accepted that noise levels at the front of the house, where the master bedroom is situated, would probably be different, there was no evidence of a significant change in the overall character and impact of the noise.

455. Mr. Carr did not suggest that the AM values or indeed the impact of AM and thump AM would be appreciably reduced as one proceeds from the back to the front of the house. Whilst there will always be some variation throughout a dwelling, WTN, particularly with low frequency content, is not well attenuated by structures and will penetrate buildings.

456. Although therefore AM values cannot be accurately calculated for the HH master bedroom specifically, this is of little import. As I understand it, Mr. Carr, who has carried out many nuisance investigations, has never considered it necessary to take any internal readings at all for the purposes of measuring internal AM values. Nor has he ever performed an internal IOA RM analysis. There can therefore be little objection to approximating AM value in the master bedroom by reference to the values presenting in another room in the same house.

Issue 6: Does an analysis under the Defra criteria support the argument that characteristics of the WTN amount to a substantial interference with the plaintiffs' use and enjoyment of their land?

457. I set out below my analysis of the Ballyduff WTN under what I call the "Defra criteria". In doing so, I primarily consider the relevant expert evidence advanced by both parties on each criterion. In this regard, whilst the plaintiffs' experts carried out an in-depth analysis of the

WTN by reference to the Defra criteria, the defendant's experts did not. However, in so far as the defendant's experts addressed the issues arising, I set out below the key aspects of their response to the evidence of the plaintiffs' experts in respect of each criterion. As will be apparent, although I do not accept all of the conclusions of the plaintiff experts, e.g., their calculation of background sound levels and their application of the 2009 WHO Lmax limit - I accept the substance of the other points made which together are more than sufficient to establish on the balance of probabilities that the impact of the WTN is objectively unreasonable.

Sensitivity of the complainant

458. In *Smyth v. RPA*, the uncontradicted evidence of the RPA's acoustic expert was that the Smyths were not among a group who could be classified as "ordinary". Rather they were highly sensitive and representative of only a very small proportion of the population - 2.5% - who would experience a high level of annoyance at the noise levels demonstrated. In the present case the defendant has tendered no evidence whatsoever that any of the plaintiffs are highly sensitive or hypersensitive to noise, or indeed otherwise.

459. On the contrary, the evidence of the medical experts is that Ms. Webster is a woman whose basic disposition is one of considerable resilience and fortitude who does not allow herself to become overwhelmed by emotion. She approached the turbine with an open and optimistic frame of mind and did not expect it to negatively impact on her enjoyment of her property to a substantial extent. In addition, there is no suggestion of significant sleep disturbance prior to the commencement of the operation of the turbine. In the case of Ms. Webster (and indeed Mr. Rollo), this is confirmed by discovery of several years of prior medical records.

460. I also accept Dr. Murray's opinion, that Ms. Webster has not suffered from any pathological reaction to the WTN. I find that Ms. Webster's reaction to her experience of the windfarm at least for the first several years of its operation – was entirely proportionate and in no way hypersensitive. She has, as Dr. Murray said, coped with a difficult situation by managing her reaction to it and managing her emotions. In accordance with Prof. Gournay's view, I further find that, although Ms. Webster describes the WTN as getting worse - which objectively is unlikely to be the case – this perception can reasonably be attributed to its cumulative impact which is becoming more difficult for her to cope with.

461. In so far as concerns Mr. Rollo, the evidence of both medical witnesses is that he is a robust person who is not risk adverse or hypersensitive. I find that Mr. Rollo did not meet the diagnostic criteria for depression until mid to late 2020, three years after the turbine was erected. From mid to late-2020, I find that the WTN brought about a hypersensitive condition in Mr. Rollo who was formerly a well-balanced person. Even at this stage, Prof. Gournay's opinion was that whilst there will always be a difference between how two normal people will respond to the same stimuli, a substantial number of reasonable people would react in precisely the same way as Mr. Rollo. As Charleton J. stated in *Lanigan v. Barry*, although a plaintiff cannot be a sensitive soul who complains unreasonably, the defendant cannot use this argument if his own conduct has resulted in the plaintiff being hypersensitive to the intrusion in question
(quoting from *Salmond on the Law of Torts* (London, Sweet & Maxwell, 1977).[51]

462. In short, all indications are therefore that the Webster-Rollos are reasonable, tolerant individuals. I have no reason to believe that the position is otherwise in relation to the Carty Shortens.

463. I also accept the truthfulness of their evidence as to their experience of the WTN. In this, I am assisted to some extent by the clinical impression of both medical witnesses that Mr. Rollo was very straightforward and was not attempting to present a false impression. Dr. Murray stated that "*everything points to a very genuine responder who was not exaggerating his symptoms*". Both medical witnesses also formed a similar impression in relation to Ms.

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[51] As will become apparent, this observation may have a particular resonance with respect to Mr. Rollo.

Webster. I formed a similar view in relation to all four plaintiffs.

464. Overall, I find that, to quote Henchy J. in *Hanrahan*, the *"notions and standards of behaviour and responsibility* [of all four plaintiffs] *correspond with those generally pertaining among ordinary people in our society at the present time, who seldom allows emotions to overbear reason, whose habits are moderate and whose disposition is equable.* In short, the plaintiffs are, to quote Henchy J. again, ordinary persons *"whose requirements are objectively reasonable in all the particular circumstances"*. To quote from the defendant's legal submissions, the plaintiffs are *"ordinary* [persons] *with reasonable objective expectations"*.

465. Establishing that the plaintiffs are ordinary persons *"whose requirements are objectively reasonable in all the particular circumstances"* and that their evidence of the turbine impact is unexaggerated is of course only one step in the assessment of nuisance. This is because the primary focus of the assessment must remain on the objective nature of the interference itself.

466. I therefore move on to consider the other Defra criteria.

Level of the noise/ loudness

467. The plaintiffs' experts time domain data presents only short term measurements and therefore does not inform one of general noise levels at a range of windspeeds. For this, one needs to rely upon the defendant's planning compliance data as described at 300 *et seq* above.

468. Mr. Carr's view was that the overall noise levels from these wind turbines should be a significant factor in determining whether nuisance is made out. He states that the Ballyduff noise levels are "*very low*"[52].

[52] This fed into Mr. Carr's impression that this was not a borderline or *"critical"* case requiring a more nuanced assessment.

469. However, this tells us comparatively little as it would be the case with WTN in general. In contrast to other forms of industrial noise, WTN is not by its nature received at high dBA levels; hence the relatively low absolute noise limit suggested in draft WEDG 2019 of 43dBA L90/45dBA leq.

470. In order to consolidate his view that the Ballyduff noise levels are "*very low*" Mr. Carr stated that the HH data demonstrates that the WTN complies with this recommended limit in draft WEDG 2019. Indeed, he states that there is "*headroom*" to spare. He further asserts that the WTN would comply with this recommended limit regardless of any character penalty that could be applied.

471. As I mention above at para 214, I fail to see a valid basis for this assertion. To summarise:

- Unlike WEDG 2006, draft WEDG 2019 proposed a relative rated noise limit of 5 dBA above existing background noise within the range of 35 to 43 dBA L90. Compliance cannot therefore be established without assessing background noise levels.
- Even if noise levels were within range, character penalty for AM may well result in non-compliance. The defendant has made no attempt to calculate - or even estimate - what level of possible character penalty might apply.
- There is no HH night hours data from comparatively low windspeeds of 8 m/s.
- The *"headroom"* contended for is in part at least premised on a 3 dB façade deduction from the measured noise levels at HH. In light of the lack of clarity as to Mr. O' Reilly's measurement position at HH and due to the failure to record and calculate the angle of incidence, I am not satisfied that this 3 dB façade deduction can be applied (see para 320 -325 above)

472. The NF data - upon which Mr. Carr did not comment - is even less convincing in this respect. During night hours, total operational noise is either at or slightly beyond the maximum total permitted noise level in draft WEDG 2019 (43 dBA L90) from windspeeds of 9.5m/s. There is no assessment of either background noise levels or potential AM penalty. Depending upon how these factors play out, there is a clear potential for breach of the indicative limit in the draft WEDG 2019.

473. In Mr. Carr's view, the overall noise levels from these turbines are well below the point at which a breach of planning permission or nuisance would arise. In actual fact, on the correct interpretation of condition 15, total operational noise at both locations is well above the 40 dBA leq limit set in the permission.

474. One of the defendant's other key submissions was that average sound levels below 30 dBA leq could never constitute nuisance. Provided this is understood to apply to external sound levels, this is generally correct. It is also however somewhat beside the point as total operational noise during night-time exceeds 30 dBA leq at HH and NF at windspeeds above 4 m/s and 6 m/s respectively. In addition, the MAS 2017 NF external data includes numerous examples, albeit for brief time intervals, when external sound levels are 41, 42, 43 dBA leq.

475. Turning to internal sound levels, Mr. Carr states that noise levels below 30 dBA leq would not be expected to impact one's ability to sleep.

476. Again, this point goes nowhere as the defendant's planning compliance data shows that total operational noise externally at NF rises to 40 dBA leq at windspeeds of 7m/s and to 45 dBA leq at windspeeds of 9 m/s. Allowing for an external to internal transfer function of approximately 10 dBA (with windows slightly open), one would anticipate that internal levels would be above 30 dBA leq on a regular basis.

477. In direct examination, Mr. Carr was asked about his impression of the WTN in the main bedroom at HH where he spent 5 to 10 minutes during the site visit on 8th November, 2018.

Mr. Carr confirmed that the purpose of this visit was "*more of a listening experience… just hearing it rather than there to take measurements to show any compliance or otherwise*". He stated that he could hear the wind turbine outside but that the impact of the turbine reduced significantly internally. Mr. Carr's evidence was that he stood in the HH master bedroom with the window open and couldn't hear the turbine.

Q. And in terms of your own experience inside the property, would you have considered the noise that you were able to barely hear to comprise a nuisance or not?
A. No, not inside that bedroom.

478. Although my own experience on the day of the site visit was different, I fully accept that Mr. Carr was unable to hear WTN in the HH master bedroom over this 5 to 10 minute period. However, it cannot realistically be contended that such a short visit could ever mirror the plaintiffs' experience of the WTN in the master bedroom over so many years.

479. Whilst the key complaint here is not of the absolute average decibel levels, I conclude that as total operational noise during night hours externally at NF reaches 45 dBA leq (and due to a paucity of data, maximum sound levels at HH are unknown), there is significant potential for dominance and unacceptable intrusiveness when combined with other features.

Type of noise

480. I fully accept Mr. Carr's opinion that the AM values calculated by Ms. Large and Mr. Stigwood on foot of the time domain graphs cannot be directly equated with values derived under the IOA RM. In other words, the application of different metrics will yield different AM values.

481. However, Mr. Stigwood's report-suggests that the AM values calculated on his time domain method would differ by 1 or 2 dBs from those likely to be yielded on foot of the IOA RM. As I observe at para 436 above, Mr. Carr did not contradict this passage and indeed drew it to the court's attention. In my view, it is reasonable to expect that when the AM is regular rather than intermittent/ variable (i.e. AM that disappears and returns again or fades in and out), the AM values derived under both methods for a particular time interval would generally be of a similar order.

482. In this regard, I further accept Mr. Stigwood's opinion that the data derived from his application of the IOA RM to the 2021 NF and HH data is generally consistent with and confirmatory of the AM values shown on the time domain graphs produced by Ms. Large in 2017 (on foot of the 2017 NF external audio recordings and 2017 HH internal audio recordings). I further accept that this IOA RM data is also generally consistent with and confirmatory of the AM values on the time domain graphs produced by Mr. Stigwood in 2021 (on foot of the 2021 internal NF audio recordings and the 2021 HH internal audio recordings).

483. I further accept the views of both Ms. Large and Mr. Stigwood that the IOA RM analysis of six weeks of continuous internal data from NF and HH (the 2021 HH and NF internal data), demonstrates regular and substantial internal AM. The primary relevance of this internal IOA RM analysis is in demonstrating consistency of impact over a longer period of time than that represented by the intermittent audio recordings and time domain graphs. This IOA RM analysis cannot be used for the purposes of calculating potential AM penalties for planning purposes. Indeed, it was not tendered by Mr. Stigwood for that purpose.

484. Draft WEDG 2019 notes, citing the Phase 2 reports that the setting of a threshold for excessive AM is not straightforward and that the available research does not identify a clear onset of increased annoyance from AM or a clear level at which the impact of WTN or AM becomes *'significant'*, *'excessive'* or *'unacceptable'*. It goes on to note an onset of perception for AM at about 2 dB and an association of rising annoyance with increasing depth of AM above 2 dB. Furthermore, Draft WEDG 2019 recommends attaching penalties for AM values in excess of 3dBA.

485. I accept Ms. Large's evidence that AM values of 5 dBA and above, if audible at a sufficient level, are capable of amounting to an unreasonable impact. This is consistent with the rationale behind the Phase 2 Report and draft WEDG 2019.

486. I further accept Ms. Large's evidence that, on foot of the 2017 monitoring, AM values significantly in excess of 5 dBA are a substantial feature of this WTN. The MAS reports summarise the time domain graphs as showing that: (a) typical AM values on foot of the 2017 HH internal data were 7-13 dBA, (b) typical AM values on foot of the 2017 NF external data were 8-13 dBA, (c) typical AM values on foot of the 2021 HH internal data were 5-12 dBA and 5-14 dBA and (d) typical AM values on foot of the 2021 NF internal data were 5-12 dBA and 5-10 dBA. Mr. Carr accepts that the time domain graphs accurately reflect the sounds at the microphone locations, and he did not dispute the accuracy of these summaries.

487. I conclude that even on the most conservative analysis, the time domain graphs reveal a common thread of AM value in excess of 5 or 6 dBA. Although, as I say these typical AM values cannot be directly translated to values of the same order derived on foot of the IOA RM, this conclusion is nonetheless highly significant. In this regard it must be recalled that the view that AM values in excess of 3 dBA leads to increasing levels of annoyance emerged well before the IOA developed the IOA RM for rating AM. This consensus as to the increased annoyance occasioned by higher value AM therefore developed before and independently of the IOA RM.

488. Ms. Large's evidence went even further. She stated that the time domain graphs show that an AM value of 10 dBA is frequently present both externally and internally. Mr. Carr did not dispute this finding. He accepted that externally such AM values would be experienced as a doubling and halving of loudness.[53] Mr. Carr was inclined to emphasise that this doubling and halving of loudness was only momentary. I fail to see how this ameliorates matters. If anything, rapid peak to trough rise and fall can be particularly distracting and attention drawing.

489. When further cross examined on this issue, Mr. Carr's view was that internally these 10 dBA peak to trough differentials would not necessarily be appreciated as a halving and doubling of noise because the troughs would be below the level of audibility. I accept the logic of this. On the other hand, he also accepted that internally AM peaks of 40 dBA leq and above - which I emphasise are a regular occurrence internally - would be clearly audible. Indeed, the audio recordings demonstrate that this is manifestly the case. Although therefore internal AM values would not necessarily be experienced as a doubling and halving of loudness *per se*, it cannot reasonably be disputed that this

[53] In this respect, it is common case that a rise or fall of 10 dBA will be perceived as a doubling or halving of volume.

characteristic is highly intrusive and unreasonable, particularly in HH where lower frequency sound and vibration also feature prominently.

490. I accept that the AM is likely to be experienced somewhat differently at each property and that it varies somewhat externally to internally as well as between different rooms and different floors of the houses. However, this does not alter the broad picture emerging.

491. Despite criticising the methodology of the plaintiffs' experts, Mr. Carr did not carry out any monitoring capable of identifying AM values. Nor did he engage with the vast amount of external and internal data collected by the plaintiffs' experts over two lengthy periods of monitoring. This data, which was then painstakingly presented by the plaintiffs' experts in almost 100 separate time domain graphs illustrating AM values (and the other characteristics of the AM), was just brushed over by the defendant's expert.

492. Irrespective entirely of its AM values, I also find that the audio recordings (and the associated graphs) support the plaintiffs' evidence as to the varying character of the WTN. I accept that on occasion the sound is more swishy, constant and monotonous with little variation. This in my view is a sound that one would be expected to habituate to. However, I also accept, and again this was not disputed by Mr. Carr, that the WTN also displays a clear

whoomphing sound and distinct thump AM. I accept the evidence of the plaintiffs that this whoomphing and thumping is highly variable and unpredictable.

493. I further accept that the audio recordings and time domain graphs support the plaintiffs' evidence that, overall, the WTN is highly changeable and unpredictable. I accept MAS's view that the AM displays considerable impulsivity (sudden changes in sound level), erraticism (with no clear periodicity or rhythm, exhibiting spikes and double spikes of AM) and variability/intermittency (when AM disappears and returns again). None of this was disputed by Mr. Carr. These latter characteristics, which are particularly evident in light of the high AM values, mean that the WTN lacks any pattern to which one could acclimatise and therefore impacts coping mechanisms.

Aggravating features - Spectral content of the noise

494. Low frequency noise (sound up to approximately 150 hertz) only slightly above the threshold of audibility can cause considerable disturbance and is more difficult to mask and get used to than other types of noise.

495. Ms. Large conducted a spectral analysis of the data collected during the 2017 monitoring period. Her conclusion is that whist there is substantial variability in the spectral content of the noise, low and lower frequency energy is present externally and internally.

496. Ms. Large states that there are many periods when the sound energy is dictated by lower frequency energy at 200/250 hertz. This is important because it impacts upon the character of the AM. Thus, whilst AM in the range of 500 to 800 hertz would be heard as a swish, AM below 315 hertz will be heard as a lower pitched whoomph or rumble or thump. Sound at this end of the spectrum is rumbling in nature and is described as being felt like a vibration as well as merely heard. Ms. Large's evidence was that during the 2017 monitoring period there were also regular periods characterised by lower frequency sound within the 100 to 200 hertz third octave bands. This was manifest both externally at NF and internally at HH. If this low frequency noise occurs at peaks of AM, then it will be heard as a thump or a beat.

497. Ms. Large indicated that this low frequency impact is particularly prevalent internally at HH and notes that low frequency noise propagates further and is more effective at transmitting through structures. Thump AM will therefore be enhanced indoors because it is less well attenuated by structures. In addition, the ETSU Review observes that thump AM is more prevalent at night, due to atmospheric conditions.

498. All of this is entirely consistent with Ms. Webster and Mr. Rollo's description of thumping noise which comes through the walls and ceiling of their bedroom, particularly at night. Ms. Large also referred the court to the Defra low frequency curve against which the acceptability and audibility of low frequency noise is assessed. Whilst spectrograms of the WTN at HH showed that average sound levels were just below the low frequency curve, lower frequency sound modulated above the curve and would therefore be audible. Ms. Large's report demonstrated that audible low frequency sound at peaks of AM were present on multiple occasions within measurement periods as short as 2 minutes.

499. Ms. Large also gave evidence that in both dwellings she personally experienced periods of significant low frequency noise producing thumps, rumbles and thudding. Subsequent correlation with spectral frequency identified that the periods were impacted by significant low and lower frequency sound energy. Mr. Stigwood's evidence was that the thumping rise and falls of the WTN was the dominant noise internally even with the window shut.

500. Mr. Carr's written report noted that a particular period of low frequency noise identified by Ms. Large would not fall within the audible range. However, he did not give any oral evidence to this effect. In any event, Mr. Stigwood referred the court to other data in Ms.

Large's reports which demonstrated that lower frequency noise was clearly audible.

501. Mr. Carr did not conduct any monitoring capable of identifying low frequency characteristics. In his direct evidence to the court, he did not contradict the plaintiff's experts in relation to the presence, and at times, dominance of sound at the lower frequency end of the spectrum. Nor did he contradict the proposition that the audio recordings and time-domain graphs (with associated spectral correlation) confirm that this lower frequency is manifesting as thump AM.

502. When cross examined about the impact of low frequency noise and low frequency AM in particular, Mr. Carr's response was once again to refer to the IOA RM as the appropriate manner in which to present, assess and rate AM. This, in my view, was a wholly inadequate response. Although the IOA AM report expressly recognises that there are two manifestations of WTN – blade swish and periodic thumping or whoomphing noise containing relatively low frequencies - the metric described in the report does not reflect any change in subjective response with modulation frequency. The defendant does not contend that the IOA RM distinguishes between AM of the swish variety and AM of the thump variety. Therefore, whilst recognising the existence of whoomph or thump AM, the IOA metric is relatively insensitive to it.

503. In light of the above evidence, I find on the balance of probabilities that whilst low frequency noise is not the dominant characteristic of the WTN, there is a significant element of audible low and lower frequency noise which manifests as thump AM. I also accept the evidence of the plaintiffs, and indeed of Ms Large that, even with the windows entirely shut, thump AM is evident and further that one can feel the vibration of thump AM in the structure of both houses.

Characteristics of the neighbourhood

504. The impression I gained of the area during the court visit fully supported the plaintiffs' account of the character of the locality. This is a quiet, rural area and the sound environment is characterised by the sounds of nature. Absent the WTN, there would otherwise be a fairly predictable pattern of noise (e.g. decreasing noise levels at night-time, temporarily increasing noise levels at dawn during the dawn chorus and largely unintrusive levels of noise throughout the day from local traffic and other manmade noise).

505. As this is not in dispute, I accept that the location is in a wind shadow sheltered from the prevailing winds. One would expect that wind related noise at the plaintiffs' properties would, more often than not, be fairly low.

506. Generally, therefore there is little specific manmade noise in the area which the plaintiffs' experts argue contributes to the nuisance posed by the *"alien"* and *"industrial"* character of the WTN. In so doing the plaintiffs' experts assume that, absent the nuisance, the character of the locality would include no WTN at all.

507. This is a false comparison. Mr. Carr's opinion is that it is not appropriate to "set" baseline noise at the level that would be expected without any turbines in the vicinity. As a matter of principle, I agree with Mr. Carr. There is planning permission for a windfarm at this location which carries with it the assumption of a level of WTN and associated AM and on occasion lower frequency noise. In assessing the character of the area, the court must have regard to the fact of the permission and the existence of such turbines.

508. As I state above, the wind was low at the time of the court's site visit and the 10 m standardised windspeeds at T2 varied and averaged between 4.1 and 4.8 m/s. Although T2 was therefore only turning slowly, the WTN was audible inside and outside both HH and NF. It is common case that, although audible, the WTN evident on this occasion would not be considered unreasonably intrusive.

509. However, the clear and unavoidable conclusion from the audio recordings is that both the external and internal soundscape is dominated by the WTN. Although certain background and extraneous noise is discernible, it rarely masks the characteristic rise and fall of the turbines which is the predominant noise. On the majority of the audio recordings, both external and internal, the WTN is the *only* noise that one can consistently identify. It constantly draws one's attention. Other ambient noise might ebb or flow, but it does not mask the WTN to any appreciable extent. With very few exceptions, the defendant did not by reference to the audio recordings, realistically contend to the contrary.

510. I cannot say whether this dominance is a function of the level of exceedance of the WTN over background noise levels (as to which see below), the high AM values, the comparatively low spectral frequency or the other attention drawing characteristics of the WTN. Most likely it is a combination of all these features. One can say however that this dominance exacerbates the dissonant qualities of the WTN to an extent that an ordinary person would not be expected to tolerate. I am satisfied that windfarm noise such as this cannot be considered part of the character of the locality.

511. Demonstrably, the degree of dominance evident on the majority of the audio recordings is not a constant state of affairs. For a start it must occur at speeds of rotation in excess of those pertaining at the time of the court visit. However, I accept the evidence tendered by the plaintiffs that such dominance occurs commonly and for sustained periods. Such dominance will also be particularly evident at night when the impact of AM - in particular thump AM - is more prevalent and when other background sounds are lower.

The exceedance of WTN over background noise

512. An overriding theme of the cross-examination of Ms. Large and Mr. Stigwood was that they had failed to assess background noise levels at a range of different windspeeds. There is no doubt that this impedes the analysis. For example, whilst total operational noise appears to be above the limits fixed in condition 15, without accounting for background noise one cannot draw a definitive conclusion on planning compliance. For present purposes, it also means that one cannot assess whether this is a "*low noise environment*" within the meaning of WEDG 2006. Nor can one assess the level of exceedance of WTN over background noise in order to benchmark the WTN against the commonly applied relative limit of 5 dBA over background noise (see both WEDG 2006 and draft WEDG 2019).

513. The problem, however, is that a formal background noise assessment cannot be carried out unless both turbines are turned off for a substantial period which is wholly outside the control of the plaintiffs and wholly within the control of the defendant.

514. Mr. Carr stated that the plaintiffs could have estimated background noise levels in a number of different ways, such as in upwind conditions. However, at this proximity, Mr. Stigwood says that WTN would elevate noise levels even in upwind conditions. Alternatively, Mr. Carr suggested that one could estimate background noise levels using a proxy location. However, given that Mr. Carr did not identify a suitable proxy location, I can comment no further on this.

515. In the absence of a formal background noise assessment, both parties advance other evidence to approximate background noise levels.

<u>Evidence of the plaintiffs' experts on background noise</u>

Comparing windy periods with still periods

516. Ms. Large and Mr. Stigwood compared noise levels during periods when T2 was turning very slowly - or not at all - with periods when it was turning more rapidly. The difference in sound levels is then said to approximate the "turbine off" noise level versus the "turbine on" noise level .The contention is that the former approximates "background sound" and that T2 increases background sound levels internally at HH by 10-15 dBA (with the window open) and by 9-11 dBA (with the window shut). In each case, Ms. Large states that this is more than a doubling of volume.[54] It is also contended that T2 increases background noise levels externally at NF by 15-19 dBA above background noise levels - almost a quadrupling of volume.

517. However, this approach ignores that fact periods of high WTN are generally also characterised by higher windspeeds which, even absent the WTN, would be associated with commensurately higher levels of background wind noise. Windier periods are noisier than still periods.

518. To meet this difficulty Mr. Stigwood argues that residents will be disturbed by high WTN irrespective of the fact that it might be somewhat noisy even without the WTN. He states that psychologically speaking, residents will compare periods of high WTN to periods of calm when WTN and wind noise are absent. Not only do I find his view unconvincing but, in expressing it, Mr. Stigwood was beyond the limit of his area of expertise.

Comparing periods of lull in the windfarm activity with periods of activity at the same windspeed

519. To estimate background noise and approximate the "turbine off" noise level, Ms. Large's report presented data pertaining to a lull in WTN shortly after 4 a.m. on several mornings every week. By correlating this data with the SCADA data for T2, Mr. Stigwood ascertained that an adjustment of the blade angle of T2 occurred at the time of each lull. During the lull, there is a discernible drop in overall noise - by as much as 14 dBA - but crucially, no associated drop in windspeed. He therefore concludes that the drop in noise levels is attributable to the adjustment of T2 and further that background noise at the relevant time is less than the

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[54] In this respect, it is common case that a rise or fall of 10dBA will be perceived as a doubling or halving of volume.

noise level pertaining during the lull (as T1 is still operational). This all suggests that at the times in question WTN exceeds background noise by substantially more than 5 dBA.

520. However, even assuming that this is correct, one cannot extrapolate from here to a proposition that this is generally the case. These lulls, although occurring on a regular basis, are of very short duration (no more than a minute or so).

521. In any event, a formal assessment of exceedance of WTN over background noise levels is calculated by reference to a range of windspeeds. The plaintiffs' experts merely estimate such exceedance at the particular time of each audio recording without reference to windspeed.

This is not a robust assessment methodology.

522. In short, I cannot be satisfied on the balance of probabilities that the WTN exceeds background noise by in excess of 5 dBA such as to breach this aspect of modern planning guidance (WEDG 2006 and draft WEDG 2019).

Evidence of the defendant's experts on background noise

523. I am equally unconvinced by the defendant's suggested approach to the assessment of background noise levels. This was to derive same from Mr. O'Reilly's HH planning compliance graph. The HH planning compliance graph shows that at low windspeeds, the trend line is above 30 dBA L90 which Mr. Carr tentatively suggests might approximate background noise levels. This is not a recognised method of calculating background noise levels. A trend line is designed to present noise levels over the entire graph. Mr. Carr accepted that if a trend line were to be derived for these lower windspeeds only, this would "*pull down the polynomial line*".

524. In any event, applying the same methodology to Mr. O'Reilly's NF compliance graphs suggests very low background noise levels both during quiet waking hours (well below 30 dBA L90) and night-time hours (well below 20 dBA L90). Furthermore, a line of data points at 20 dBA on both the NF quiet waking hours graph and the NF night-time hours graph which is indicative of unrecorded sound levels below the level of sensitivity of the sound recording instruments. This would pull the trend line down still further, implying that background levels at NF are very low indeed.

Conclusion on background noise

525. Overall, I find that neither the plaintiffs nor the defendant's estimation of background noise levels are reliable.

526. It has not been established that the WTN is in breach of the commonly applied relative noise limit (5 dBA above background noise levels). Nor can I be satisfied on the balance of probabilities that this is a "low noise environment".

527. Notwithstanding this, and recalling my observations at para 509-511 above, I find that on account of its characteristics (rather than its absolute decibel level) the WTN commonly dominates the plaintiffs' sound environment over sustained periods of time.

528. The intent of a relative noise limit is that background sound might mask WTN to a degree, rendering it less distinguishable. Therefore, although it may not be possible to formally assess exceedance over background noise levels, I am nonetheless satisfied that WTN which dominates the plaintiffs' sound environment can fairly be characterised as inconsistent with the purpose and intent of relative noise limits.

The impact of the noise on basic needs such as sleep

EPA Guidance Note on Noise Assessment of Wind Turbine Operations at EPA Licensed Sites ("EPA NG3").

529. In June 2011, the EPA produced a guidance note on the noise assessment of wind turbine operations at EPA licenced sites, EPA NG3. Although EPA NG3 is not applicable to this windfarm, it is nonetheless relevant to note that it expressly recognises the additional annoyance and sleep disruption that can be occasioned by AM. EPA NG 3 records that excessive audible AM attracts attention, particularly if heard while trying to get to sleep either at the start of a night or when a person has been woken by other causes. It states that although the level of noise generated internally, even with windows open, is usually insufficient to cause sleep disturbance, the stress it may generate, even if only just audible, may be sufficient to extend the time required to fall asleep. Such effects may give the impression of a noise which is 5 dBA or more louder than a noise of the same level without any such components. EPA NG3 notes that it is therefore necessary to develop appropriate corrections for regulatory purposes.

WHO Guidance Lmax and Lden

530. Both parties rely on World Health Organisation guidance in relation to the level of sound thought to effect sleep, health and wellbeing. Ms. Large notes that the 2017 HH internal data shows AM peaks (known as the Lmax) of 40-43 dBA leq with the window open and 2021 dBA leq with the window closed. She also notes that the 2017 NF external data demonstrates that Lmax is regularly in the regions of 50-50 dBA leq but also reaches 54-57 dBA leq. Ms. Large states that AM demonstrating Lmax of this magnitude would be viewed by the WHO

2009 Night Noise Guidelines for Europe ("WHO 2009") as likely to cause sleep effects.

531. However, this focus on the Lmax of noise has not been carried through to more recent WHO Guidance, the 2018 Environmental Noise Guidelines for the European Union (WHO ENGER). WHO ENGER, which, unlike WHO 2009, contains recommendations on WTN specifically sets a *"conditional recommendation"* for WTN of 45 dBA leq on an Lden basis.

532. Mr. Carr suggests that the noise limits set out in the Ballyduff permission complies with the WHO ENGER recommendation. He also maintains that, as Mr. O'Reilly's compliance graphs show that total operational noise is below 45 dBA leq during quiet waking hours and night hours, the WTN also complies with WHO ENGER.

533. However, Lden is an entirely different measurement metric to either L90 or leq. The Lden (also referred to as "DENL") indicator is calculated as the A-weighted average sound pressure level, measured over a 24-hour period, with a 10 dB penalty added to the average level at night, a 5 dB penalty added to the average level during the evening and no penalty during the daytime. The penalties are introduced to indicate people's extra sensitivity to noise during the evening and night.

534. Neither parties' experts have even attempted to calculate how one might convert the data in Mr. O'Reilly's compliance graphs to the appropriate Lden metric, which in any event should presumably be ascertained for all wind directions (and not solely downwind).

535. Overall, there is entirely insufficient evidence to apply the WHO Lden conditional recommendation in ENGER to this site.

536. In any event, ENGER acknowledges the low quality of the evidence reviewed in the formulation of this recommendation, which is conditional only. Therefore, although the guidance of WHO clearly carries much weight, I do not consider it a robust framework for assessing whether or not the WTN in the present case is likely to disturb sleep to the extent of posing a nuisance.

Conclusion on sleep impacts

537. Rather, the potential impact of this WTN on sleep must be assessed by reference to the audio recordings (and the associated graphs), all of the expert evidence as to the characteristics of this WTN and to the factual evidence of the plaintiffs, Ms. Doran, Ms. McGinn and the plaintiffs' experts as to the "real world" sleep impacts experience as a result of this WTN. For the reasons set out above, I am satisfied that high AM values and thump AM due to the presence of lower frequency sound energy are common and sustained features of this WTN. These are also the primary characteristics of which the plaintiffs complain. ENGER notes that these characteristics are not captured by standard methods of measuring and that this differentiates WTN from other noise sources. These are characteristics which are known to heighten annoyance and disturb peace, rest and sleep. I therefore find that there is more than adequate evidence in this case to make the case of substantial sleep impacts.

How easily the noise can be avoided/ Measures to reduce or modify the noise

538. Externally, limited measures are open to the plaintiffs to reduce or modify the noise. Although they can attempt to mask the noise by playing music or wearing headphones, this is an unsustainable long term solution. I also find that given its characteristics (e.g., with typical AM values exceeding 5 or 6 dB and regular thump AM etc), the WTN regularly intrudes to an unacceptable degree into the plaintiffs' homes over sustained periods of time. Although overall noise levels will be lower with the windows completely shut, at higher speeds of rotation the WTN- and associated vibration-still intrude to an unacceptable degree. In any event, a large part of the population desire to sleep with their windows slightly open and having to close windows effects, fresh air and connection with the outside world. In a quite rural location such as this (albeit one which includes permission for two turbines) , it is not reasonable to compel residents to shut their windows in an attempt to partially mitigate the impact of unacceptable noise instruction.

539. During the day, this WTN may be somewhat masked by the sounds of household appliances, the dogs and conversation. However, it will be obvious during times of calm. At night, the plaintiffs have already taken such measures as are reasonably open to them to mask the sound to aid sleep.

540. Whilst the defendant contends that insulation would assist, Ms. McGinn states that this has made very little difference at NF.

541. I do not find the defendant's suggestion that the plaintiffs should simply avoid the worst affected rooms is a reasonable means of escape from the noise. There is no authority whatsoever for this proposition. A resident should be able, without nuisance, to relax or sleep in any room they chose. Having to avoid the rooms where the noise is most intrusive merely demonstrates adverse impact on the ordinary comfort and enjoyment of the house as a whole.

542. There are, however, a range of options identified by Mr. Mayer which could be implemented by the defendant to modify or reduce the noise such as constraining the speed of rotation of T2. None of these have been adequately explored to date by the defendant.

How often the noise occurs and the time of day or night when the noise occurs

543. The intrusiveness of the noise varies as between different audio recordings, each of which will be rendered more or less intrusive by reference to a range of factors such as their sound pressure level, their AM characteristics etc. Moreover, the intrusion noise likely to arise varies with the time of day and the duration over which the noise represented by the recording persists.

544. Unquestionably, the most intrusive feature of the WTN is its AM and thump AM in particular. I accept that, as is typical, this is more pronounced at night. The ETSU Review suggests that the same is true of the early mornings and evenings. This means that the worst noise is likely to conflict with the most sensitive periods of the day when background masking sound levels are lower as compared to WTN. This all tallies entirely with the evidence of the plaintiffs and their experts.

Frequency and duration of noise impact

545. Frequency and duration of impact are critical factors in assessing whether nuisance is made out. One can confidently say that if the conditions complained of pertained only for short periods or on rare occasions then nuisance would not be made out. Equally, if there were a less intrusive noise source present all day every day, then this also might not be a cause of nuisance. There is no hard and fast level of intrusion which can be set as the barometer for nuisance. One has to make a judgment call based on all of the factors identified above as to how the plaintiffs as objectively reasonable people could be expected to relate to the noise.

546. However, bearing in mind that the defendant's experts did not contend that the MAS audio recordings (and the associated graphs) were unrepresentative of the general WTN on site,

I accept the evidence of the plaintiffs' experts (and the plaintiffs themselves) that the conditions so demonstrated occur commonly and on a sustained basis.

<u>Issue 7: What is the response of the defendant and its experts to the plaintiffs' case? Does the evidence of the defendant's experts suggest that the WTN is not a substantial interference with the plaintiffs' use and enjoyment of their land?</u>

547. As will be apparent from the above, I find that the analysis of the WTN - as demonstrated by the MAS audio recordings and the associated time domain graphs and spectrograms - under the Defra criteria strongly corroborates the plaintiffs' evidence of unreasonable interference with residential amenity. It is now appropriate to relate the overall response of the defendant and its experts to all of the above. Does this argument or evidence suggest that the WTN is not a substantial interference with the plaintiffs' use and enjoyment of their land or otherwise incline the court towards a finding that nuisance is not made out?

548. In the preceding sections of this judgment, I have set out and analysed the defendant's experts' evidence on the various issues falling for consideration under the Defra Guidance. At substantial risk of repetition, I will make the following more general observations.

549. Mr. Carr , the defendant's principal witness, gave evidence over the course of approximately 6 days. He appears to have attended the properties for a total of 40 minutes on 8th November, 2022.

550. The following extract from the beginning of his cross-examination assists in an appreciation of Mr. Carr's general approach to this case.

Q. So you got that material [the 2017 and 2021 MAS data]. And what I'm concerned about is, you're complaining about the listening, and my impression is that you don't see value in the [MAS] recordings, is that right?

A. Yes.

Q. You don't see value in the recordings, is that your evidence, is that right?

A. It is. I don't -- I don't believe that the [MAS] recordings were taken in a way that the conclusions or the information that came out of them stand over for the reasons that we have said in relation to how the recordings were taken.

Q. Well I'll go back then to my question. Why did you not advise Mr. Brazil to make his own recordings?

A. Judge, as I understand this, we have to meet the case that's put to us. We assess the site for compliance with the guidelines and the guidance as I know them and then I reviewed the additional information [i.e. The MAS recordings and their reports], and to my mind the evidence wasn't there to show a nuisance.

Q. I see. So, at this point, on reflection, do you think you might be better advised, and Mr. Brazil be better advised, if he had his own measurements?

A. *Judge, the requirements on Mr. Brazil was to assess -- my understanding of it was to assess compliance with the planning and then to look at any evidence in relation to the other guidelines. And to my mind there still isn't evidence of a nuisance there because the way the other data was obtained.*

Q. *Because of the way the other data was obtained?*

A. *And presented.*

Q. *So, the reality of it is then that the Defendant is meeting this case relying on compliance and relying, in essence, on your advice that there isn't a nuisance, isn't that right?*

A. *Well --*

Q. *Isn't that right?*

A. *The overall noise levels from this wind turbine are a significant factor on whether there is going to be a nuisance there or not. In my mind the overall noise levels from these turbines are well below a threshold that would be significant which point to breach of planning, breach of licensing or a nuisance.*

Q. *So that's the advice you gave to Mr. Brazil and that's really the basis on which this case is fought, is it?*

A. *Well that's my advice.*

This passage exemplifies the three main components to Mr. Carr's evidence.

1. The starting point appears to be to assess whether the WTN complied with the planning permission and with "*guidelines* "and "*guidance*" which in Mr. Carr's opinion it did. The only real data pertaining to the WTN on site put before the court by either of the defendant's witnesses was the planning compliance graphs prepared by Mr. O'Reilly. Mr. Carr's report and oral evidence was based exclusively upon the HH planning compliance graphs and he did not appear to have informed himself of the NF planning compliance graphs.

   For all of the reasons already set out, I do not accept that planning permission is the determinant of nuisance in this case. Furthermore, I do not accept that planning compliance is demonstrated in this case.

   The primary pieces of "guidance" relied upon by Mr. Carr were WEDG 2006 the IOA RM and draft WEDG 2019. Although I accept that compliance with WEDG 2006 is demonstrated on the balance of probabilities, this guidance does not in my view, delineate the parameters of nuisance in this case. The IOA RM does not set any "*threshold*" for "*noise levels*" at all, whether for by decibel level or AM values. The defendant's attitude to draft WEDG 2019 varies. On the one hand its counsel submitted that WEDG 2019 is draft only and cannot be the determinant of nuisance. On the other hand, Mr. Carr asserted that the WTN complies with draft WEDG 2019, "*with headroom*". I agree with counsel's point. Whist draft WEDG 2019 might give some indication of the likely future approach to balancing wind turbine development with protection of amenity (which, it appears likely, will involve a combination of relative noise limits and character penalty), it has since been withdrawn and cannot be the determinant of nuisance.

Further, although Mr. Carr asserts that the WTN complies with draft WEDG 2019, this is not even close to being demonstrated on the balance of probabilities.

2. Mr Carr's view is that the overall noise levels are "*very low*" and well below any "*threshold of significance*". Given his overall assessment of the noise levels, this was not a "*critical*" case requiring him to listen to the WTN or to engage in further monitoring.

   However, how is this threshold of significance to be set? In a case which is "*all about AM*", it cannot be set by the bare noise limits designated in the planning permission or in WEDG 2006.

   Further, in so far as draft WEDG 2019 might be said to provide any indication of the "*threshold of significance*", there is no valid basis for Mr. Carr's assertion that the WTN is well below this threshold or otherwise "*low*". On the contrary, Mr. O'Reilly's NF compliance graph shows that from windspeeds of 9 m/s total operational noise levels at NF is right at or slightly over the 43 dBA L90 maximum threshold recommended by draft WEDG 2019 (irrespective entirely of any possible character penalty). The noise levels on the HH planning compliance graphs are admittedly lower, but these graphs can only inform one on noise levels at comparatively low windspeeds. Likewise, background noise is an unknown so compliance with the draft WEDG 2019 relative limit cannot be assessed at either location.

   In short, I do not see compliance with draft WEDG 2019 "*with headroom*".

3. Mr. Carr sees no value in any of the MAS data by reason of the manner in which it was collected and presented.

   Insofar as concerns the collection of the MAS data, there could be no legitimate criticism of the manner in which Ms. Large collected the 2017 MAS data. The 2017 NF external data was recorded with a double skinned windshield in an appropriate free field location and the 2017 internal HH data was recorded in accordance with the Defra Guidance for internal measurements.

I am fully satisfied that even if one relied upon the 2017 data alone, same is sufficient to confirm high AM values, lower frequency sound content, thump AM etc. Moreover, Ms. Large's opinion, on which she was not contradicted, is that there is no material difference between the 2017 and 2021 data. This supports the conclusion that the 2021 internal data is reliable. Although therefore there is legitimate criticism of the 2021 NF external data (which I therefore disregard), the analysis of the internal NF and HH 2021 data is on balance robust.

Insofar as concerns the presentation of the MAS data, I am satisfied that the methodology used reliably presents the key features of the plaintiffs' general sound environment - the dominance of the WTN and its erraticism, impulsivity and variability. I am also satisfied that reliance can be placed upon MAS's calculation of AM values which is supported by the application of IOA RM to the 2021 internal data (in particular the 2021 NF internal data which was recorded in an unoccupied house). I am further satisfied that spectral analysis demonstrates significant lower frequency sound manifesting as thump AM.

For all these reasons, it is entirely illegitimate for Mr. Carr to place "*no value*" on all of this data and to effectively ignore it.

544. Beyond criticising their methodology, the defendant's evidence did not engage at all with the plaintiffs' expert's audio recordings (and the associated graphs). Unless one accepts the contention that the planning permission and WEDG 2006 are the determinants of nuisance, the defendant's experts gave the court very little to go on. Mr. Carr offered little or no substantive evidence in response to the audio recordings (and the associated graphs) illustrating and analysing the features of WTN. He and Mr. O'Reilly ignored the propositions of the plaintiffs' experts outlined in exhaustive detail that this demonstrates that AM values are excessive, and that low frequency characteristics and thump AM are commonly present in the WTN.

545. The defendant's evidence did not engage in any meaningful way with the evidence of the plaintiffs as to their experience of the WTN. Mr. Carr has not read the Webster Rollo noise diaries. He did not comment in any detail on how the sound might present itself to the residents.

546. The defendant's experts, both of whom are extremely experienced in relation to windfarms, offered no substantive evidence that the impact of the WTN was not as described by the plaintiffs and their experts. There was, for example, no suggestion that the level of erraticism, impulsivity and variability described by the plaintiffs in the AM was not present on the audio recordings or on site. Nor did the defendant's experts contend that thump AM was not a regular feature of the WTN. They did not contradict the plaintiffs' experts finding that this was evident on the audio recordings and indeed, during their visits to the site. Although many passages in the guidance to which he referred noted the distinction between swish and thump AM, Mr. Carr did not address the reported impact of regular, substantial and sustained thump AM at this site.

547. The defendant's experts did not assist the court in understanding how they contend that the experience described by the plaintiffs and features of the WTN highlighted by the plaintiffs' experts on the audio recordings (and the associated graphs) do not represent an unreasonable intrusion on amenity. If indeed this was their opinion it was not, by reference to any of the MAS data (or any other data), either explained or substantiated.

548. Neither Mr. Carr nor Mr. O'Reilly contradicted the view of Ms. Large and Mr. Stigwood that the noise from the Ballyduff turbines is exceptionally intrusive and out of the ordinary for WTN. I therefore accept the evidence of the plaintiffs' experts that this WTN is considerably more intrusive than one would usually encounter. Although Mr. Brazil states that the WTN is not unusual, I cannot accept this as Mr. Brazil has paid only a short visit to the plaintiffs' homes and beyond that has only heard the WTN from the public road which is set back from their properties.

549. Mr. Carr stated that in general he would advise wind turbine operators that if there is an issue with AM complaints, they should try and identify the environmental circumstances under which this occurs to ascertain if mitigation measures are required or can be devised. This is a step which for reasons best known to itself the defendant and its experts have steadfastly declined to take.

550. In many cases, in untangling an issue on which expert evidence has been given, particularly one on which the crux of the case in large part depends, only one of the two competing experts' views can be preferred. This case is somewhat different because whilst the plaintiffs' experts addressed the features of the WTN said to give rise to nuisance in detail, the defendant's experts have not. To emphasise the "appalling vista" that would present should this court find for the plaintiffs, the defendant and its experts stressed that a large number of windfarms are situated within 500 meters of a residence. I have no reason to doubt this. But this case is not about statistics. It is about *this* noise from *this* windfarm as heard at *these plaintiffs' residences*. This is the issue on which I would have appreciated the assistance of the defendant's experts.

Issue 8: Did the acousticians experts fail to discharge their duties to the court?

551. Both sides criticise the experts of the other for failing to understand their duty to the court. The defendant submits that the MAS reports (and Mr. Stigwood's oral evidence in particular) displayed many of the features which were sharply criticised by the Court of Appeal in *Duffy v. Mcgee* [2022] IECA 254. The plaintiffs maintain that Mr. Carr deliberately curated his evidence to focus only on planning guidance and that he deliberately ignored the separate issue of nuisance. It is said that he thereby brought only part of his expertise to the court.

Defendant's criticisms of Mr. Stigwood and Ms. Large

552. Mr. Stigwood is an acoustician who has no metrological, scientific or statistical qualifications. The defendant criticises him for giving evidence touching upon these issues. However, such evidence was not advanced in a vacuum. Rather, the vast majority of such evidence was advanced either by reference to the contents of established guidance and standards which were themselves the subject of extensive comment by both parties (such as ETSU, the IOA AM report, draft WEDG 2019 etc) or by reference to relevant guidance on the assessment of nuisance (such as the Defra Guidance and EPA NG 4). At other times the views expressed - e.g. that the plaintiffs' residences were in a wind shadow or that the position of T2 on a height would increase the impact of windshear- was uncontested and /or was common sense. This criticism is not therefore merited.

553. The defendant criticises Ms. Large's first report for citing legal authority. However, it is evident that the primary purpose of these passages is to place the expert evidence in context and to draw attention to the factors which are viewed by the court as relevant to the assessment of noise nuisance. In any event, the factors discussed[55] either have their genesis in the Defra Guidance on assessing statutory nuisance or they are so self-evidently relevant to a noise nuisance assessment as to be uncontroversial. Detailing these factors does not imply a failure to understand an expert's duty to the court.

554. Nor do I view the evidence of either Ms. Large or Mr. Stigwood assessing the Ballyduff WTN as against these factors as anything other than relevant, helpful and thorough. Rather, I agree that Mr. Carr's failure to substantively engage with these factors is regrettable. As a result, Mr. Carr did not assist the court on matters which are demonstrably relevant and within his field of expertise.

555. The defendant also criticises the plaintiffs' experts for citing various publications and expressing their opinion in relation to the functioning of the human brain and aspects of neuroscience. In so far as concerns Ms. Large, this criticism is entirely ill founded. This is a case about noise annoyance and factors likely to decrease or increase noise annoyance are of obvious relevance. Ms. Large's written and oral evidence, whilst containing some limited commentary on one's physiological response to noise – in each case, citing appropriate publications – did not in my view stretch the limits of her expertise as an acoustician. Much of this evidence - for example in relation to the enhanced impact of low frequency noise – was in the field of (or intersected with) acoustics. Other considerations discussed by Ms. Large- e.g. that unpredictable, unexpected noise is more annoying than steady, monotonous noise - are common sense.

556. I agree that, at times, particularly under cross-examination, Mr. Stigwood's answers strayed over the line of his expertise into matters of physiology. I have rejected such evidence where appropriate - e.g. Mr. Stigwood's view that one's appreciation of background noise levels should be calibrated by reference to periods of low windspeeds rather than by reference to increasing background noise levels at increasing

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[55] 58 Essentially the Defra criteria.

windspeeds.[56] However, over the course of extremely lengthy testimony, this was a rare occurrence and does not overall undermine his evidence.

557. The defendant also criticises Ms. Large and Mr. Stigwood for expressing the opinion that the data collected by MAS "*corroborates*" the evidence of the plaintiffs. I accept that it is not the function of an expert to express views as to whether one piece of evidence corroborates another. This is clearly a matter for the court. On the other hand, context is everything. This opinion was offered as part of the presentation of the audio recordings of the WTN at the plaintiffs' homes (and the associated time domain graphs). In this context, the plaintiffs' experts presented the features of the WTN – high AM values, thump AM etc- to demonstrate correlation with the plaintiffs' complaints about those self-same features of the WTN. I do not view this as an illegitimate exercise.

558. The defendant submits that the court should attach diminished weight to Mr. Stigwood's evidence because he acted as a partisan advocate throughout the trial. Although there were times when this might have been so, I do not in general accept this characterisation. Much of Mr. Stigwood's dogged perseverance can be explained by the fact that for many years he has argued through his research and publications that the standard ETSU approach does not protect windfarm neighbours against excessive AM. In this, he has been largely proved by contemporary science to be correct. His views are therefore held, and expressed, with vigour, as one would expect in the circumstances. Further, it would be hard to escape the impression that Mr. Stigwood, and indeed, Ms. Large have considered the impact of AM - both in general and at Ballyduff in particular - at far greater length and in far greater depth than Mr. Carr, who did not even attempt to address or assess its impact.

559. Having said that, Mr. Stigwood was at times overly defensive, occasionally refusing to make legitimate concessions even when on somewhat thin ice. For example, I find little merit in his argument that it is legitimate to assess exceedance over background noise by comparing windy periods affected by WTN with still periods which are not. Likewise, Mr. Stigwood gave

[56] See para 518 below.

evidence as to likely sleep impacts by reference to the WHO 2009 to the unwarranted exclusion of the more recent WHO ENGER. As will be apparent from my analysis above, I do not accept Mr. Stigwood's views in these two respects. In addition, I accept that at times, Mr. Stigwood's use of language appeared somewhat extreme. For example, in presenting the audio recordings to the court, he tended to refer to the WTN as a *"roar"* even when - albeit intrusive and dominant - it could not fairly be so described. Emotive language such as this is unhelpful.

Plaintiffs' criticisms of Mr. Carr

560. The defendant correctly submits that it is a matter for the court to determine whether nuisance has been made out or not on the evidence. Indeed, the defendant appears to have approached the case on the basis that the expert witnesses ought not to offer an opinion on this matter at all.[57] Mr. Carr therefore offered no real commentary on the aspects of the Ballyduff WTN which the plaintiffs and their experts say are demonstrated by the audio recordings (and associated graphs) and which are said to amount to nuisance.

561. However, this rather overlooks the fact that in order to assess whether or not this particular windfarm poses a nuisance, the court must engage with the plaintiffs' complaints and attempt to assess the nature and impact of the WTN at the plaintiffs' homes. In so doing, it is appropriate for the court to be guided by the evidence of experts as to what features of the WTN might be relevant to the noise nuisance assessment, as to the presence or absence of such features in the Ballyduff WTN and as to the extent to which, if present, such features are known or recognised to increase annoyance or can otherwise be characterised as adverse or unreasonable. Contrary to the view apparently held by the defendant and its experts, an informed qualitative commentary on such features is of assistance to the court.

562. Furthermore, in a case in which the defendant relies so heavily on the fact that there is planning permission for the wind turbines, one would expect that Mr. Carr would assist the court in assessing whether the features of the WTN complained of by the plaintiffs

[57] The defendant's written legal submissions argue that it is not appropriate for expert witnesses to express a view on matters of law which are for the Court to determine and that the Court should accordingly disregard entirely the assertions which have been made by MAS to the effect that nuisance has been proven on the evidence.

and highlighted by the evidence of MAS, are conventional features of WTN or are, as MAS

contends excessive, out of the ordinary[58] or otherwise non-conventional for WTN? However, Mr. Carr's evidence did not illuminate the court at all on this issue.

563. This is unfortunate not least because this court has no expertise in distinguishing between conventional and non-conventional WTN. By contrast the experts on both sides have vast experience in his area. There is nothing improper therefore in the plaintiffs' experts expressing the view that the particular features of this WTN render it non-conventional and far more intrusive than would usually be the case.

564. Like Mr. Stigwood, there were times when Mr. Carr pushed his argument too far. For example, I was surprised by his insistence that compliance with the planning permission (and with WEDG 2006) defines the parameters of nuisance. This inevitably entailed a refusal to acknowledge that the science has changed since WEDG 2006. In fact, Mr. Carr appeared to view that the primary innovation of draft WEDG 2019 was the promotion of consistency in measurement methodologies and the reinforcement of the GPG and the IOA RM. It seems that the proposed introduction of a penalty for "excessive" AM barely merited a mention. Yet the theory behind draft WEDG 2019 (and indeed behind the IOA AM report, the Phase 2 Report and the ETSU Review) can only be seen as a significant departure from the "decibel limit only" approach to planning practice espoused by Mr. Carr. Furthermore, Mr. Carr's casual assertion that the WTN would comply with the recommended limits in draft WEDG 2019 regardless of any potential AM penalty was not only unsupported by the evidence but, in my view, displayed a partisan approach.

[58] Note that my reference to "out of the ordinary" or "non-conventional" WTN should not be read as a reference to a principle of the United Kingdom law of private nuisance that even where the defendant's activity substantially interferes with the ordinary use and enjoyment of the claimant's land, it will not give rise to liability if the activity is itself no more than an ordinary use of the defendant's own land. This is not a feature of the Irish law private nuisance. My use of the words "out of the ordinary" is simply to denote particularly intrusive characteristics that are not thought to be a commonly occurring feature of WTN (such as high AM values and thump AM).

565. I was also struck by Mr. Carr's apparent dismissal of Mr. Stigwood's view that AM is often worse at night-time due to stable atmospheric conditions, However, the relevance of stable atmospheric conditions to the enhancement of WTN AM has been clear in this jurisdiction since at least 2011. Thus NG 3 notes that features which were thought to enhance

AM included stable atmospheric conditions[59] particularly at night and topography leading to

different wind directions being seen by the blades at different points in their rotation. This view is also recently confirmed by the ETSU Review. It is difficult to understand how Mr. Carr, a highly expert witness operating in the field of acoustics, could depict Mr. Stigwood's views on this issue as somewhat exotic.

566. Overall, it is hard to disagree with the plaintiffs' submission that Mr. Carr displayed a stark failure to engage with the complaint actually made or with the evidence illustrating such complaint. There is force in the plaintiffs' argument that Mr. Carr's refusal to engage with any material which was inconsistent with his central thesis means that he brought only part of his expertise to the court.

Conclusion on issue 8

567. I should emphasise that my reservations as just outlined do not go nearly far enough to justify a finding that either Mr. Stigwood or Mr. Carr failed to discharge their duties as experts to the court. It is however the case that their evidence had less of a sense of balance than I would have expected, which inevitably impacts to some degree upon its weight. Particularly in the case of Mr. Carr, there was little sense that the propositions being put to him were being carefully considered. Rather, he repeatedly restated his central thesis.

568. By contrast, Ms. Large, gave the impression, through her evidence, of a witness who was trying to be helpful to the court and who did not in any way oversell the cogency

[59] Stable atmospheric conditions are conditions under which mixing of layers in the atmosphere is minimised. This leads to a much greater increase in windspeed with height.

of her argument. She conceded points where appropriate and answered all questions put with logic, thoroughness and diligence. I do not see how any complaint of partisanship or incompleteness could credibly be levelled at Ms. Large's evidence. Therefore, in adjudicating upon this complex case I have placed considerable weight upon her evidence.

Issue 9: What on the balance of probabilities are the characteristics of the Ballyduff WTN

569. I find on the balance of probabilities that the evidence supports the plaintiffs' account as to the characterises of the noise. I also find on the balance of probabilities that such characteristics occur commonly and on a sustained basis.

570. I am fortified in these conclusions by the following inter-related observations:

571. First, the descriptions given by all four plaintiffs of the particular characteristics of the WTN – (e.g. dominance, erraticism, impulsivity, excessive AM values and thump AM) - were mutually consistent and were not shaken in cross-examination. The Webster-Rollo's who gave detailed and extensive evidence about this were subject to exacting cross-examination over the course of 4 days. Mr. Shorten who gave similarly detailed and extensive evidence on the WTN was not cross-examined in relation to his experience of WTN and Ms. Carty, who did likewise, was not cross-examined at all.

572. Second, the experience of living with the WTN as described by Ms. Webster and Mr. Rollo in their evidence to the court is chronicled in daily diary entries going back over three years. As I observe above, the reliability of these diary entries was thoroughly tested in crossexamination and passed muster.

573. Importantly, Ms. Large's report correlated the description of the WTN in key parts of the 2020-diary entries with the contemporaneous audio recordings (and the associated graphs) to ascertain whether the plaintiffs' descriptions were borne out. Her report confirmed consistency between the two. Mr. Stigwood performed the same exercise in relation to key parts of the 2021 noise diaries. This is of significance as Ms. Webster and Mr. Rollo could not have known when making the diary entries what the audio recordings (and the associated graphs) would show.

574. The Webster-Rollo diary entries, Ms. Large's report and the full suite of audio recordings (and the associated graphs) have long since been furnished to the defendant. The defendant could have challenged the reliability of either the plaintiffs' diary entries or of Ms.

Large's descriptions of the relevant data by contending for example that excessive AM or thump AM etc was not present on the recordings. It did not do so. This all suggests that the diary entries can be seen as a valid contemporaneous account of the plaintiffs' experience of the WTN.

575. None of this means of course that all of the features described in the diary entries (or indeed all of the features demonstrated by the MAS 2017 and the MAS 2021 data) were present on a constant basis over these years or even that all of the features described were continuously present throughout the individual days and nights represented by the relevant entries. However, the preponderance of the evidence is that these features were present on a common and sustained basis - albeit not continuously – during the periods recorded in the diaries. Furthermore, there is no reason whatsoever to conclude that the nature of the WTN has changed since 2017 and 2021 and I accept the opinion of MAS that it has not.

576. Third, the plaintiffs' descriptions of these characteristics of the WTN were consistent with the personal on site observations of both Ms. Large and Mr. Stigwood on which neither expert was convincingly challenged. Ms. Large, spent an extended period of time at both NF and HH and gave evidence that the WTN at both sites was the worst case of WTN nuisance which she had ever experienced.

577. Fourth, the court is also informed by its own appreciation of the noise as it appears on the audio recordings presented by the plaintiffs' experts. On any fair assessment the audio recordings support the plaintiffs' evidence that the WTN disturbs their peace and disrupts their sleep. I find that the evidence comprised by the audio recordings (and the associated graphs) is consistent with the plaintiffs' description of the characteristics of the WTN.

578. Fifth, the observations of the plaintiffs' experts-- based on the audio recordings (and the associated graphs) – as to the characteristics of the WTN was consistent with the plaintiffs' own descriptions of same and further strongly supports the plaintiffs' evidence of significant adverse impact. This is important because the observations of the plaintiffs' experts (to the effect that the audio recordings and associated graphs demonstrated erratic, impulsive AM together with high AM values and thump AM) was scarcely challenged in cross-examination or in the defendant's experts' evidence. Thus, although Mr. Carr did contend that AM values should not be derived from the time domain graphs, he did not dispute that the graphs themselves, which correctly captured the noise at the microphone locations at HH and NF showed that high AM values were present over the periods depicted in the graphs. The defendant's primary response to much of the above was that the sound levels were "low" which has not been demonstrated and which furthermore misses the heart of the argument. As I explain above, WTN levels are generally "low". The point however is that, even if the decibel level of the Ballyduff WTN is roughly as one might generally expect, it is its other features thereof which render it objectively unreasonable and, indeed, dominant.

Findings of fact in relation to the characterises of the WTN

579. On the basis of all of the above, the following are my findings of fact:

580. Generally, T1 is barely audible from the plaintiffs' homes and, when audible is not intrusive.

581. By contrast, when it is turning, T2 is audible at all times in the gardens and recreational area outside the plaintiffs' properties. When T2 is turning, even slowly, WTN is also audible from inside the plaintiffs' homes with the windows only slightly ajar. Whether the WTN is audible with the windows closed will depend upon the speed of rotation of the rotors and on other ambient noise. Likewise, whether at any given time audible WTN - and associated vibration - causes an unreasonable interference externally or internally- will also vary with the speed of rotation of the rotors, with other ambient noise and with metrological conditions.

582. I find that there are frequent and sustained periods during which AM values are conservatively in excess of 5 or 6 dBA. I also find that there are regular periods during which the AM values are considerably in excess of 6 dBA, in the order of 10 dBA or more. I find that such high AM values exacerbate the other intrusive features of the AM such as its erraticism, impulsivity and intermittency. I find that although noise levels will be lower when the windows are fully closed, high AM values remain. I find that there is a significant audible lower frequency component to the WTN. This produces clear whomping, thumping and whacking sounds. These whoomphing and thumping sounds are themselves highly variable and unpredictable. In addition to being heard, this lower frequency WTN is felt as a vibration or a sense of pressure. The WTN is audible and "felt" both outside and inside NF and HH, including in the master bedrooms at both properties. I find that, when even with the windows are entirely shut this lower frequency noise is clearly audible throughout both houses and that thump AM can be felt as a vibration in the structure of NF and in particular HH. I am satisfied that this thump AM is commonly present over sustained periods.

583. I find that when the turbine is turning slowly- as exemplified at the time of the court's visit – it is not particularly intrusive. However, I also find that at higher speeds of rotation as a result of the characteristics outlined above, the WTN dominates the plaintiffs' sound environment both externally and internally. I find that at moderate to high speeds of rotation the impact of the WTN far exceeds masking levels; it is the primary noise that is experienced in the plaintiffs' sound environment.

584. I further find that although internal noise levels are lower in both houses when the windows are shut, at higher speeds of rotation the WTN is nonetheless dominant particularly due to the sense of vibration associated with thump AM.

585. I further find the WTN AM is more prevalent during the night, early morning and evening periods than during the daytime. This is in all likelihood due to the atmospheric and situational conditions that prevail at these times, contributing to increased AM occurrence, and potentially enhanced sound propagation.

586. As I explain above,[60] bearing in mind current scientific uncertainty on this issue, the most that the various guidelines (such as the WHO guidance variously relied upon by both parties' experts) can do is illustrate the likely sound level at which sleep impacts are anticipated. As in *Hanrahan* such evidence cannot dethrone the factual evidence of the plaintiffs that the combined characteristics of the WTN are such as to regularly disturb their sleep. I accept that the WTN is such as to cause sleep disturbance at both NF and HH with the windows open and with the windows closed. I accept the evidence of all four plaintiffs as to the sleep difficulties experienced as a result of the WTN. I accept that Ms. Webster continues to do all that she can to mask the noise but nonetheless continues to experience serious sleep disturbance. In Mr. Rollo's case I accept that the impact of the sleep disturbance was profound and unremitting. I accept that this sleep deprivation was ultimately instrumental in causing Mr. Rollo to suffer a psychiatric injury.

587. I accept that during spring and autumn the turbines intermittently cause shadow flicker, albeit that I am not satisfied that this pertains for more than 30 minutes per day such as to exceed WEDG 2006.

Issue 10: Does the court accept the plaintiffs' evidence that the characteristics of the noise amounts to an unreasonable interference with the plaintiffs' enjoyment of their property? Is liability in nuisance established?

588. As will be apparent from all of the forgoing, the answer to this question is a resounding affirmative.

589. The Ballyduff planning permission does not delineate the parameters of noise nuisance in this case principally because it does not assess or regulate the aspect of the WTN complained of, which is AM. Even if the planning permission did delineate the parameters of noise nuisance, total operational noise at both NF and HH is above the applicable 40 dBA leq limit for windspeeds above 7 and 6ms/ respectively. Although, the absence of a formal background noise assessment means that planning non-

[60] 63 See para 536 above.

compliance has not been demonstrated on the balance of probabilities, nor can the defendant make out the defence advanced.

590. I find that two features in particular of the WTN AM render the WTN an unreasonable interference. First, there are frequent and sustained periods during which the AM manifests typical AM values at a level widely acknowledged to be associated with high levels of annoyance. Second, this WTN displays periods of thump AM. The oral evidence of all four plaintiffs and the Webster-Rollo diary entries all suggest that thump AM, together with its association vibration, is the most intrusive quality of the WTN. This thump AM vastly adds to the nuisance posed by the wind farm. In combination, I find that this is WTN which reasonable people would find it impossible to habituate to.

591. Regular and sustained AM values of this order and thump AM combine to produce WTN which is a world away from the usual noise that one would associate with wind turbines – viz. reasonably regular and monotonous swish AM. Mr. Lawlor, the defendant's planner, stated that the understanding of planners is that blade swish is "*normal AM*". He stated that whoomphing or thumping AM is called "*adverse AM*" or "*other AM*". As the ETSU Review notes it is also commonly described as *"abnormal AM"* or *"enhanced"* AM. Mr. Lawlor acknowledged that whoomphing or thumping AM, "*is likely to cause adverse reaction in the community*". Although he stated that this form of AM is thought to occur only for short durations of time at very specific meteorological conditions, I am satisfied that the evidence establishes that it is a common and sustained feature of the Ballyduff WTN, particularly at night, in the early morning and in the evening.

592. I am satisfied that these two features combine to render the WTN the dominant noise in the plaintiffs' sound environment. These are the features of WTN that one hears and feels both outside and inside HH and NF with the windows open and closed. Such an intrusion of noise and vibration into the plaintiffs' homes could not be an objectively reasonable impact of a windfarm located in a quiet rural environment such as this, albeit one which includes permission for a windfarm.

593. I accept the evidence of the plaintiffs' and their expert witnesses that the noise impact demonstrated on the audio recordings and graphs occurs commonly and for sustained periods. To expand on this somewhat, I do not find that high AM values and thump AM occur constantly in the Ballyduff WTN. Their level and presence fluctuates. However, I accept that these features occur commonly albeit at irregular intervals. These irregular intervals are frequent and can occur on repeated occasions in a 24 hour period. Sometimes these intervals are sufficiently frequent and sustained in duration as to define the relevant day or night from the perspective of those experiencing it. On such occasions, the overriding impression will be of adverse impact punctuated by periods of more acceptable WTN; e.g. when it is more steady and monotonous with AM of the swish variety. On other occasions the opposite might be the case and the adverse intervals will be infrequent or of short duration meaning that the overriding impression will be of acceptable WTN punctuated by periods of adverse impact.

594. This provides context to Ms. Webster's broad estimation that the WTN unreasonably intrudes on her comfort and enjoyment up to 80% of time. Objectively speaking, it is unlikely that these adverse intervals persist for 80% of the time overall. Such periods of adverse impact are of their nature likely to be intermittent. However, I am equally satisfied that there are few 24 hour periods that escape substantial intervals of sustained adverse impact. Even if not present for the majority of a given 24 hour period, a substantial number of intervals of sustained adverse impact means that the day/night in question cannot fairly be characterised as a period of respite. Crucially, the unpredictability of occurrence and the plaintiffs' lack of control over when and for how long these unacceptable impacts manifest increases the level of nuisance overall. Although therefore adverse impact comes and goes, the annoyance occasioned thereby largely persists. My strong sense is that if the overall intensity or prevalence of these adverse intervals were mitigated, then the perception of overall nuisance would reduce considerably and probably exponentially.

595. For all the reasons set out above, the plaintiffs' complaints of nuisance are objectively justified. The WTN interferes to a substantial extent with the ordinary comfort and enjoyment of their homes. I am satisfied and find, on the balance of probabilities, that nuisance is established.

596. As appears from the audio recordings, the plaintiffs' evidence and that of their experts, T1 does not cause a nuisance to the plaintiffs. However, I hold that T2 causes a nuisance to Ms. Webster and Mr. Rollo and also caused a nuisance to the Carty-Shortens while they lived at NF.

597. While the WTN is liable to annoy during the working day, it does not substantially interfere with the plaintiffs' enjoyment of their property. This is because, although there will still be some intrusion, AM is likely to be less prevalent due to meteorological conditions and further it is reasonable to expect that during this time the occupants of NF and HH would be working and further that ambient noise will assist in masking the WTN. Although this is a narrow judgment call, I therefore find that the noise can reasonably be tolerated and/or masked during working hours.

598. On the other hand, I find that the noise from the turbine poses a nuisance to the plaintiffs in the evenings and indeed at weekends (in other words during quiet waking hours) when one could expect to be enjoying recreation in the garden and/or peace in one's dwelling. Although one is more likely to be spending time outside during the summer months, one should also be able to do so during the winter months.

599. Equally, I have no hesitation whatsoever in finding that the WTN poses a nuisance at night (in other words during night hours) when a quiet environment is at a premium. Although it is more likely that windows will be closed in winter one should, if one chooses to be, able to open windows for ventilation at night. It is unreasonable to expect occupants of a house to have to sleep with windows shut in an attempt to mitigate unreasonable WTN. In any event, as a result of its characteristics, the WTN-and associated vibrations-is an unreasonable inference even when the windows are shut.

600. I also find that in spring and autumn the shadow flicker caused by the turbines is intrusive and unpleasant. Whilst this is not in and of itself sufficient to constitute nuisance, this shadow flicker is wholly avoidable with inexpensive mitigation measures. Such mitigation should long since have been put in place and ought now to be actioned.

601. As such, the plaintiffs are entitled to damages for unreasonable interference with the enjoyment of their properties (but not to damages for personal injuries, as to which see below). The measure of such damages is accepted by both parties as being for module 2. The plaintiffs argue that nuisance has been established and that the defendant has not suggested any mitigation measures. As such the plaintiffs argue that they are entitled to a permanent injunction as of right to restrain the nuisance. However, I accept the defendant's argument that whether an injunction ought to be granted and if so the terms of such injunction is for module 2. Likewise, the issue of whether the plaintiffs ought to be confined to damages in lieu of an injunction is for module 2.

Issue 11: Does the court accept the defendant's submission that the evidence of Ms. McGinn means that nuisance is not made out in this case?

602. I considered Ms. McGinn's testimony as part of my overall assessment of the evidence in the case. However, in light of the reliance placed by the defendants on Ms. McGinn's evidence, it is convenient to separately explain here my approach to her testimony.

603. As stated above, I accept that the plaintiffs represent *"ordinary person/s with reasonable objective expectations"*. Although I find that Mr. Rollo's reaction to the WTN ultimately became disproportionate by mid to late 2020, this was not the case for the vast majority of the time that he lived beside the turbines. Nor is there evidence that this was ever the case in respect of the other plaintiffs. Further, there was no suggestion that any of the plaintiffs are generally "bad sleepers", hypersensitive to noise or unusually intolerant.

604. The defendant submits that *"Ms McGinn represents an ordinary person with reasonable objective expectations, and, these expectations are not being exceeded by the Defendant herein"*. The defendant argues that this rules out interference with the ordinary comfort and enjoyment of the property of the plaintiffs *"beyond what an objectively reasonable person should have to put up with in the circumstances of the case"* (to quote Henchy J. in *Hanrahan).*

605. Liability in nuisance depends on whether the amenity *of the property* has been unreasonably interfered with. Would ordinary members of society - the putative reasonable person - consider that their amenity is unreasonably impacted by the WTN?

606. Although Ms. McGinn is a *"good sleeper"*, there is no evidence that she is hypersensitive to noise. I fully accept that, in everyday parlance, Ms. McGinn is a reasonable person - indeed she struck me as such. However, the question is whether, in her response to the WTN, Ms. McGinn represents the putative objectively reasonable person, which as a legal construct, is a different issue.

607. The plaintiffs rely on aspects of Ms. McGinn's evidence which they contend demonstrate that, even from her perspective, the WTN interferes with her comfort and enjoyment of NF. The WTN is "*pretty obvious*". It makes a "*whoomph*" noise as the blades spin that can generally be heard all the time, both externally and internally. As a result of the WTN, Ms. McGinn takes longer to fall asleep. WTN wakes her from her sleep, albeit only occasionally. Ms. McGinn has made a conscious effort to ignore the WTN and is afraid that if she focussed on it, the noise would "*get in on [her] more*". All of this is indicative of some degree of "*interference with*" Ms. McGinn's "*ordinary comfort and enjoyment of the property.*"

608. The defendant relies upon other aspects of Ms. McGinn's evidence. Although the WTN kept her awake on her first night in the house, this was the loudest night she experienced it. She likes the master bedroom in NF and is "*sticking with it*". Ms. McGinn gave evidence that she has either got used to the noise or ignores it and that she did not regret buying NF (albeit that her view is that she purchased NF for a lower price which reflected the presence of the turbines). The defendant places significant emphasis upon the following extract from Ms.

McGinn's cross-examination:

> *Q. Yes. So you have effectively habituated to it, and it doesn't seem, just from what you have said, to be creating a terribly great problem for you in your enjoyment of the property? A. In general, no.*

609. Despite her answer to this particular question, in light of the general tenor of Ms.

McGinn's evidence, the submission that the WTN *"does not adversely affect Ms McGinn's enjoyment of the property"* goes too far. Ms. McGinn has clearly made a conscious and deliberate effort to ignore the WTN and, to that extent, she has habituated to it. Such coping strategy is necessary because the WTN is audible both outside and inside her home. The very need for such a coping strategy suggests some level of interference with the comfort and enjoyment of NF. Despite this, Ms. McGinn is prepared to *"put up with"* the WTN.

610. However, as the defendant says, the test is objective. Whether or not interference by way of noise is beyond *"what an objectively reasonable person should have to put up with"* will depend on the objective nature of the noise. The individual experience of particular occupants of the relevant property - past or present - whilst relevant, is not determinative.

611. In so far as coping strategies are concerned, one must assess whether it is reasonable to expect occupants of a property to deploy such coping strategies, and of course whether, if reasonable, such coping strategies are likely to be effective or ineffective for the putative reasonable person. None of this can be determined solely from the individual perspective of either Ms. McGinn or the plaintiffs themselves.

612. Ms. McGinn is not a litigant in the case and her evidence is of course more impartial than that of the plaintiffs. She also lives in one of the affected properties unlike Ms. Doran

(albeit that the latter lives in the locality). Ms. McGinn's evidence is therefore non-partisan and relevant. As part of the overall assessment, the court must therefore pay careful attention to her evidence.

613. Overall, although there are features of Ms. McGinn's evidence which can be said to support either party's case, in the round, her depiction of the WTN is undoubtedly less negative than the evidence of the plaintiffs. The point however is that such dichotomous thinking - in which only the evidence of Ms. McGinn or that of the plaintiffs can be accepted - is somewhat simplistic. Despite their superficial discordance, both sets of evidence can be and, to my mind are, simultaneously, true.

614. It is perfectly plausible that a reasonable person - in the lay sense of the term - would be prepared, for their own reasons, to put up with a particular noise even though it is objectively unreasonable. Indeed, I imagine that this occurs reasonably regularly. I find that, for her own reasons, Ms. McGinn is prepared to put up with noise that, objectively speaking, she should not have to put up with. I find that, although she is a reasonable person (in everyday parlance), in her reactions to the turbine, Ms. McGinn does not represent the putative objectively reasonable person. I hold that the reaction of such an objectively reasonable person would be akin to that of the plaintiffs.

615. The assessment of whether the noise is an unreasonable interference with amenity is not a numbers game; it is an exercise in judgment in which the court must consider the totality of the evidence. This includes that of Ms. McGinn, Mr. Brazil and the defendant's acoustic, medical and planning experts. It also includes that of the plaintiffs, Ms. Doran and the plaintiffs' acoustic, medical and planning experts. Further, the court must consider the audio recordings of the noise on site (and the associated graphs) and the evidence gained on its site visit. The court must also consider guidance concerning the appropriate noise measurement techniques and the features of WTN thought to contribute to the annoyance levels. Ms.
McGinn's reaction to the noise is undoubtedly of relevance to the issues in the case. But the court would be falling into error were it to conclude that the evidence that she is prepared to put up with from WTN outweighs the other evidence in the case which in my view established that, objectively speaking, the WTN is intolerable and unreasonable.

616. It is reasonable to expect people to be tolerant and to cope as best they can with the vicissitudes of living beside a turbine for which permission is granted. If, judged objectively, the noise can be ignored and effectively habituated to, then the noise in unlikely to be adjudged a nuisance. However, there will be circumstances in which, although some people will be prepared to deploy coping strategies to tolerate the noise, the fact remains that the character of noise is such that it is unrealistic to expect that such strategies will, in the main be effective or successful. Having regard to the totality of the evidence and to my above analysis of the WTN under the DEFRA criteria, I find that this point has been well passed in the present case. The WTN causes a serious adverse noise impact exceeding reasonable tolerability by a substantial margin.

Concluding remarks on nuisance

617. The Defra Guidance recognises that the emission and propagation of WTN is often strongly dependent on meteorological conditions, investigation of statutory noise complaints should therefore include detailed measurement and recording of the windspeed and direction, rainfall, temperature and relative humidity simultaneously with any noise observations or measurements. The plaintiffs' experts did not adhere to this aspect of the Defra Guidance. Their view is that their data clearly establishes unreasonable noise impact and that it is for the defendant to investigate the cause of this and the possibility of mitigation measures.

618. I have some sympathy for the defendant's frustration at this failure to identify the prevailing conditions under which adverse impact arises. Presently, the court has data from the defendant correlating windspeeds with noise levels (at certain wind directions) and data from the plaintiffs illustrating the features of the WTN complained of. However, there is no correlation between the two.

619. My sympathy for the defendant is not unlimited. The defendant undertook several weeks of monitoring at both NF and HH in 2017 which Mr. O'Reilly used to populate the planning compliance graphs. In addition, the defendant has long since been furnished with all of MAS's audio recordings (and the associated graphs) detailing the noise impact complained of. If the defendant had wished to further analyse either set of data, as against IOA RM or otherwise, it could presumably have done so. It could also have used the SCADA data to correlate periods of adverse impact identified by the plaintiffs' experts with speed of rotation, blade pitch, windspeeds and other meteorological conditions.

620. The plaintiffs' experts do not control the operation of the turbine or have real time access to the SCADA data for simultaneous correlation with noise observations as required by the Defra Guidance. Nor could the plaintiffs' experts secure turbine shut down to ascertain potential exceedance of WTN over background noise at a range of winds speeds. Such constraints might explain why modern planning conditions require the wind turbine operator, and not the complainant, to carry out noise monitoring in response to a WTN complaint in order to identify the conditions under which the alleged nuisance presents and, more importantly to devise appropriate mitigation measures.

621. I am satisfied that it is not necessary for the plaintiffs to establish the precise conditions under which nuisance arises in order to succeed on liability. Rather, this will inform module 2 which will determine the appropriate remedy for nuisance.

622. One cannot presently know why this particular turbine is causing WTN nuisance. Counsel for the defendant emphasised that this Court should turn its face against any finding which suggests that all turbines within 500 metres of a residence are likely to cause nuisance. I make no such finding. It is clear that although planning guidance since WEDG 2006 has recommended a separation distance of at least 500m, this is primarily to combat visual intrusion and not noise intrusion. Although it is quite possible that proximity to the plaintiffs' homes is part of the problem here there are many other factors which may contribute to the particular characteristics of this WTN. I have in mind factors such as the relative height of T2 as compared to the plaintiffs' homes, the fact that these homes are in a sheltered location/wind shadow, the blade pitch of T2, inflow turbulence from T1, unanticipated wake effects and the many acoustic and meteorological factors associated with thump AM, which presently are not well understood.

623. On the other hand, as discussed above, it is reasonable to conclude that adverse impact occurs at windspeeds/speeds of rotation in excess of those which were prevalent at the time of the court's visit. Indeed, although absolute sound levels are not a reliable determinant of nuisance, there is a strong link between WTN sound levels, and the annoyance caused by other characteristics of the WTN. Even if high value AM is present on a fairly sustained basis, I believe that it is at higher speeds of rotation that this characteristic comes to the fore. This impression is endorsed by the ETSU Review which concludes that the interaction between absolute sound levels and AM value influences response. In other words, the louder the WTN, the more likely the AM is to annoy. Further, although thump AM is slightly different - in the sense that it is experienced, a vibration as well as heard- rapidly turning rotors is a common denominator in the plaintiffs' descriptions of its impact.

624. Albeit that this will potentially require to be re-visited in module 2, it is highly likely that the worst features of this WTN are associated with at least moderately higher speeds of rotation. It is also highly likely that features often coincide with the most noise sensitive periods of the day (early morning, evening and nighttime). However, it is not presently possible to be more specific than that.

625. Due to the complex range of interrelated causative factors, identifying the conditions under which unreasonable adverse impact presents and discerning mitigatory measures will be an iterative exercise. Such an exercise is uniquely unsuited to the adversarial arena. As Mr.
Carr states, mitigation of WTN nuisance is often a process of trial and error. This is best approached on site and not in a court room. A court order is an unsuitably blunt instrument with which to tailor a solution to address the WTN nuisance without unnecessarily inhibiting the operation of T2.

626. The defendant cannot rest its laurels on the proposition that the generation of renewable energy is a socially valuable activity which it is in the public interest to continue. There is not a binary choice to be made here between the generation of clean energy by the wind farm, and a good night's sleep for its neighbours. It should be possible to achieve both.

627. However, effective mitigation will require a far more constructive attitude than has thus far pertained in this case. In their insistence that planning compliance negates nuisance, the defendant has exhibited an unwarranted rigidity in its response to the plaintiffs' complaints. On the other hand, the plaintiffs must realise that, in light of its social utility, this court will be reluctant to order the shutdown of T2, even just at sensitive periods (early morning, evening and nighttime) if a more tailored solution can ameliorate the nuisance.

628. I set out the above as a prelude to the exercise of my inherent jurisdiction to direct the parties, in advance of module 2, to engage in mediation in relation to appropriate mitigation measures and with a view to resolving all outstanding issues between them.

I am conscious that mediation has not thus far proved fruitful. However, with the benefit of this court's judgment, it is reasonable to expect that mutually acceptable mitigation measures are capable of being agreed.

Issue 12: Are Mr. Rollo and Ms. Webster entitled to an award of damages for personal injuries?

629. I am satisfied on the balance of probabilities that Mr. Rollo has suffered personal injury in the form of a recognisable psychiatric illness. I also find that this injury was caused by the sleeplessness caused by the WTN, and so caused by the nuisance in suit.

630. The following matters arise:-

- The impact of the Personal Injuries Assessment Board Act 2003 ("the 2003 Act") on the claim to damages for personal injuries
- The recoverability of damages for pure psychiatric injury unaccompanied by physical injury

Application of the Personal Injuries Assessment Board Act 2003

631. The defendant states that this aspect of the plaintiffs' claim is in breach of s. 12 of the 2003 Act and out be struck out.

Section 12 of the 2003 Act provides:-

"Unless and until an application is made to the [Personal Injuries Assessment Board] *under section 11 in relation to the relevant claim and then only when the bringing of those proceedings is authorised..., no proceedings may be brought in respect of that claim."*

632. Section 3 applies the 2003 Act to civil actions which, in turn, are defined by s. 4 as *"an action intended to be pursued for the purpose of recovering damages, in respect of a wrong, for personal injuries, or for both such injuries and damage to property"*.

633. As originally instituted, these proceedings sought both injunctive relief and damages for nuisance together with injunctive relief pursuant to s. 160 of the Planning and Development Act 2000 (as amended). No claim to damages for personal injuries was originally advanced. It is common case that at inception, the proceedings were not a civil action.

634. After Mr. Rollo's diagnosis with a major depressive disorder, the plaintiffs notified the defendant by letter dated 21st December, 2020 that they intended to include a claim for personal injuries. The plaintiffs took no step to amend the pleadings until very shortly prior to the trial.

635. The plaintiffs' application to amend the proceedings was objected to by the defendant, *inter alia*, on the basis that it infringed s. 12 of the 2003 Act. On the authority of *Clarke v. O'Gorman* [2014] 3 IR 340, I determined that s. 12 of the 2003 Act did not operate as a jurisdictional bar to the initiation of personal injury proceedings (or to the amendment to include such a claim). The application of the 2003 Act was rather a matter for the defendant to plead in its defence. Accordingly, I allowed the amendments sought and the defendant duly delivered an amended defence pleading, *inter alia*, that, as the necessary PIAB authorisation had not been obtained, the claim ought to be struck out.

636. Relying upon *Clarke v. O'Gorman*, the defendant maintains that, even if the claim to damages was based on nuisance, the term "civil action", as defined by s. 4(1) of the 2003 Act does not refer only to the particular cause of action pursued. It is a description of the type of damage suffered as a result of the facts giving rise to the cause of action. Civil actions for personal injury are, therefore, not limited to those wrongs in which proof of personal injury is a necessary element of the cause of action. As such an action in nuisance is still capable of being a civil action within the meaning of the 2003 Act where the remedy sought includes damages for personal injuries. Therefore, a claim to nuisance which, *inter alia*, advances a claim to damages for personal injuries cannot proceed without the relevant authorisation.

637. In response, the plaintiffs invoke the *caveat* set out at s.4(b)(i) of the 2003 Act which exempts an action intended to be pursued in which, in addition to damages for personal injuries, it is *bona fide* intended and not for the purpose of circumventing the operation of the Act to claim damages or other relief in respect of any other cause of action. The plaintiffs argue that the proceedings are intended to claim relief in respect of another cause of action, namely both the underlying nuisance claim and the claim to injunctive relief pursuant to s. 160.

638. If the plaintiffs' only cause of action - whether based in nuisance or otherwise - advanced a claim to damages for personal injuries, then there would be merit in the defendant's argument. However, this is not the case. Here the plaintiffs also pursue a s. 160 application. It has not been submitted that the plaintiffs' application for injunctive relief pursuant to s. 160 is advanced for the purposes of circumventing the operation of the 2003 Act. Indeed, both parties called extensive evidence on the issue of planning compliance. It is not, of course, necessary for this additional cause of action to succeed in order for the proceedings as a whole to benefit from s. 4(b)(i). Accordingly, I reject the defendant's submission that the claim to personal injuries must be struck out as being in breach of s. 12 of the 2003 Act.

May damages for personal injury may be sought in the context of a claim to nuisance?

639. The defendant argues that nuisance is a property-based tort which imposes liability in respect of a substantial interference in the enjoyment of land and that damages for personal injury may not be awarded.

640. This is established law in England and Wales. In *Hunter v. Canary Wharf*, [1997] AC 655 where a claim for nuisance was brought by residents who claimed that construction work had been interfering with their television signal strength, Lord Hoffman gave the leading judgment and stated :-

> *"In the case of nuisances "productive of sensible personal discomfort," the action is not for causing discomfort to the person but, as in the case of the first category, for causing injury to the land. True it is that the land has not suffered "sensible" injury, but its utility has been diminished by the existence of the nuisance. It is for an unlawful threat to the utility of his land that the possessor or occupier is entitled to an injunction, and it is for the diminution in such utility that he is entitled to compensation."*

641. Lord Hoffman suggested that any personal injury claim should be pursued through negligence, rather than through nuisance.

642. As an adjunct to the principle that damages for personal injuries were not payable, Lord Hoffman also found that damages are not increased by there being more than one occupier.

> *"I cannot therefore agree with Stephenson L.J. in* Bone v Seale [1976] 1 W.L.R. 797 *when he said that damages in an action for nuisance caused by smells from a pig farm should be fixed by analogy with damages for loss of amenity in an action for personal injury...*
> *There may of course be cases in which, in addition to damages for injury to his land, the owner or occupier is able to recover damages for consequential loss. He will, for example, be entitled to loss of profits which are the result of inability to use the land for the purposes of his business. Or if the land is flooded, he may also be able to recover damages for chattels or livestock lost as a result. But inconvenience, annoyance or even illness suffered by persons on land as a result of smells or dust are not damage consequential upon the injury to the land. It is rather the other way about: the injury to the amenity of the land consists in the fact that the persons upon it are liable to suffer inconvenience, annoyance or illness."*

643. It appears that this has not been the approach taken in jurisdiction. In *Patterson v. Murphy*, [1978] ILRM 85 *("Patterson*") blasting on the defendant's land caused physical harm to the plaintiffs' residence. The plaintiffs were awarded damages for the repair of the property, but it was also held that general damages were payable to each of the plaintiffs separately for annoyance, discomfort, inconvenience and mental distress.

644. More importantly, some of the discussion in *Hanrahan*, appears to run directly counter to the proposition that a personal injury claim should be pursued in negligence, rather than through nuisance. The Supreme Court, per Henchy J., noted that although originally advanced in both negligence and nuisance, the claim had centred on nuisance and would be determined accordingly. Having concluded that the defendant was liable in nuisance, the court then went on to hold that its environmental pollution has caused Mr. Hanrahan to suffer damage to his health - in the form of lung disease.

645. The question of whether, as a matter of principle, damages for personal injury were recoverable as a property based tort does not appear to have been argued in *Hanrahan*. Rather, the court's consideration focused upon causation. However, there is no suggestion that the Supreme Court viewed damages for personal injuries as restricted to negligence and in terms of outcome, the case was remitted to the High Court for the assessment of damages.

646. The plaintiffs submit that irrespective of whether the matter was argued in *Hanrahan*, I am bound to apply that authority if satisfied that the interference found to constitute the nuisance in this case is causative of personal injuries. In so far as concerns this *"property based tort"* ground of objection, I accept that this is so.

647. However, it seems to me that the present case is distinguishable from *Hanrahan* as Mr. Rollo does not allege personal injury in the form of damages to his physical health but rather personal injury comprising pure psychological injury. The entitlement to damages for pure psychological injury unaccompanied by physical injury has always been treated by the courts as somewhat *sui generis*. As the recoverability of damages for this type of injury was not in issue in *Hanrahan*, I must therefore consider separately whether different considerations might apply.

Does *Kelly v. Hennessy* apply to all claims for damages for pure psychiatric injury? 648. The defendant maintains that there is no basis for recovery of damages for purely psychiatric injury in this jurisdiction save when occasioned by a sudden calamitous event. The defendant relies upon *Warren Harford v. Electricity Supply Board* [2021] IECA 112. In that case, the Court of Appeal, per Noonan J., considered a claim brought by a network technician employed by the defendant for damages for posttraumatic stress disorder occasioned as a result of his apprehension that he had narrowly missed being electrocuted and suffering death or very serious injury in the course of his work.

649. It is important to emphasise that the claim in *Harford* was not of course for the tort of nuisance but negligence. Specially, it was a claim for nervous shock. It was therefore common case that the plaintiff had to satisfy the 5 criteria set out in *Kelly v. Hennessy* [1995] 3 IR 253, in which, Hamilton C.J. in a judgment in which Egan J. concurred, held that:

> *"1. ...a plaintiff must prove that he or she suffered a recognisable psychiatric illness...*
>
> *2. A plaintiff must establish that his or her recognisable psychiatric illness was 'shockinduced'...*
>
> *3. A plaintiff must prove that the nervous shock was caused by a defendant's act or omission...*
>
> *4. The nervous shock sustained by a plaintiff must be by reason of actual or apprehended physical injury to the plaintiff or a person other than the plaintiff.*

> 5. *If a plaintiff wishes to recover damages for negligently inflicted nervous shock, he must show that the defendant owed him or her a duty of care not to cause him a reasonably foreseeable injury in the form of nervous shock.*
>
> *...It is not enough to show that there was a reasonably foreseeable risk of personal injury generally. Deane J. stated in Jaensch v. Coffey,* 155 C.L.R. 540*:*
>
> *'a duty of care will not arise unless risk of injury in that particular form (i.e. psychiatric injury unassociated with conventional physical injury) was reasonably foreseeable.'"*

650. In *Harford*, although, satisfied that the plaintiff had suffered a recognisable psychiatric illness, the court was not satisfied that he fulfilled either the second or fourth criteria in *Kelly v. Hennessy*. In particular, the Court of Appeal was not satisfied that the plaintiff's injury was *"shock induced"*.

651. The defendant accepts that Mr. Rollo's claim to damages for psychiatric injury is not a claim to nervous shock *per se*. However, it relies upon para. 34 of the judgment in *Harford* in which Noonan J. states *"Thus, psychiatric injury is not compensable, even though reasonably foreseeable, unless it is accompanied by physical injury or alternatively is the result of "shock"."*

652. The defendant therefore submits that, in this jurisdiction, damages for pure psychological injury can never be recovered outside the boundaries of a nervous shock claim. Thus articulated, the defendant's submission overreaches. It is clear that damages for negligence causing a recognisable psychiatric illness have been awarded beyond the strict confines of nervous shock cases. For example, in the case of employer's liability, damages may be awarded for psychiatric injury occasioned as a result of workplace bullying or occupational stress.

653. However (although once again in the negligence context), it is undoubtedly the case that the courts have been extremely cautious in expanding the boundaries of cases in which damages will be awarded for pure psychiatric injury. In the negligence context, control mechanisms on the recovery of such damages have been developed over time to restrict both the limits of the duty of care and the limits of the types of damage recoverable. The second of these considerations – the limits of the types of damage recoverable - is in my view relevant here. In this respect, the issue of reasonable foreseeability has been key to the question of remoteness and to the consequent imposition of liability in cases of pure psychological injury. I will now consider the approach adopted to foreseeability of pure psychological injury in negligence before turning the question of foreseeability of both physical injury and pure psychological injury in nuisance.

The role of foreseeability

The role of foreseeability of pure psychological injury in the tort of negligence

654. In *Fletcher v. Commissioner for Public Works* [2003] 1 IR 465 the Supreme Court considered whether, and if so, to what extent and subject to what limitations an action may lie in negligence where the sole injury is a psychiatric condition resulting from fear of contracting an illness (in that case, asbestos related disease) in the future, as a consequence of the admitted negligent acts and omissions of the defendant.

655. Keane CJ. emphasised the requirement of foreseeability in an action in negligence in which the plaintiff claimed damages for pure psychological injury:

> *"The issue, accordingly, which this court has to resolve is whether the plaintiff was entitled to recover damages for the impairment of his "mental condition" which, according to the evidence of the psychiatrist, has resulted from his exposure to the risk of contracting mesothelioma, a risk which, it is beyond argument, was created by the failure of the defendants to take the precautions which a reasonable employer would have taken to ensure that he was not exposed to any such risk.*
>
> *That in turn depends, initially at least, on whether the consequences which have ensued for the plaintiff ought reasonably to have been foreseen by the defendants.*
>
> *It is unnecessary , in my view, to arrive at any conclusion as to whether this is so because, if the personal injury was not foreseeable, liability in negligence cannot arise or because, if it was not foreseeable, the damage was too remote. In either case, reasonable foreseeability is a precondition to liability. The question as to whether those consequences were reasonably foreseeable cannot, of course, be answered by assessing the state of knowledge of the defendants at the material time. The test is an objective one, i.e., as to whether a reasonable person would have foreseen that the consequences suffered by the plaintiff might be the result of the defendant's want of care."*(Emphasis added)

656. In his concurring judgment, Geoghegan J. noted that *Kelly v. Hennessy* did not govern the claim as it should only be taken to relate to "aftermath damages". Given that the courts in all common law jurisdictions show caution in relation to the circumstances in which damages for psychiatric injury could be recovered, Geoghegan J. stated that it was important to consider each kind of liability situation separately. Unless, therefore, one puts all psychiatric injury on an exact par with all physical injury, it makes little or no sense to regard a nervous shock case as being analogous to a fear of disease case. Therefore, in approaching the fear of disease case, Geoghegan J. regarded the court as being in virgin territory.

The role of foreseeability of (physical) personal injury in the tort of private nuisance **657.** There has been no express consideration in this jurisdiction of the requirement of foreseeability of personal injury in a nuisance claim.

658. This may be because foreseeability has generally been analysed in a negligence context as being one of the components of the imposition of a duty of care. As liability in nuisance does not require want of care, it may at first blush be doubted that foreseeability is a necessary ingredient for recovery of damages for nuisance.

659. However, foreseeability has a role to play, not only in the imposition of a duty of care, but also more generally in tort in relation to remoteness of damages. The dual relevance of foreseeability was referenced by Keane CJ. in the extract quoted above: " *if the personal injury was not foreseeable, liability in negligence cannot arise or because, if it was not foreseeable, the damage was too remote.* ". Whilst I fully appreciate that this consideration was in the context of negligence, foreseeability - in the sense of remoteness - is a more general ingredient in the law of tort.

660. Returning to *Hanrahan,* on the facts of that case, it is unsurprising that foreseeability was not separately analysed. The plaintiffs (and many others in the vicinity) had complained of the emissions for years. Once causation was held to have been established, damage to health may be seen as a wholly foreseeable impact of the particular nuisance in issue, i.e. toxic emissions. In a less stark case, foreseeability of personal injury is likely to require closer examination - even in the case of physical injury. However, it is not necessary to consider this further as this case does not involve physical injury of the kind considered in *Hanrahan* but pure psychological injury which, as I say, has always been treated as *sui generis.*

The role of foreseeability of pure psychological injury in the tort of private nuisance

661. It is clear that foreseeability of damages *"of that particular kind"* is an essential precondition to recovery of a claim for pure psychiatric injury arising from a defendant's negligence. However, in considering Mr. Rollo's claim to pure psychiatric injury arising from the defendant's noise nuisance, this court is in virgin territory unguided by any Irish precedent.

662. It is important at the outset to delineate the ingredients of nuisance from those of negligence. The former tort unlike the latter does not depend on the establishment of breach of duty of care. There is in my view no room for arguing that liability in nuisance (as opposed to negligence) turns upon foreseeability. In *Hanrahan,* Henchy J. stated:

> *It is sufficient if it is shown as a matter of probability that what they complain of was suffered by them as occupiers of their farm in consequence of the way the defendants ran their factory...*
> *In this case the plaintiffs' main complaints, namely that the emissions from the factory damaged their health and that of the livestock on the farm, are of so pronounced and serious a nature that no question of nicety of reaction arises. Either those complaints were caused by the emissions from the factory or they were not. If on the balance of probabilities they can be said to derive from factory emissions, then the case for nuisance has been made out.*

663. Therefore, foreseeability is not relevant to the establishment of liability in nuisance. However, as emphasised above, foreseeability plays a dual role and *Hanrahan* does not analyse its second iteration. This is that, whilst, foreseeability of the risk of harm may be irrelevant in establishing liability in nuisance, foreseeability of the type of harm suffered is nonetheless relevant in considering the issue of remoteness of a particular category of damages.

664. This accords with common sense. If a plaintiff in a negligence action may claim damages for pure psychological injury only where they can prove foreseeability of that particular kind of injury, it is difficult to see why a plaintiff should be in a stronger position to claim such damages for interference with the enjoyment of land which has occurred without any negligence or want of care?

665. As a matter of principle and practicality, I am of the view that, in the tort of nuisance, reasonable foreseeability of pure psychiatric injury is a precondition to the award of damages for such injury. The test is an objective one, i.e., as to whether a reasonable person would have foreseen that the consequences suffered by the plaintiff might be the result of the nuisance alleged.

666. In analysing whether this test of remoteness has been met one must distinguish between mental distress and psychological injury. Damages for mental distress may be awarded - as in *Patterson* - as an aspect of damages for loss of amenity. It is in my view, wholly foreseeable that constant and intrusive noise will lead to mental distress – annoyance, frustration and lack of calm. It is also foreseeable that it will lead to loss of sleep, irritability, loss of concentration etc. It is not however generally foreseeable that a recognisable psychiatric illness would ensue.

667. There is likely to be significant overlap as between the damages for loss of amenity and diminished enjoyment on the one hand, and any damages likely to be awarded to Mr. Rollo for pure psychiatric injury. The former includes damages to reflect inability to relax in the property and sleep disturbance. Although it may seem illogical to compensate the plaintiffs for mental distress but not for psychological injury, this is because the former can be accommodated in loss of amenity and the latter cannot.

668. Although this was not determined in *Hanrahan*, I would tend to the view that foreseeability is also relevant in a claim to damages for (physical) personal injury. However, even if I am wrong in this, the approach of the courts to pure psychological injury has always been to proceed with caution and, most particularly to insist on a form of supercharged foreseeability in which not just injury but psychological injury specifically must be foreseeable. To proceed otherwise in this case would not be in harmony with the courts' cautious approach to damages for pure psychological injury. In short, I believe that foreseeability is a separate ingredient in a claim for pure psychological injury caused by nuisance.

Conclusions on issue 12.

669. In summary, on this issue, the relevant questions and my answers are as follows:

1. **Should the claim to damages for psychiatric injuries be struck out as being in breach of the 2003 Act?**

   No.

2. **Is foreseeability necessary to establish <u>liability</u> in nuisance?**
   No. This was not expressly addressed in *Hanahan* but seems to me to have been impliedly excluded. As a matter of first principles and given that nuisance does not depend upon the establishment of a duty of care and its breach, foreseeability of the risk of harm is irrelevant in establishing liability in nuisance.
3. **Can general damages for personal injuries be recovered for nuisance given that same is a property based tort?**
   The question of whether damages for personal injury were recoverable for the tort of private nuisance does not appear to have been argued in *Hanrahan.* It will fall to the Supreme Court in an appropriate case to consider whether, as a matter of principle, damages for personal injuries should be awarded for a property based tort.
   However, one can say that the <u>outcomes</u> of *Hanrahan* and *Patterson* suggest that the answer to this question is in the affirmative. It seems that such general damages can include compensation for loss of amenity, property damage, damage to capital value, loss of rent, temporary relocation costs, damage to human, animal health and plant life, damages for diminution in enjoyment, (which can include e.g. sleeplessness, lack of ability to rest and enjoy the property and mental distress).
4. **Is foreseeability of the type of harm necessary to establish liability for general damages for personal injuries in nuisance?**
   In my view, yes. Although this issue was not the subject of argument or analysis in *Hanrahan,* I take the view that whilst foreseeability is generally irrelevant in determining whether liability for nuisance is established, foreseeability of the type of harm remains relevant in determining whether the type of injury claimed is too remote.
5. **Even if I am incorrect at 3 above, is foreseeability of the type of harm suffered nonetheless a prerequisite to recovery in the case of pure psychological injury?**
   Yes.

669. In this case, I am not satisfied that psychiatric injury was reasonably foreseeable. Therefore, echoing Noonan J. in *Harford,* imposing liability for such injury in this case would involve an extension of the existing law in this jurisdiction of the circumstances in which an award is made for such injuries. This would ultimately be a matter for the Supreme Court.

<u>Issue 13: is the defendant guilty of negligence?</u>

670. The case in negligence was not in truth pressed with any real vigour and can be briefly dealt with.

671. It seems that the primary evidence relied upon to establish negligence is Mr. Mayer's opinion that the defendant ought to have recognised at the time of installation that there was a significant risk of unreasonable WTN impact.

672. As stated above, I am not satisfied as to Mr. Mayer's expertise to give this opinion evidence. In any event, this evidence provides far too vague a basis for a finding of breach of duty of care. The plaintiffs have not detailed the kinds of investigations which the defendant ought to have carried out prior to applying for or implementing the planning permission. No evidence has been given as to industry standards in this regard. For the avoidance of doubt, I wholly reject any suggestion that it can be considered negligent to locate a wind turbine within 500 meters of a residence or that in doing so, one ought to reasonably anticipate a noise nuisance.

673. Post implementation, I am of the view that the defendant adopted an inflexible and overly rigid attitude towards the plaintiffs' complaints. This however does not amount to a breach of duty of care.

674. Although the plaintiffs complained about the WTN in 2017, the defendant was not put on notice of the severe difficulties experienced by Mr. Rollo as a result of his sleep disturbance until this psychiatric condition had already emerged. There was no intervening occasion on which a duty of care could have arisen.

675. As neither the parameters of any duty of care nor the specifics of any breach thereof have been identified, the plaintiffs cannot succeed in a claim for negligence.

<u>Issue 14: Have the plaintiffs made out a case for relief under Section 160?</u>

Alleged breaches of the planning permission

676. Arising from a report of Ms. Mulcrone, the plaintiffs' plead that the defendant has breached the terms of the planning permission and seeks an injunction pursuant to s. 160 of the 2000 Act. The defendant's response to this case was based on the evidence of Mr. Lawlor.

677. As I explain above, compliance with the planning permission is part of its defence to the nuisance action and, in that context, the defendant bears the onus of proving such compliance.

678. The position is arguably slightly different in the context of the s. 160 application. In such applications, the usual position is that the onus of proving compliance with the relevant planning permission would be on the developer. In the present case, I have concluded that total operational noise exceeds the condition 15 limits and further that the defendant has not demonstrated that this exceedance may be explained by background noise. In other words, the defendant has failed to discharge the onus of proving compliance with planning permission.

679. Does this mean that the plaintiffs can and should succeed in their application for a s. 160 injunction? I would answer this question in the negative.

680. There is generally no provision for exchange of pleadings in a s. 160 application. Notwithstanding this, in the present case, the plaintiffs fully pleaded each and every aspect in which they contended that the defendant had beached the planning permission (with each of which I deal below). No case was advanced in pleadings - or indeed in expert evidence - that the WTN exceeded the condition 15 permission limits. Likewise, as neither party had apparently directed their mind to the correct interpretation of condition 15 of the permission, it goes without saying that no case was advanced to the effect that the WTN exceeded the permission limits as interpreted above. Therefore, whilst it is not in general permissible for a defendant to pray in aid a pleading point as a ground for resisting a s.160 injunction, this case is an exception.

681. Granting a s.160 injunction at this stage for non-compliance with condition 15 would in my view perpetuate a significant unfairness upon the defendant. In the present case, the defendant had no prior notice that the plaintiffs would allege breach of the condition 15 limits and prepared its case on that basis. In addition, because the correct interpretation of the permission only arose for the first time during the course of trial, the defendant also had no real opportunity to carry out appropriate background noise studies to demonstrate whether the exceedance of total operation noise over the permission limits - when correctly interpreted - may be attributed thereto. This also means that the court has not been able to properly weigh and apply many of the important discretionary factors which would usually influence the grant or withholding of relief pursuant to s. 160. For example, this court has no evidence as to the extent of any breach of the permission limits. Is the exceedance minor or technical; or is it significant? None of this is yet established or even argued as of yet.

682. For all of these reasons, I do not believe it is feasible for this court to presently attempt to adjudicate upon whether the exceedance of total operational noise over the permission limits is such as to merit an order pursuant to s.160. Furthermore, remedy is in any event for module

2.

683. I will therefore confine this analysis to the breaches advanced in the plaintiffs' pleadings and evidence.

684. Ms. Mulcrone contends that the defendant is in breach of conditions 1, 10 and 15.[61]

Condition 1

685. Condition 1 required *"the development to be carried out strictly in accordance with the plans and particulars lodged with the planning application except.... as otherwise required by the conditions of (the) permission"*. The stated reason was "*to ensure that the proposed development strictly accords with the permission and that effective control is maintained"*.

686. Ms. Mulcrone's view is that the defendant has breached condition 1 because the grid connection did not follow the indicative route set out in the planning application documents but was secured via a different substation (which at the time of the initial planning application was neither built nor permitted).

[61] Although breach of condition 9 was initially alleged, this was not proceeded with.

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687. In my view, the indicative grid connection did not bind the defendant to comply rigidly therewith. It was made clear in the planning application that the proposed route was indicative only and that a firm grid connection offer had not yet been made by ESB networks.

Condition 10

688. It is common case that the laying of underground cables and the construction of overhead transmission lines for conducting electricity would usually be exempted development pursuant to Classes 26 and 27 of Schedule 2, Part 1 of the Planning and Development

Regulations 2001 ("the Regulations"), as amended. However, Article 9 (1) of the Regulations de-exempts such development if same contravenes a condition attached to the grant of planning permission.

689. Condition 10 provides that *"prior to the commencement of the development, planning permission shall be obtained for the erection of power lines to facilitate the connection of the proposed wind turbines to the national grid"*. The stated reason is *"in the interests of proper planning and development"*.

690. The plaintiffs argue that the combined effects of Article 9 (1) and Condition 10 is to de-exempt the grid connection, which is therefore required planning permission. By contrast, the defendant maintains that condition 10 only applies to a grid connection facilitated by overhead powerlines and not to underground grid connection which is in issue here.

691. Ms. Mulcrone's view is that if the planning authority had wished to confine condition 10 to an overground route only, it would have stated this quite clearly. The Oxford dictionary defines *"erection"* as to *"establish or build"*. The definition of *"development"* under the Planning Act comprises works in, on or under land and would therefore catch an underground connection route. Ms. Mulcrone contends that this is a pre-commencement condition, meaning that lawful implementation of the permission is predicated on a second permission for the grid connection, which has not been obtained. This, Ms. Mulcrone classified as a *"very serious breach of the planning code"* rendering the entire infrastructure unauthorised *ab initio*.

692. As pointed out by Mr. Lawlor, the indicative grid connection route in the permission application documents included both overhead and underground elements. In my view, the reference to the *"erection of powerlines"* refers to the overground element only. The words

"erection of powerlines" are more likely to be interpreted by the reasonable person having some knowledge of these matters as referring to overhead powerlines and not to an underground connection. As such, the condition only obliges the defendant to apply for permission in respect of an overground grid connection.

693. In support of her interpretation of condition 10, Ms. Mulcrone relies on four decisions of An Bord Pleanála on s. 5 references in respect of four other wind farms in the locality. In each case, the Bord determined that permission had been required for the relevant grid connection. However, these s. 5 references were determined against a different factual backdrop. Three of the relevant permissions required the developer to apply for permission for a grid connection *simpliciter* (with no reference to overhead or underground connection). Although the condition in the fourth permission also expressly referred to overhead lines, the grid connection for the wind farm in question was via a combination of underground and overground lines/cables. As such, the failure to apply for permission for that grid connection appeared to be in breach of the parent permission irrespective of whether or not same applied only to grid connection by overhead lines.

694. In short, I find that, because in this instance grid connection in this instance was completed wholly by way of underground cables, no enabling planning permission was required.

Condition 15

695. Ms. Mulcrone correctly observed that there is no evidence of assessment of likely noise impact in either the planning application or on the planning authority's file. The only reference to noise is in condition 15 which, after setting out the specific noise limits already discussed, states: "*...In the event that the reviews show that any turbine may have a detrimental impact, mitigating measures shall be proposed and submitted for the agreement of the Planning Authority.*" The stated reason is "*In the interests of residential amenity and the proper planning and development.*"

696. In Ms. Mulcrone's view, the two parts of condition 15 must be read disjunctively. The defendant must comply with the noise limits specified. In addition, even if the WTN complies with the noise limits on the permission, *"reviews"* must be carried out to establish if detrimental impact is shown and, if so, the developer must propose mitigation measures to the planning authority for its agreement.

697. Mr. Lawlor accepts that the condition is poorly worded. Although it provides for "reviews" there is no express statement as to what triggers such review. Nor is there any indication by whom or how frequently such reviews may be requested and/or must be carried out. One would expect that a planning condition such as this would set out a methodology for post completion noise surveys and reporting together with a documented complaints handling process.

698. I cannot accept the plaintiffs' argument that condition 15 must be read disjunctively. This interpretation would render the condition so vague as to be unworkable. In my view, the requirement to carry out reviews and mitigation is triggered by WTN in excess of the condition 15 limits and not by a more general complaint of *"detrimental impact"*. Overall, therefore, I agree with the defendant that if the windfarm is operating in compliance with the noise limits set out in condition 15, the permission does not require the developer to carry out further review or mitigation.

699. In the present case, I have found that the defendant has not demonstrated that the windfarm is operating in compliance with the noise limits set out in condition 15. If noncompliance is born out, this could trigger the condition 15 requirement for reviews, assessment of detrimental impacts and potentially mitigation measures. However, in light of the considerations outlined at para 681 above, I do not view this potential non-compliance as having been fully investigated by the defendant. For that reason, I am not presently prepared to make any order under s. 160 in this regard.

Conclusion on issue 14

700. I am not satisfied that the plaintiffs have made out a case of breach of permission on any of the grounds pleaded. As such, the application pursuant to s.160 must fail.

Independent Noise Working Group

INWG Analysis of WSP Report tled:

A review of noise guidance for onshore wind turbines

WSP report Ref: No. 70081416-001-03-03 PUBLIC dated October 2022 and released 10 Feb 2023

Analysis of the report prepared by WSP for the UK Government Department for Business, Energy & Industrial Strategy (Now the Department for Energy Security and Net Zero)

INWG analysis dated April 2023

INWG Analysis of WSP Report tled:

'A review of noise guidance for onshore wind turbines'

Author: Richard Cox

Contribu ons by: Melvin Grosvenor, Bev Gray, & Susan Crosthwaite

Notes:

Text quoted from the WSP report, website or Linkedin page is shown in blue italics.
Text quoted from other documents is shown in black italics.
INWG comments or statements are shown in red and highlighted in grey

Web links iden fied by 'open here' are provided for convenience to access documents referred to in the text. All documents are in the public domain and we believe that all the websites accessed via these links are safe to use.

Contents

Sec on 1 - Execu ve Summary

The report tled; '*A review of noise guidance for onshore wind turbines*' was released by acous c consultant WSP on their company website on 10 February 2023 with an announcement appearing on their WSP Linkedin social media page, open here. An ini al review of the web site report summary, open here raised some serious concerns regarding the integrity, impar ality and accuracy of this report to Government. As a result, the INWG decided to conduct an analysis of the WSP report.

At 400 pages in length, two or three mes longer than needed, repeve and with an excess of jargon it will dissuade all but the most determined reader to properly evaluate the findings. When we analyse the report, its methodology, authors and invited stakeholders it is concluded this review of ETSU-R-97 is biased with conflicts of interest throughout.

For the evidence review workstream at sec on 3, WSP admit they examined a restricted evidence base and u lised an inferior review methodology that they also admit is subject to a lower level of accuracy and greater risk of bias. There are several important topics that have been dismissed or not properly examined including low frequency noise, uncertainty (tolerances) and alterna ves to ETSU-R-97.

The stakeholder engagement survey at sec on 4 of the report, is arguably the most important workstream within the review. Whereas the engagement objec ves would appear to be reasonable, the implementa on is judged to be deficient and compromised by bias. The survey composi on of the 'by invita on only' stakeholders creates a bias in favour of the wind industry and is par cularly imbalanced as it excludes those with direct experience of living near wind turbines and their representa ves.

The poor LPA response rate of just 9% for the survey must be ques oned as it indicates that something was fundamentally wrong with the way WSP invited LPAs. This 9% rate compares poorly against the 77% rate obtained by the INWG during a similar survey during 2014, open here. However, despite the survey bias and the poor LPA response rate, the findings do provide a useful benchmark for decision makers when considering the future guidance. The top 5 issues by number of respondents from Figure 4-12 and Figure 12-20 are:

- Guidance needs to establish how AM impact should be taken into account
- ETSU-R-97 is outdated and needs to be reviewed: technology and understanding have advanced since publica on
- Difficult, costly or me-consuming to robustly establish compliance/non-compliance
- More / updated guidance on cumula ve assessments is needed
- The ETSU-R-97 principles underlying the limits need to be reviewed

Despite this overwhelming evidence from the stakeholder survey that ETSU-R-97 has failed, WSP chose to include the wri en statement from two professional associa ons (see pages 162 and 163), which recommended to con nue with the use ETSU-R-97. The unnamed professional associa ons in making this statement demonstrate their denial of the facts, the shortcomings of ETSU-R-97 and denigrate the so-called 'objector groups'. This would appear to be an unprofessional a empt to pressure government to retain ETSU-R-97 and to prevent independent scru ny.

The field survey workstream at sec on 5 to obtain a snapshot of detectable AM has realised some helpful results. However, other than confirming what is already well known, the WSP field survey does not advance the understanding of AM or wind turbine noise.

Given the strength of the evidence revealed within the WSP report there is a clear and obvious disconnect between this evidence, and the report's conclusions and recommenda ons. This leads to the belief that the WSP report recommenda ons were predetermined.

INWG Recommenda ons

Following this review of the WSP report, the INWG make the following recommenda ons to Government, expanded below;

ONE	Reject the recommenda ons made by WSP in their review for ETSU-R-97 to be retained albeit with some revisions.
TWO	Replace ETSU-R-97 with BS4142:2014+A1:2019 as the official guidance for wind turbine noise assessment.
THREE	Reject the WSP suggested proposal for a government posi on statement on low frequency noise. This proposal is unsupported by the evidence and would conflict with the World Health Organisa on (WHO) posi on.
FOUR	Conduct independent research into the effects on health and well-being of wind turbine noise including impacts from long term exposure, low frequency noise, infrasound, amplitude modula on and tonal noise as recommended by the WHO.
FIVE	Introduce licencing and regula on of wind power genera on by a na onal agency such as the Environment Agency. This to include con nuous monitoring and recording of noise and turbine data (SCADA) with the data available for compliance and complaint purposes.

ONE - The recommenda on made by WSP for the reten on of ETSU-R-97 with a few revisions is not supported by the report findings. The sheer volume and nature of the cri cisms of ETSU-R-97 iden fied in the report, and especially the stakeholder survey responses point to faults with the fundamental methodology underlying ETSU_R-97. These are faults that cannot be fixed by more revisions or further studies. The evidence from the WSP review plus two decades of cri cisms make a clear case for replacement of ETSU-R-97. Retaining ETSU-R-97 and its fundamental methodology around derived noise limits appears to have been pre-determined and were a key objec ve of WSP when execu ng this review.

TWO - Arguably the most important omission by WSP in the report is considera on of an alterna ve to ETSU-R-97 and the con nued avoidance of any discussion on the subject.

During 2015 the INWG proposed that ETSU-R-97 be replaced by BS4142. BS4142 applies to all other comparable industrial and commercial noise source assessment. BS4142 has been regularly updated and its suitability as examined at Table 1 must be fully evident to any competent acous cian.

BS4142 has been tested with wind turbine noise data by the INWG. There can be no technical, environmental or ethical reasons why BS4142 could or should not be used. BS4142 would provide the same level of protec on to wind farm neighbours as is currently afforded for comparable forms of industrial and commercial noise sources. Also, BS4142 is much be er understood by LPAs and its adop on would overcome the iden fied cri cisms of ETSU-R-97 including control of AM, post construc on compliance and complaint inves ga on.

THREE – WSP make the unsupported recommenda on to government for a posi on statement to be made indica ng that: "*infrasound from wind turbines at typical exposure levels has no direct adverse effects on health*".

This WSP recommenda on concerning low frequency noise is completely at odds with the INWG findings at Work Package 2.1, open here and more recent evidence including the IARO scien fic commentary, open here see Sec on 9 - Appendix. It would also be at odds with the WHO 2018 noise guidelines, open here . Addi onally, such a posi on statement would be dangerous as it would effec vely block further progress with understanding low frequency sound and; its health effects and would hinder resolu on for affected communi es seeking respite from wind turbine noise.

FOUR - The World Health Organisa on (WHO) *Environmental Noise Guidelines for the European Region* dated 2018, open here states at sec on 4.2, page 100; "*Further research into the health impacts from wind turbine noise is needed so that be er-quality evidence can inform any future public health recommenda ons properly.*" And at Table 53: "*Exposure to noise at a wide range of levels and frequencies (including low-frequency noise), with informa on on noise levels measured outdoors and indoors (par cularly relevant for effects on sleep) at the residence is needed.*"

FIVE - In order to ensure an effec ve and consistent path for dealing with wind turbine noise nuisance, the INWG propose that industrial wind turbines should be licenced and subject to oversight by a na onal agency, such as the Environment Agency. Regula on by a na onal agency would make it easier to ensure a consistent approach na onally, to maintain appropriate levels of technical competence and would bring wind power in line with other rural located pollu ng industries.

Net Zero

A theme not so subtly emphasised throughout the WSP report, is the use of the climate emergency as leverage to maintain a commercial advantage for the onshore wind industry. WSP are using this Net Zero threat as jus fica on for being allowed to con nue to inflict higher levels of noise than permi ed from other comparable industries.

The deployment of wind power does not need to be a binary choice between protec ng communi es and residen al amenity versus figh ng climate change and mee ng the objec ves of Net Zero. It should be possible to generate the renewable power required, and from the most suitable sources, while s ll protec ng host communi es, residen al amenity and the environment.

A key feature in a democracy such as the UK is that the rights of the minority are protected by the majority. Such protec ons for communi es and the environment are now core values being promoted by the government for the ongoing review of the Na onal Planning Policy Framework. The Levelling up and Regenera on Bill which is currently before parliament puts communi es at the heart of the planning system.

Sec on 2 - Introduc on

It is understood that the WSP report was intended to provide a high-level review of the issues surrounding the ETSU-R-97 guidance, and not intended as a pla orm for in-depth technical discussion. Therefore, this INWG analysis and cri que of the WSP report also a empts to minimise detailed technical discussion while aiming to iden fy the key issues, and provide recommenda ons for government decision makers. A er this introductory sec on, the INWG analysis generally follows the WSP report workstreams, these being:

- Evidence review
- Stakeholder engagement survey
- Field measurements

This is followed by a general discussion, then the conclusions and recommenda ons. It is also recognised that the ETSU-R-97 guidance applies to the whole of the UK, not just England.

Why this analysis and cri que?

The report tled; '*A review of noise guidance for onshore wind turbines*' was released by WSP on their company website on 10 February 2023 with an announcement appearing on Linkedin social media, open here. INWG were informed of this announcement by a third party shortly a er its release. From the WSP Linkedin page it was possible to download the 400-page report via the WSP website, open here.

The report release occurred as INWG were finalising a response to the government Department for Levelling Up, Housing & Communi es (DLUHC) consulta on to proposed reforms to na onal planning policy. It was considered that the WSP report was highly relevant to the DLUHC consulta on, but the limited me remaining before the 2 March consulta on closing date only permi ed a preliminary review of the WSP report. As a result, only the summary informa on provided on the WSP website was reviewed at that me.

This ini al review detailed at page 4 of the DLUHC consulta on INWG response, open here raised some serious concerns regarding the integrity, impar ality and accuracy of the WSP report.

What was especia llya larming is that WSP has recommended reten on of ETSU-R 97 a er some minor amendm ents. This recommenda on is made despite overwhelmin g evidence fromo ver tw o decades that ETSU-R-97 is unfit for purpose . What was most striking about the website summary was what has been excluded from the review. It was therefore decided that INWG would conduct a detailed cri que with a view to presen ng a report to government ministers.

Background and objec ves to the WSP survey

Informa on provided by WSP on their website indicates that the review of noise guidance for onshore wind turbines was commissioned by the Department for Business, Energy & Industrial Strategy (DBEIS), now the Department for Energy Security and Net Zero.

The government tendering contract informa on dated April 2021 for the review subsequently awarded to WSP is available at the procurement website, open here. This shows a contract start date of 24 May 2021, an indica ve contract value of £50,000 and the scope of the review is shown as;

"The successful bidder will deliver a research report and recommenda on as to whether the current ETSU guidance requires refreshing or if it remains suitable. To inform this research report and recommenda on, the contractor will conduct desktop research of exis ng literature rela ng to ETSU and wind turbine noise, including AM. They will also conduct stakeholder engagement with those involved in the use of ETSU. The successful bidder will also be expected to conduct field measurements at different onshore wind installa ons to provide a snapshot of the magnitude of Amplitude Modula on that can be an cipated from the sample of turbines. The results of this work are expected to provide an ini al guide as to whether there is any link between different turbine types and the extent of EAM and help iden fy whether further EAM measurement campaigns are needed and if so how these should be conducted and carried out. The outputs of this work will inform the research report and recommenda on at Task 1. We invite bidders to suggest their own methodologies as to how they would undertake this task. Please ensure you review all a ached informa on to ensure a full understanding of this requirement."

DBEIS would appear to have provided a clear and reasonable scope of supply and objec ves.

The understanding by the INWG of the scope and objec ves is to determine whether the ETSU-R-97 noise guidance dated from 1997 and the IoA Good Prac ce Guide (on the use of ETSU-R-97) dated 2013 for onshore wind turbines are fit-for-purpose or should be updated or replaced. Then based on this determina on to make recommenda ons to government.

WSP survey and report metable

The INWG only became aware that this review of ETSU was taking place quite late in the process and only a er being informed by a 3rd party during late August 2021. It was then discovered that the survey and review was being carried out by the acous c consultant WSP on behalf of DBEIS and that the survey was by invita on only. The INWG had clearly not been invited despite having been ac ve with wind turbine noise issues since 2014. Also, the INWG members are well known to the WSP authors.

A request was immediately made by the INWG to DBEIS to be allowed to par cipate in the survey and this was agreed by DBEIS on 1 September 2021. INWG subsequently responded to the survey by making a submission to WSP on 24 Sept 2021, open here.

Some 16 months later on 10 February 2023 the report was released by WSP on their own website. This 400-page report is dated October 2022 so would indicate that the report was likely delivered to DBEIS some 4 months previously. The report is also marked 'PUBLIC'.

This raises the ques o nof whether th ereis another, possibly 'PRIVATE' vers ion of the repo rt inexistence that co uld provde gr eat er transparency of th eWSP review process.

WSP report structure and contributors

When reviewing the report, the first aspect of note is that the report is much longer than expected or needed, possibly by a factor of 2 or 3. There is a lot of repe on throughout contribu ng to this excess. For example, there is a 4 page 'Brief Non-technical Summary' followed by a 23 page 'Execu ve Summary'. The sheer length of the report at 400 pages plus the use of excessive jargon is in mida ng. As such much of the report will be difficult for anyone unfamiliar with acous cs to fully understand and it is considered most unlikely that any government decision maker would read the full report.

The iden fied WSP report authors, Michael Lo nga and Toby Lewis are well known to the INWG as they have represented wind turbine developers and operators with planning applica ons and at planning public inquiries. Toby Lewis will also be especially familiar with the noise problems with the Co on Farm windfarm from his me as EHO at Hun ngdon District Council where resident noise complaints are s ll unresolved. The INWG have provided support to the Co on Farm residents group over several years. On an earlier version of their website, WSP proudly claimed their experience with onshore wind projects sta ng, "*We have a long track record suppor ng wind developers, u li es, funders and investors throughout the project life cycle.*"

WSP commissioned Bernard Berry to peer-review sec ons 3, 6.1, 6.2 and 7 of the report. These sec ons being, Evidence Review, Discussion sects 6.1 and 6.2, Conclusions & Recommenda ons, these being the key technical sec ons. It should be noted that Bernard Berry is one of the original authors of ETSU-R-97 so may have a personal interest and reasons for ETSU-R-97 to endure. He also has had close connec ons with the wind industry for many years so cannot reasonably be considered as independent. Addi onally, the peer review process does not appear to be the rigorous, independent and largely autonomous process normally applied to scien fic and academic papers, but a much more informal inhouse process.

There is an obvious conflict of interest with WSP u ndertak ingthis survey an d with Bernard Ber ryas the peer rev iewer.

The report also acknowledges seven others who have contributed; "*Andrea Bauerdorff, Dick Bowdler, Professor Guillaume Du lleux, Dr Kristy Hansen, Dr Anders Johansson, Dr Yasuaki*

Okada and Dr Fei Qu in responding to research queries.". Although these individuals are associated with the wind industry in the UK and overseas, their contribu ons would appear to be more limited in scope.

About the Independent Noise Working Group (INWG)

The INWG's mission open here is ensuring that the acous c impacts from wind turbines are properly controlled in order to protect public health and wellbeing.

The INWG, formed during August 2014, is a mul -discipline team fully independent of the wind industry supply chain and was jointly sponsored by Chris Heaton-Harris MP, Conserva ve, Daventry open here, and the Na onal Alliance of Wind Ac on Groups (NAWAG). Most of the founding members of the INWG were associated with NAWAG but a er the Wri en Ministerial Statement in 2015 from Greg Clarke open here that set much stricter controls for further wind turbine developments, the need for NAWAG in England was greatly reduced and it subsequently became dormant.

The main task of the INWG at that me was to conduct an independent and scien fic study into wind turbine noise amplitude modula on (AM). This study needed to be able to credibly challenge the methodologies and findings of the Ins tute of Acous cs (IoA) sponsored AM study. There is great concern with IoA working group member conflicts of interest due to most of them working for the wind industry.

The results of this INWG AM study were presented to Government at Westminster on 13 October 2015 (DECC presenta ons 1 open here & presenta on 2 open here) and at the Ins tute of Acous cs Conference at Harrogate on 15 October 2015 (open here). The thirteen AM study work packages are available on the INWG website, open here. Although this work dates from 2015, much of the work is s ll relevant today and is relevant to this latest review of the guidance.

The recommenda ons made to Government by the INWG during October 2015 included:

- ETSU-R-97 noise guidance to be replaced with a code of prac ce based on BS4142:2014.
- Independent research is required into the health effects of wind turbine noise including AM and low frequency noise.
- An effec ve AM planning condi on required for every wind turbine planning approval.
- Con nuous noise monitoring (with data transparency) should be required for every medium & large wind turbine planning approval.
- Effec ve remedy required for retrospec vely dealing with noise nuisance including AM from exis ng wind turbines.

Sec on 3 - Evidence Review

For the WSP report Sec on 3, Evidence Review (pages 71 to 132), the research methodology at 3.2.1 was focused on the single primary ques on rela ng to the adequacy or otherwise of ETSU-R-97; *"Does the evidence indicate that the ETSU-R-97 guidance, when considered alongside the government-endorsed IOA best prac ce applica on guidance, requires upda ng to be consistent with the aims and objec ves of current government policy and regulatory frameworks, and if so which aspects of it should be revised?"*

There also being a secondary focus with two secondary ques ons:

1. What further evidence or informa on would be needed to support any upda ng to the current guidance
2. Evidence if there is any on influence of turbine age and design on sound emission.

It is noted that WSP adopted the Quick Scoping Review (QSR) methodology and not the more rigorous Rapid Evidence Assessment (REA) and Systema c Review. Therefore, the selected QSR methodology is an cipated to be less robust, subject to a lower level of accuracy and with a greater risk of bias.

The search strategy at sec on 3.2.2 states; *"Pilot searches were carried out using a broad range of topics relevant to wind turbine noise assessment guidance, which iden fied a volume of publica ons that was not feasible to screen within the project mescales."* It is clear that a restricted evidence base was reviewed and the review process would be vulnerable to a lower level of accuracy and risk of bias.

A summary of the key findings in response to the primary and secondary ques ons are provided at the report sec on 3.5 (page 128 to 132). The stated findings from the evidence review would appear to reflect many of the earlier findings by the INWG. As a result, the INWG concluded during 2015 that ETSU-R-97 should be replaced, preferably by guidance based on BS4142.

Despite the clear evidence in the report suppor ng the view that ETSU-R-97 is not fit for purpose, WSP have con cluded on page 130 that the guidance (ETSU-R-97) should be retained with some updates. There does not appear to have been any considera on of alterna ves to ETSU-R-97 or discussion of the merits of BS4142.

Significantly, WSP have ignored the INWG Work Package 2.1 authored by Richard Cox tled Review of Reference Literature and dated July 2015 open here. This evidence review provides arguably a more balanced and complete review of the issues currently under considera on. Although dated from 2015 most of the findings, conclusions and recommenda ons are s ll relevant today.

Sec on 4 - Stakeholder Engagement

The stakeholder survey, sec on 4 of the report (pages 134 to 170), is arguably the most important workstream within the ETSU-R-97 review. This sec on of the INWG cri que focuses on chapter 4 of the WSP report with addi onal material at Appendix C2.

Methodology and stakeholders

The engagement objec ves (sect. 4.1.1) and engagement strategy (sect. 4.1.2) would appear to be fair and reasonable. However, par cipa on was by invita on only and the survey was promoted exclusively to government en es (central government and local planning authori es) and industry professional organisa ons. Table 4-1 iden fies all the respondent stakeholders. Community groups and individuals independent from the wind industry were effec vely excluded.

The INWG were only by chance informed by a third party that the survey was taking place. Then only a er lobbying DBEIS were the INWG allowed to par cipate in the survey. At Table 4.1 the INWG is shown as the only 'civic organisa on' par cipa ng, no other independent groups or individuals are iden fied.

The INWG are aware of at least three survey submissions that were made by others. Since these are not acknowledged in the report, it would appear they were rejected from the survey. By excluding survey par cipa on by individuals, it would have also excluded any industry professionals who may have differing views to their professional associa on.

For the survey to be effec ve and meaningful, par cipa on by Local Planning Authori es (LPAs) is cri cal. However, only 19 LPAs are shown at Table 4-1 as having par cipated out of the 204 invited (sect 4.1.3). This poor rate of engagement with LPAs and would indicate something fundamentally wrong with the WSP stakeholder engagement strategy.

Five industry professional associa ons are listed at Table 4.1. These are:

- **RenewableUK** – The UK trade associa on for the wind industry. WSP is a member.
- **Sco sh Renewables** – The Sco sh trade associa on for the wind industry. WSP is a member.
- **Ins tute of Acous cs (IoA)** – The UK trade associa on for acous cians. The IoA wind turbine noise working group is made up almost exclusively by IoA member acous cians closely involved in the wind industry supply chain. The WSP report authors are IoA members.
- **Associa on of Noise Consultants** – Sponsored by the IoA, is the UK trade associa on for acous c consultant companies. WSP is a member.
- **BSI PEL/88 Commi ee** - Responsible for the UK input into the work of IEC/TC88 and CENELEC/TC88 for standards for wind turbine generator systems. These standards will deal with safety, measurement techniques and test procedures.

The first four industry professional associa ons shown above are closely associated with the same group of acous cians who have controlled the wind turbine noise guidance since the 1990s when ETSU-R-97 was developed.

There must be serious concerns regar dng the sel ec vestakeholder iden fica on process, the poor engagement with LPAs, an dth e exdus ion of independent groups and individuals. Th is hascrea tedan unbalan ced survey with a clear pro-wind industry bi as.

Survey analysis

For this analysis we are dependent upon the informa on provided at sec on 4.2 and Appendix C3. The raw data in the form of the original responses have not been made available so limi ng transparency.

Figures 4-1 and 4-2 show the stakeholder response rate. This shows 20 LPAs responded to the survey out of 204 invited. The total number of responses being 31. However, Table 4.1 iden fies just 19 LPAs indica ng a coun ng error so the response rate is actually 9.3%. The report does not indicate why the response rate is so low and especially so for England. Without transparency of the invita on process, we can only speculate as to why the response rate is so low and as to why WSP did not secure a be er response rate.

In response to survey ques on 1.2, Figure 4-5 shows that 15 out of 31 responses considered that the guidance requires some upda ng and 13 out of 31 that it is inadequate and requires substan al revision. The two bullet items following a er Figure 4.5 indicate that the members of two professional associa ons have a range of views as to the adequacy of the guidance although individual views have not been included.

Figure 12-7 showing views on the current guidance by respondent type is more informa ve. It shows that only one respondent, an LPA, considered the guidance adequate. Most of the na onal government and all of the professional associa ons considered the guidance mostly adequate. With the LPAs, 11 out of the 19 considered the guidance inadequate, 6 that it was mostly adequate, and one not sure.

A total of 13 out of the 31 stakeholders (LPAs, na onal government and civic group), 42% consider the guidance to be inadequate. Onecan only speculat ewhat this per centage would h ave been had ther e been a h igher response rate by LPAs and that the survey had bee n an open consulta on .

In response to survey ques on 1.3, Figures 4-6 and 4-7 are also informa ve showing views on aspects of the guidance that are of concern. At Figure 4-6, of the 10 named topics, 7 are flagged up as being of concern by more than 50% of stakeholders. Figure 4-7 gives another helpful insight separa ng the views based on mostly adequate and inadequate. The red bars 'Inadequate and requires substan al revision' is considerably greater overall than the green bars 'mostly adequate, but requires some upda ng or amendment'.

In summary, Figures 4-5, 4-6 and 4-7 provide a clear indica on that there are concerns with many aspects of the guidance. The wind industry professional associa ons consider that these concerns can be overcome with some upda ng, and that others, mostly the LPAs and the civic group consider that the guidance requires substan al revision.

Addi onally, WSP conducted interviews with a few selected respondents that seems to have complicated the analysis and introduced an addi onal layer of topics. The report does not iden fy which stakeholders were interviewed or even how many out of the 31 were interviewed. In conduc ng these interviews to a likely small number of stakeholders in this way, WSP will have created an uneven playing field with either bias or perceived bias favouring the wind industry.

Survey ques on 1.4 asked; "*Please could you briefly outline the updates you believe need to be made to the current UK wind turbine noise assessment guidance, and iden fy any publicly accessible evidence you are aware of that would support or inform the updates indicated?*"

This request for comments on each of the topics listed at Q1.3 has resulted in 10 pages (pages 144 to 153) of analysis at Sec on 4 plus Appendix C3 (pages 362 to 384). A compila on of 125 topics has been produced by the authors at Appendix C3 Figure 1220/21/22 and Table 12-10, and in truncated format at Sec on 4, Figure 4-12.

The top 5 issues by number of respondents from Figure 4-12 and Figure 12-20 are:

- Guidance needs to establish how AM impact should be taken into account
- ETSU-R-97 is outdated and needs to be reviewed: technology and understanding have advanced since publica on
- Difficult, costly or me-consuming to robustly establish compliance/non-compliance
- More / updated guidance on cumula ve assessments is needed
- The ETSU-R-97 principles underlying the limits need to be reviewed

The INWG welcome the results of this stakeholder survey as it has highlighted many of the concerns with ETSU-R-97 that have been raised over the last two decades by numerous organisa ons and individuals. So, while the INWG agrees with many of these iden fied themes as being topics of concern, even though insufficiently defined at present, they do provide a useful benchmark for decision makers when considering the future guidance for onshore wind turbine noise assessment.

Unfortunately, a detrac on to this part of the survey is the introduc on of interviews conducted with selected stakeholders in an opaque manner. When one examines Figures 412 it is quite evident that the red bar themes (includes interviewees) significantly outweigh the blue bar themes (non-interviewees only). This again highlights concerns of bias having been applied to the survey results by holding interviews with just a small number of selected stakeholders and the lack of transparency.

In response to ques on 1.4, the INWG submi ed 10 pages of detailed responses on various topics. Unfortunately, much of the detail of these comments have been ignored in the report.

h summary, t he WSP analysis to ques on 1.4 on pages 144 to 153 highlights the sheer num ber of is sues rai sed by th e st akehold er r espon ses with th e cu rrent guidance confirming the cri cism of ETSU-R-97 made ove r the last tw o decades and more recently to the G ood Prac ce Guide.

Despite the overwhelming evidence from the stakeholder survey that ETSU-R-97 is unfit for purpose, or possibly because of it, two of the professional associa ons supplied a wri en statement that WSP has reproduced on pages 162 and 163.

It is evident from this statement that the unnamed professional associa ons are in denial of the shortcomings with ETSU-R-97. Addi onally, they have denigrated the so called 'objector groups' with the misleading statement; "*The fact that onshore wind development in the UK has a racted li le adverse a en on from those worried about noise does not mean that such an announcement would not s r up considerable interest from objector groups with no factual or scien fic basis for their asser ons*."

It should be recognised that this stakeholder survey included 31 respondents of which only one, the INWG might be described as an 'objector group'. Almost all the issues raised by stakeholders to ques on 1.4 as discussed above came from the other 30 respondents. The statement from these two wind industry professional associa ons ends with; "*While we do not feel there is a need for new UK wind turbine noise assessment guidance, any further modifica ons should include a panel of expert acous cians, wind farm, developers, government representa ves and the IOA*".

It is therefore of further concern that the suggested panel fails to include audiologists, physicians or representa ves of communi es nega vely impacted by wind turbine noise.

This statement on page 1 62 and 163 by the wind industry would appear to be an un professional aempt to retain ETSU-R-97 as the official noise guidance and to prevent ind epen dent scru ny.

Sec on 5 - Field Survey Measurements

The field survey workstream, sec on 5 of the WSP report (pages 172 to 178), with the objec ve to obtain a snapshot of detectable AM has realised some helpful results. This despite the short measurement dura on at each site, two hours at site E and just one hour at each of the other six sites. Even so WSP report that AM was detected for about half the total measurement dura on with modula on depths of up to 5dB. The report also confirms that the measurements represent non-TEDCAR-AM (also described as EAM), this being the form of AM not addressed by ETSU-R-97 and responsible for most noise complaints.

What this snapshot measurement survey confirms is that AM is a common and regular occurrence at these sites. Unfortunately, what the survey does not show is whether the AM at these seven anonymous wind farms is affec ng any of the local communi es.

WSP also confirm that the AM was detected using the IOA Reference Method. During 2015 the INWG tested the RUK method (later to be rebranded as the IOA Reference Method) and other methods as part of the Wind Turbine Amplitude Modula on & Planning Control Study. This was reported in INWG Work Package 5 tled: *Towards a dra AM Planning Condi on*, authored by Sarah Large and others, open here. WP5 Table 16 summarises the test results and commen ng on the RUK method, Large concluded; "***There are significant flaws with this method, it does not control EAM and as such it is recommended that this control mechanism is discarded as not fit for purpose***".

BS4142 was also tested and Large concluded; "***The use of BS4142 has been shown to work with wind farm noise data. Concerns raised previously with low background sound levels and influence of meteorological condi ons, namely wind speed, have been addressed in revisions along with advancement of the science and quashed. The advantage of BS4142 over separate EAM assessment methods is the ability of BS4142 to assess noise level along with different noise character, including intermi ency and tonality. BS4142 can also be used in conjunc on with an assessment of wind farm noise level. It is recommended that for a holis c assessment of wind farm impact that BS4142 is the preferred method. This is consistent with industrial noise assessment in general including other energy producing systems with which wind energy competes***".

It is quite remarkable that this WSP survey has actually taken place when less than 10 years ago acous cians ac ng for wind farm developers at planning inquiries were sta ng that either AM did not exist or if it did exist, it occurred so infrequently that it should not be subject to a planning condi on.

Had WSP really wanted to demonstrate evidence of and characteris cs of AM they could have referred to INWG Work Package 2.2 tled: *AM Evidence Review* dated August 2015 by Sarah Large, open here. This provides a much more robust evidence review of AM.

Sec on 6 - Discussion

Methodology and Process

The scope and objec ves of the stakeholder survey and review of ETSU-R-97 provided by DBEIS dated April 2021 when tendering for the review would appear to be clear and reasonable. However, the INWG only discovered by chance and quite late in the process during August 2021 that the review was taking place and that par cipa on was by invita on only. The closed nature of the stakeholder survey was an immediate cause for concern for risk of bias. Fortunately, the INWG were permi ed by DBEIS to provide a last-minute response during September 2021.

There was no subsequent feedback un l the report dated October 2022 was finally released on the WSP website, but not un l 10 February 2023. No reason is given for the apparent delay of over 3 months between report comple on and its release. When reading the report, the first impressions are that it is far too long at 400 pages, very repe ve and will be very difficult for the non-technical reader. This repe on contributes to the report being probably two or three mes longer than needed. These factors almost guarantee that government decision makers will not read the full detail of the report, relying on the final recommenda ons only.

When we delve into the report and iden fy the authors and stakeholders we see that central government, local government and the wind industry including their acous cians are the only par cipants other than the INWG. Even the appointed 'peer reviewer' is one of the original authors of the ETSU-R-97 guidance and has been closely associated with the wind industry for over two decades. There being no other independent stakeholders iden fied and the INWG is aware of several unsolicited survey responses have not been acknowledged or included in the review.

It is concluded this review of ETSU-R-97by WSP is biased throughout in its methodology and execu on.

Evidence review

The objec ves shown for this workstream are reasonable however, the scoping and screening methodology would appear to have been inadequate. The author admits that the Quick Scoping Review (QSR) methodology employed is a less robust op on, subject to a lower level of accuracy and a greater risk of bias. This becomes more apparent when we analyse the restricted evidence base that was reviewed.

The summary at sec on 3.5 does however include many of the concerns previously iden fied by the INWG and others over many years. Unfortunately, there are several areas that have not been properly examined or simply dismissed. These are discussed below and include low frequency noise, uncertainty and the use of BS4142 as an alterna ve to the ETSU-R-97 based guidance currently in use.

When one considers the number and nature of the issues iden fiedwith ETSU-R-97, any independent review is likely to conclude that there is a n eedto replace the current guidance.

In conduc ng their evidence review, WSP have ignored the INWG Work Package 2.1 authored by Richard Cox tled; '*Review of Reference Literature*' dated July 2015 open here . This provides a more balanced and comprehensive review of the issues currently under considera on and although dated from 2015 is s ll relevant. WP 2.1 reviews over 160 documents where every document was individually reviewed and a short assessment produced. This me-consuming review methodology may not be an a rac ve op on for a commercial organisa on such as WSP, but does allow for a more comprehensive and rounded assessment to be made.

WSP have taken great care to effec vely dismiss wind turbine low frequency noise as being of any significance based on some clearly selec ve evidence reviews and a claimed lack of evidence. WSP discuss this on pages 101, 114, 115, 116 and 117and fail to consider the ever increasing turbine sizes that could increase LF sound to harmful levels. They offer no recent Epidemiological field studies involving large turbines to prove their claims.

At page 116, WSP claim: "*Overall, the findings from the exis ng evidence base indicate that infrasound from wind turbines at typical exposure levels has no direct adverse effects on physical or mental health, and reported symptoms of ill-health are more likely to be psychogenic in origin*".

On what basis should medically unqualified acous cians, (as are the WSP authors) opinions on the health and wellbeing of adversely affected residents, become accepted as a statement of fact, on which large scale planning decisions are made and on which government policy is determined?

Then at page 232, WSP are mischievously recommending that government make a posi on statement indica ng that; "*infrasound from wind turbines at typical exposure levels has no direct adverse effects on health*". These conclusions and recommenda on are completely at odds with the evidence review findings by the INWG at Work Package 2.1, open here and more recent evidence, bringing to mind the age old saying; *"The absence of evidence is not evidence of absence"*.

The INWG findings from 2015 are summarised in the WP 2.1 Execu ve Review at para 5; "*The evidence regarding low frequency noise (LFN), a significant component of WTN including AM, is compelling. Despite the wind industry's con nual denial of the significance of LFN, the available evidence demonstrates conclusively that:*

- *LFN including infrasound is an integral component of WTN;*
- *Complaints regarding WTN currently classified as AM or EAM or OAM by the wind industry is an obfusca on of the true nature of the problem;*
- *Condi ons giving rise to noise complaints are o en characterised by 'sensa on' as being the major form of disturbance. In some cases, the 'noise' may not even be audible;*
- *Noise measurement using the A weigh ng may be unsuitable for WTN where low frequency components are present;*
- *Noise measurements should be made inside homes when inves ga ng noise complaints;*

- *Noise measurements where LFN is present should be made using suitable instrumenta on. IEC 61672 compliant 'Class 1', instrumenta on may be unsuitable for LFN measurement or where background noise levels are low as in typical rural areas."*

The World Health Organisa on (WHO) released its updated *Environmental Noise Guidelines for the European Region* during 2018, open here. Sec ons 3.4 and 4.2 cover wind turbine noise.

At sec on 3.4, page 85 the WHO state; "*Wind turbines can generate infrasound or lower frequencies of sound than traffic sources. However, few studies rela ng exposure to such noise from wind turbines to health effects are available. It is also unknown whether lower frequencies of sound generated outdoors are audible indoors, par cularly when windows are closed*".

At sec on 4.2, page 100 the WHO state; "*Further research into the health impacts from wind turbine noise is needed so that be er-quality evidence can inform any future public health recommenda ons properly. For the assessment of health effects from wind turbines, the evidence was either unavailable or rated low/very low quality.*"

Table 53 provides further detail including for "*Exposure of interest*" the statement; "*Exposure to noise at a wide range of levels and frequencies (including low-frequency noise), with informa on on noise levels measured outdoors and indoors (par cularly relevant for effects on sleep) at the residence is needed.*"

With these statements by the WHO, the government should seriously ques on the recommenda on made by WSP and specifically the requested posi on statement iden fied above. Such a statement would be dangerous, would effec vely block further progress with understanding wind turbine low frequency noise and its health effects and would hinder affected communi es seeking respite from wind turbine noise.

The current denial of problems with low frequency noise by the wind industry follows a close parallel with the argument from around a decade ago when the wind industry was in denial regarding amplitude modula on. Acous cians defending wind power developers were prepared to state at planning inquiries that amplitude modula on either did not exist or if it did exist it occurred so infrequently to be irrelevant for considera on in the planning balance. Only when the evidence was overwhelming in iden fying the extent of occurrence and the characteris cs of AM were the wind industry forced to acknowledge its existence.

At secon 3.3.3, WSP give minimal men on on the subject of uncertainty or its significance. Uncertainty being the errors that can accumulate within the assessment process. ETSU-R-97 fails to allow for uncertainty so may be the only area of science that works with zero error. Uncertainty will occur with each of the measurement and calcula on stages including microphone windshields, sta s cal methods used to derive limits and sound propaga on calcula ons. These errors can be cumula ve and the INWG has previously es mated the overall error or uncertainty for a wind farm noise assessment could be as high as +/-10dB. Considering that many noise assessments accompanying wind turbine planning applica ons have shown the headroom between predicted noise levels and the derived limits can be as low as 1dB, the level of uncertainty can be highly significant.

Stakeholder engagement

The stakeholder survey at sec on 4 of the report (pages 134 to 170), is arguably the most important workstream within this ETSU-R-97 review. Whereas the engagement objec ves would appear to be reasonable, the implementa on is judged to be deficient and biased.

Survey par cipa on has been limited to central government departments, local planning authori es and industry professional associa ons. Community groups and individuals external to the wind industry were excluded. This composi on creates a bias in favour of the wind industry and is par cularly imbalanced as it excludes those with direct experience of living near wind turbines or their representa ves.

In addi on to the government responses there were five responses from professional associa ons. Of these, RenewableUK, Sco sh Renewables, Ins tute of Acous cs and Associa on of Noise Consultants cons tute the UK wind industry voice on wind turbine noise issues. It should be noted that either WSP or the WSP report authors are members of these four professional associa ons.

What is par cularly disappoin ng is the survey response rate from the LPAs. Out of 204 LPAs invited by WSP only 19 par cipated. This 9% response rate compares poorly with the response rate of 77% obtained by INWG during a similar survey during 2014. This survey is documented in INWG Work Package 3.1 open here, authored by Trevor Sherman tled; *'Study of Noise and Amplitude Modula on Complaints Received by Local Planning Authori es in England'* dated February 2015. For this survey, INWG contacted 265 LPAs and received responses from 205, a response rate of 77%.

The poor LPA response rate for the WSP survey must be ques oned as it indicates that something was fundamentally wrong with the way WSP invited LPAs.

Despite the survey bias, the results presented at Figure 4-12 and Figure 12-20 highlight many of the concerns with ETSU-R-97 that have been raised by the INWG and others over the last two decades. These findings do therefore provide a useful benchmark for decision makers when considering the future guidance.

The top 5 issues by number of respondents from Figure 4-12 and Figure 12-20 are:

- Guidance needs to establish how AM impact should be taken into account
- ETSU-R-97 is outdated and needs to be reviewed: technology and understanding have advanced since publica on

- Difficult, costly or me-consuming to robustly establish compliance/non-compliance
- More / updated guidance on cumula ve assessments is needed
- The ETSU-R-97 principles underlying the limits need to be reviewed

The WSP analysis to ques on 1.4 on pages 144 to 153, even with the survey shortcomings, highlight the sheer number of issues with the current guidance raised by the stakeholder responses.

These complaints goto the heart of ET SU-R- 97and its fundamental assessment m ethodology involv ingd erived nois elimit curv es.This cri que should remove any remainin g con sidera on that ETSU-R-97 could be safely retained, even with the per iph eral change s being suggested by W SP.

Unfortunately, WSP created an addi onal complica on and 'unlevel playing field' for the survey by conduc ng interviews with some selected stakeholders but not others. Unfortunately, this results in further lack of confidence in the impar ality of the report. Due to the lack of transparency, no details of who was contacted or even how many stakeholders were contacted are provided.

With overwhelming evidence from the stakeholder survey that ETSU-R-97 is 'unfit for purpose', or possibly because of it, two of the professional associa ons supplied a wri en statement that WSP has chosen to reproduce on pages 162 and 163. These unnamed professional associa ons demonstrate their denial of the shortcomings with ETSU-R-97 and denigrate the so-called objector groups.

This statement on page162 and 163 by the wind industry would ap pear to be an unprofessional a empt to pressure govern ment to retain ETSU-R-97 as the officia lnoise guidance and to prev ent independent scru ny.

Field survey measurements

The field survey workstream, sec on 5 of the WSP report (pages 172 to 178), with the objec ve to obtain a snapshot of detectable AM has realised some helpful results. Despite the very short measurement dura ons at the five wind farms, WSP report that AM was detected for about half the total measurement dura on with modula on depths of up to 5dB. The report also confirms that the measurements represent non-TEDCAR-AM (also described as EAM), this being the form of AM not addressed by ETSU-R-97 and responsible for most noise complaints.

Unfortunately, this field survey has been presented in a way that leads the reader to assume that AM is a more benign characteris c of wind turbine noise than it really is and plays down its impact. Ot her than confirming what is already well known, theWSP field survey does not advance t heun derstanding of AM or wind turbin enoise .

Had WSP really wanted to demonstrate evidence of or the characteris cs of AM they could have referred to the INWG Work Package 2.2 dated August 2015 by Sarah Large, tled; "*AM Evidence Review*", open here. Despite its 2015 date, this provides a much more robust evidence review of AM than the WSP survey.

Large concludes at WP2.2 with; "***The data described below is conclusive that AM exists and it shows AM is being generated by the majority of wind energy developments. It also shows that AM can be generated by all turbines regardless of size, model or type. AM is not rare but is prevalent and whilst meteorology may not be the sole determinant, under certain meteorological condi ons adverse AM can occur for long periods of me***".

The argument for BS4142

On comple on of the amplitude modula on study during 2015, the INWG made an evidence-based recommenda on to government that ETSU-R-97 should be replaced by the use of BS4142. The current version at that me being BS4142:2014, but has now been superseded by BS4142:2014+A1:2019.

Whereas BS4142 has been recommended as a replacement for ETSU-R-97, wind industry acous cians have avoided any discussion on the subject. Instead, they have con nued to argue for ETSU-R-97 to be retained with a few minor revisions. BS4142 does get men oned in the WSP report but only with regard to secondary technical issues and not in the context of its use as a replacement for ETSU-R-97 or whether it could overcome the many faults iden fied.

Examina on of BS4142 shows that it is suitable for wind turbine noise assessment and is used on comparable industrial noise sources that could be located in rural areas.
Addi onally, the WSP authors should be fully aware of the suitability of BS4142, especially as Toby Lewis, one of the WSP authors is a member of the Associa on of Noise Consultants Good Prac ce Working Group for BS4142:2014+A1:2019, open here.

Tes ng of BS4142 was carried out by Sarah Large and reported in INWG Work Package 5 tled: '*Towards a dra AM condi on*' dated November 2015, open here. These arguments are s ll relevant today and chapter 8 provides a detailed assessment of the applica on of BS4142 for wind turbine noise.

ETSU-R-97 was designed firstly to assess the noise impact during the planning process but also to assess noise complaints. When ETSU-R-97 is instead used loosely for postconstruc on compliance tes ng, the averaging and vagaries in the deriva on and applica on of the noise levels and limit curves means exceedances are less likely to be found than when adhering to the complaints processing as prescribed by ETSU-R-97. Then, on the basis of the post-construc on compliance tes ng, the operator claims that the wind farm is compliant; subsequently the noise complaint remains unresolved.

The current system of reliance on the LPA for enforcement is subject to differing interpreta ons of the rules across the country, LPA budgets and a general lack of the acous c exper se needed when challenging wind turbine operators and their acous c consultants. As a result, it is apparent LPAs are reluctant to act against wind power operators.

As we have seen in the WSP report at Figure 4-12 and Figure 12-20, LPA complaints of inadequate government guidance on dealing with wind turbine noise complaints, feature as the No 3 complaint. The ETSU-R-97 noise guidance is clearly very a rac ve to the onshore wind industry and they are avoiding any discussion on changing to an alterna ve guidance.

At the planning stage the developer's acous cs consultant always has the op on to produce a noise assessment exploi ng the averaging, vagaries and derived limits claiming the proposed wind farm will be compliant with ETSU-R-97. To date the INWG are only aware of a few planning applica ons having been refused with noise as a main reason. These refusals were due to interven ons by Dr J Yelland, despite the LPA's ini al acceptance of the developer's NIA authored by an IoA qualified acous cian and declared as compliant.

Once a wind farm becomes opera onal, the operator's acous cs consultant will again claim that the wind farm is compliant with ETSU-R-97, by exploi ng the averaging and vagaries of the process. At this point the LPA will in the face of expensive li ga on costs give up, leaving the complainant with Statutory Nuisance proceedings through the courts as the only op on.

Experience to date shows that pur suing a noise complaint using Statutory Nuisance laws presents an unacceptable burden on a private ci zen and is des ned to fail. This is discussed in the INWG consulta on response dated 27 Feb 2023 to the reforms to na onal planning policy, open here. To date the INWG are not aware of any wind turbine noise complaints that have been resolved sasfactorily in England.

Only a rela vely small number of wind farms have been subject to persistent noise complaints, but where there are complaints o en involving lack of sleep and health impacts it has in some instances, required people to abandon their homes to gain respite. These local residents are effec vely abandoned and helpless in obtaining a resolu on so they have no op on other than to suffer in silence. This is not an acceptable situa on in a democracy.

The recognised method to control wind turbine noise is to curtail opera on, either by reducing output or stopping the turbine during the condi ons when nuisance occurs, typically at night-me. The a rac on to the wind industry of retaining ETSU-R-97 is that it removes commercial risk of opera onal curtailment due to noise complaints.

Hence the lengths the wind industry is going to in maintaining the status quo.

Adopng BS4142 as the offi cial gu idance would p rovide a viable and more straigh o rward route for the unquan fied number of residents impacted by noise nuisance to obtain speedy redress. Wind farm operators would be forced to adopt a more responsible a tude while the impact on renewable genera on na onally would likely be minimal.

Below at Table 1 we compare key facts and features of ETSU-R-97 with BS4142.

Table 1 : BS4142 v ETSU-R-97 Comparaisons

Feature / Ques on	**BS4142**	**ETSU-R-97**
What is it?	Titled: Methods for ra ng and assessing industrial and commercial sound, open here and, open here.	Titled: The assessment and ra ng of noise from wind farms, open here.
What is it used for?	It is the Bri sh Standard For ra ng and assessing sound of an industrial and/or commercial nature.	For noise assessment of wind turbines only.
Where is it used?	Used for inves ga ng complaints, assessing sound from proposed, new, modified or addi onal sources of sound of an industrial or commercial nature. For virtually all industrial and commercial applica ons, except wind turbines. It uses "*outdoor sound levels to assess the likely effects of sound on people who might be inside or outside a dwelling or premises used for residen al purposes upon which sound is incident.*"	For wind turbine sound assessment only. Primarily designed for noise assessments for wind turbine planning applica ons. Has been adapted for use when inves ga ng complaints and is usually included as a planning condi on Not designed for post construc on compliance tes ng but has been adapted for such assessments.

What is their history?	Originally based on the Wilson Report of 1963, first published in 1967, amended in 1975, 1980 and 1982. Revised in 1990. Revised again in 1997 and 2014. Amended 2019 with the current version designated; BS4142:2014+A1:2019 (BS4142:2019)	Dated September 1996 and produced by a wind industry noise working group facilitated by the government department of trade (DTI). ETSU-R-97 has not been revised since although the Ins tute of Acous cs issued a Good Prac ce Guide in 2013, open here.

Why was the Good Prac ce Guide (GPG) produced during 2013 and has it improved the situa on?		Was ins gated in response to many years of cri cism of ETSU-R-97. The GPG clarified several areas of the assessment process but s ll le cri cal faults inherent with the basic ETSU-R-97 methodology. The method for deriving noise limits and wind speeds is s ll the root cause of most of the noise complaints. Does not adequately account for wind shear and allows undue la tude with the se ng of noise limit curves. Also fails to control AM.

Why was ETSU-R-97 created?		The emerging wind industry considered BS4142:1990 to be too restric ve and unsuitable for several reasons for wind turbine applica on. ETSU-R-97 is described as; *"...a framework for the measurement of wind farm noise and gives indica ve noise levels thought to offer a reasonable degree of protec on to wind farm neighbours, without placing unreasonable restric ons on wind farm development or adding unduly to the costs and administra ve burdens on wind farm developers or local authori es."*
If BS4142:1990 was unsuitable, why is the current version of BS4142:104+A1:2019 now suitable?	Summarised by S. Large @ WP5 page 160 11.5: *"The use of BS4142 has been shown to work with wind farm noise data. Concerns raised previously with low background sound levels and influence of meteorological condi ons, namely wind speed, have been addressed in revisions along with advancement of the science and quashed."*	

Is BS4142 in its latest revision ready for use with wind turbine noise assessment	Yes It is recommended though that some addi onal user guidance be produced specifically for use with wind turbine noise	

What are the main concepts or differences between ETSU-R-97 and BS4142	U lises the 'Ra ng' method of assessment. Compares the noise impact at a specific loca on by assessing noise loudness and character (Ra ng) compared with the actual background noise level.	U lises a 'derived limit' method of assessment. Compares either predicted or measured noise with noise limits derived from data from a background noise and wind speed survey data. Relies on the masking effect of wind induced noise to mask the turbine noise.
How does it work?	The basic process being; Make measurements of all noise at the assessment loca on, including the "problem" noise, in terms of LAeq - termed the "ambient" noise level, then; A measurement is then made of all the noise excluding the "problem" noise in terms of both LAeq and LA90; these measurements are termed the "residual" and "background" noise levels respec vely, then; The "residual" LAeq measurement is then subtracted (logarithmically) from the "ambient" LAeq measurement to produce the noise level produced by the "problem" noise alone - termed the "specific" noise Level, then; If the "problem" noise is tonal [containing a no ceable hiss, whine or hum] or if it is impulsive [contains bangs cla ers, clicks or thumps] or if it is irregular enough to a ract a en on, a correc on is added to	The basic process being; Conduct a background measurement survey of the wind farm site either before the turbines are built or when not opera ng. Sound measurement in $LA90_{10}$min, also metrological data including wind speed. Sound measurement at receptor loca ons where the noise will be experienced, then; Derive noise limits for day and night from the background sound levels plus 5dB except for the lower limit over a range of derived wind speeds, then; Predict turbine noise levels over a range of wind speeds, then; Compare predicted noise levels with the ETSU-R-97 derived limits. If predicted noise exceeds the limit, the result is a fail. If the predicted noise is below the limit the result is a pass. Noise limits are subject to separate regimes for day and

	the "specific" level to produce the "Ra ng level ", then; The "background" LA90 measurement is then compared against the "ra ng" level, then; If the "ra ng" level exceeds the "background" by around 10 dBA or more this "indicates a significant adverse impact". A difference of around 5 dBA 'indicates an adverse impact'; at a difference below 5 dBA, the lower the adverse impact and below 0dBA – Low adverse impact likely – 'All dependant on the context'.	night. For day me, the minimum is 35 – 40 dB $LA90_{10}$min increasing with increasing wind speed. For night me the minimum is 43dB $LA90_{10}$min increasing with increasing wind speed. For financially involved receptors the minimum limit day and night is 45dB $LA90_{10}$min. Not designed for compliance tes ng.
What was the purpose of the Good Prac ce Guide (GPG) for ETSU-R-97?		Defined in the GPG para 1.2.1 by; *"This guide presents current good prac ce in the applica on of the ETSU-R-97 assessment methodology for all wind turbine developments above 50 kW, reflec ng the original principles within ETSU-R-97, and the results of research carried out and experience gained since ETSU-R-97 was published. The noise limits in ETSU-R-97 have not been examined as these are a ma er for Government."* The GPG has been cri cised as the fundamental defects with ETSU remain and as witnessed by the WSP stakeholder survey.

Does the guidance control for tonal, impulse and amplitude modula on, and if so, how?	Yes Applies graduated correc ons for both tonal and impulsive character including AM. Tonal correc on of up to 6dB, impulse correc on of up to 9dB. Correc ons are cumula ve.	Tonal only. Does not control impulsive character or AM. The IOA have proposed a separate control method for AM but when tested by the INWG it was found to underes mate AM and declared not fit for purpose, see above.

Is low frequency noise controlled	No	No
ETSU-R-97 is cri cised for using the LA90$_{10}$min index whereas BS4142 uses the LAeq measurement index. What are the implica ons?	Uses the LAeq measurement index that effec vely averages all the sound energy over the measurement period. A separate frequency analysis using fast me data is used to iden fy tonal and for impulsive calcula ons.	Uses the LA90$_{10}$min measurement index effec vely recording a sound level exceeded for 90% of the me and averaged over a 10-minute period. As such it fails to iden fy impulsive or modula ng sound including AM.
Does the guidance allow for uncertainty in the process, also known as measurement error or tolerance	Yes - The latest version now allows for uncertainty.	No - Has been cri cised as being possibly the only applica on of science where uncertainty has not been recognised. This assumes zero error in the measurements and calcula ons. The INWG has es mated that the cumula ve uncertainty in a typical noise assessment with noise predic on could be as high as plus/minus 10dB. The guidance should allow for the aggrega on of errors represen ng a reasonable worst case

The ETSU-R-97 derived noise limits have been a topic for cri cism for many years. What are the issues?	Does not use fixed limits or require derived noise limit curves.	Heavily cri cised for improper sta s cal modelling of the background noise data when determining the noise limit curves. Many noise assessments found to have poorly fi ed curves unsupported by physics and determined mostly by the analy c method employed. They almost always favour the developer with higher noise limits than warranted.
There has been cri cism of the fixed noise limits, what are the issues?	There are no fixed noise limits. The Ra ng assessment method compares the impact of the noise at the receptor loca on. This eliminates the ambiguity of derived wind speeds, derived noise limits and the effects of wind shear.	Limits are derived via a complex and opaque process to create limit curves based on background noise level, wind speed and minimum limits. This can result in significant adverse noise impact, typically during evenings and night and for extended periods while s ll remaining 'compliant' with ETSUR-97. Failing to account correctly for high wind shear condi ons, typically occurring during the night is a fundamental fault with ETSUR-97. Compared to other jurisdic ons, ETSU-R-97 has some of the highest minimum noise limits for wind turbines. Is also unique in having night rates higher than day rates.
Is the guidance designed for post construc on compliance tes ng	Yes	No Ambiguity on this allows the operator considerable la tude in the assessment process such that it becomes inevitable that the wind farm is declared 'compliant'. The LPA is therefore unlikely to challenge this finding by the operator's consultants.

Is the guidance designed for post construc on complaint resolu on	Yes	Yes However, ambiguity on this allows the operator considerable la tude in the assessment process such that it becomes inevitable that the wind farm is declared 'compliant' with ETSU-R-97. The LPA is then most unlikely to proceed with Statutory Nuisance proceedings leaving the complaint unresolved.

Sec on 7 – Conclusions

The recommenda on made by WSP for the reten on of ETSU-R-97 with just a few revisions is not supported by the report findings. The sheer volume and nature of the cri cisms of ETSU-R-97 iden fied in the report, and especially the stakeholder survey responses, point to faults with the fundamental methodology suppor ng ETSU-R-97. These are faults that cannot be fixed by more revisions or further studies. The evidence from the WSP review plus two decades of cri cisms make a clear case for replacement of ETSU-R-97.

Given the strength of the evidence revealed within the WSP report there is a clear and obvious disconnect with the report's recommenda ons. This leads to the conclusion that the WSP report's recommenda ons were predetermined. The report itself appears to have been designed with obfusca on as an objec ve. At 400 pages, highly repe ve and full of jargon it will dissuade all but the most determined reader to properly evaluate the findings. With this level of obfusca on there is a risk that decision makers could rely on the WSP conclusions and recommenda ons without examining the suppor ng evidence.

Arguably the most important omission by WSP is the considera on of an alterna ve to ETSU-R-97 and the con nued avoidance of any discussion on the subject. Retaining ETSU-R97 and its fundamental methodology around derived noise limits would appear to have been an overriding objec ve for WSP when execu ng this review of ETSU-R-97.

The INWG proposed during 2015 that ETSU-R-97 be replaced by BS4142. While BS4142 applies to virtually all other comparable industrial and commercial noise source assessment, its suitability for wind turbine noise as examined at Table 1 must be fully evident to any competent acous cian.

BS4142 has been tested with wind turbine noise data by the INWG. There is no technical reason why BS4142 could not be used. The use of BS4142 would provide the same level of protec on to wind farm neighbours as is currently afforded for all other forms of industrial and commercial noise sources. Also, BS4142 is much be er understood by LPAs and its adop on would overcome virtually all the iden fied cri cisms of ETSU-R-97 including control of AM, post construc on compliance and complaint inves ga on. It is recognised that some addi onal user guidance specifically for wind turbine noise assessment with BS4142+104+A1:2019 may be required to ensure a consistent approach to its use and to prevent any of the undesirable features from ETSU-R-97 being applied.

In order to ensure an effec ve and consistent pathway for dealing with wind turbine noise nuisance, the INWG propose that industrial wind turbines should be licenced and subject to oversight by a na onal agency, such as the Environment Agency. Regula on by a na onal agency would make it easier to ensure a consistent approach na onally, to maintain appropriate levels of technical competence. This would bring wind power in line with other rural located pollu ng industries.

ETSU-R-97 has served the wind industry well by providing a much more permissive noise guidance than for any other industry. It does appear quite remarkable that such an excep on could persist for so long in support of a single industry, testament to the lobbying power of the wind industry. Very few planning applica ons have ever been refused for noise assessment reasons and very few noise complaints have ever been resolved. As a result, most complainants eventually give up and con nue to suffer in silence. Pursuing noise complaints through the courts using Statutory Nuisance has been shown to be unworkable.

The WSP review claims insufficient evidence of any health effects from wind turbine noise including low frequency sound. However, the absence of par cipa on by suitably qualified health professionals must give li le weight to this claim.

On page 232, WSP make the unsupported and unevidenced recommenda on to government for a posi on statement to be made indica ng that: "*infrasound from wind turbines at typical exposure levels has no direct adverse effects on health*".

This WSP conclusion and recommenda on concerning low frequency noise is completely at odds with the INWG findings at Work Package 2.1, open here and more recent evidence including the IARO scien fic commentary, open here at Sec on 8, Appendix . Especially sec on H; '*Exclusion of Infrasound & Low Frequency Noise*', and sec on K; '*What you can't hear can't hurt You*'.

Such a government posi on statement would also be at odds with the WHO 2018, open here noise guidelines where they recommend;

At sec on 3.4, page 85; "*Wind turbines can generate infrasound or lower frequencies of sound than traffic sources. However, few studies rela ng exposure to such noise from wind turbines to health effects are available. It is also unknown whether lower frequencies of sound generated outdoors are audible indoors, par cularly when windows are closed*".

And at sec on 4.2, page 100; "*Further research into the health impacts from wind turbine noise is needed so that be er-quality evidence can inform any future public health recommenda ons properly. For the assessment of health effects from wind turbines, the evidence was either unavailable or rated low/very low quality.*"

Such a posi on statement as proposed by WSP would be dangerous as it would effec vely block further progress with understanding low frequency sound and; its health effects and would hinder affected communi es seeking respite from wind turbine noise.

There can be no pretence that the WSP review is impar al. Throughout the review from the methodology, restricted stakeholder invita ons, through to the analysis and recommenda ons there is a strong bias towards mee ng the needs of the wind industry. Unsolicited survey responses have been rejected or ignored and the INWG response was only included as DBEIS agreed to INWG par cipa on. There being no other independent voice allowed.

A most significant failure with the stakeholder survey is the poor response rate by LPAs at just 9%. This compares poorly against a response rate of 77% realised during a similar survey of LPAs conducted by the INWG during 2014. One can only ques on the effec veness of the WSP process in invi ng LPAs and whether this poor response rate was inten onal or due to incompetence.

The wri en statement submi ed by two of the professional associa ons that WSP has chosen to reproduce on pages 162 and 163 demonstrate arrogance and denial of the failures of ETSU-R-97. This toxic culture within the wind industry leads local communi es to have li le trust in the way wind power has been deployed in their neighbourhoods or is likely to be deployed in future. Communi es hos ng wind power development are simply considered as 'collateral damage', and an inconvenience if they dare complain.

This lack of trust with an arrogant wind industry will present an addi onal barrier to any future deployment of onshore wind power.

A theme not so subtly emphasised throughout the report, is the use of the climate emergency as leverage to maintain a commercial advantage for the onshore wind industry. WSP are using this Net Zero threat as jus fica on for being allowed to inflict higher levels of noise than permi ed from other comparable industries.

The significance of the planning balance between the protec on of residen al amenity and the deployment of wind power is eloquently summed up by Jus ce Richards in the landmark Bald Hills judgement (***Uren v Bald Hills Wind Farm Pty Ltd [2021]***) Victoria, Australia) open here where she quotes at Para 243: "***The genera on of renewable energy by the wind farm is a socially valuable ac vity, and it is in the public interest for it to con nue***"

And at Para 244: "***The evidence did not suggest, however, that there is a binary choice to be made between the genera on of clean energy by the wind farm, and a good night's sleep for its neighbours. It should be possible to achieve both***"

A key feature in a democracy such as the UK is that the rights of the minority are protected by the majority. Such protec ons for communi es and the environment are now core values being promoted by the government for the ongoing review of the Na onal Planning Policy Framework. The Levelling up and Regenera on Bill which is currently before parliament puts communi es at the heart of the planning system.

Sec on 8 – Recommenda ons

Following this review of the WSP report, the INWG make the following recommenda ons to government;

1. Reject the recommenda ons made by WSP in their review for ETSU-R-97 to be retained albeit with some minor revisions.

2. Replace ETSU-R-97 with BS4142:2014+A1:2019 as the official guidance for wind turbine noise assessment.

3. Reject the WSP proposal for a government posi on statement on low frequency noise. This would set a dangerous precedent, is unsupported by the evidence and would conflict with the WHO posi on.

4. Conduct independent research into the effects on health and well-being of wind turbine noise including impacts from long term exposure, low frequency noise, infrasound, amplitude modula on and tonal noise as recommended by the WHO.

5. Introduce regula on of wind power genera on by a na onal agency such as the Environment Agency. This to include con nuous monitoring and recording of noise and turbine (SCADA) with the data to be made available for compliance and noise complaint purposes.

Sec on 9 – Appendix

IARO Scien fic Commentary

Scien fic Commentary on the UK Government's Department of Business,

Energy and Industrial Strategy (DBEIS) "Scoping review of current onshore wind turbine noise assessment guidance"

The Interna onal Acous c Research Organisa on (IARO) submi ed an unsolicited response to the DBEIS survey during 2021 but this response was rejected by WSP so is not included in the WSP review. Details of the IARO response with an addi onal scien fic commentary is available on their website, open here. The IARO document provides a highly cri cal appraisal of ETSU-R-97 and provides an insight into recent developments into wind turbine low frequency noise.

The IARO findings support the INWG recommenda ons ONE, THREE and FOUR at Sec on 1, Execu ve Summary and Sec on 8, Recommenda ons.

The IARO scien fic commentary sec on H; EXCLUSION OF INFRASOUND & LOW FREQUENCY NOISE (paras 42 to 62) present compelling new evidence rela ng to wind turbine low frequency sound, its characteris cs and effects. The following IARO scien fic commentary statements are especially relevant:

Para 9 – "*Medical exper se is conspicuously absent from the list of the Members of the Working Group responsible for ETSU-R-97, and yet, ETSU-R-97 is touted as appropriate for the protec on of Public Health against wind turbine noise*".

Para 11 – "*Unsurprisingly, given the absence of representa ves of the medical community, noise limits suggested by ETSU-R-97 do not priori ze, or even conscien ously consider, the health and well-being of UK ci zens.*"

Para 67 – "*It is shocking that a policy-decision document which has served as the core document for wind turbine noise assessments, with direct implica ons on Public Health, and where scien fic evidence is of cri cal importance, is absent of any accountability or responsibility.*"

Para 78 - "*If the medical community was not represented in the prepara on and publica on of ETSU-R-97, how can the UK Government allow ETSU-R-97 be used to establish public policy with direct implica ons on Public Health?*"

Scientific Commentary on the UK Government's Department of Business, Energy and Industrial Strategy (DBEIS)

"Scoping review of current onshore wind turbine noise assessment guidance."

Document number IARO21-6

December 2021

International Acoustics Research Organization

IARO Is an international group of researchers with a mission to investigate acoustical environments, especially with respect to features that affect humans and animals, and to publish the results. IARO holds the ethics approval for the CSI-ACHE, the Citizen Science Initiative into Acoustical Characterisation of Human Environments, the results of which are publicly disseminated.

Contacts:

IARO, 37 Ferguson St, Palmerston North, 4412, New Zealand

Tel: +64 21 270 7575

Email: contact@iaro.org.nz

Website: https://iaro.org.nz

Authors of this Report *(alphabetical)*

Mariana Alves-Pereira, Ph.D., Universidade Lusófona, Lisbon, Portugal

Huub Bakker, Ph.D., Massey University, Palmerston North, New Zealand

Philip Dickinson, Ph.D., (ret.), Auckland, New Zealand

Richard Mann, Ph.D., University of Waterloo, Waterloo, Ontario, Canada

Rachel Summers, BSc., Massey University, Palmerston North, New Zealand

Contents

A. EXECUTIVE SUMMARY

1. This Scientific Commentary was prepared by Scientists concerned with the health of human communities living in the vicinity of wind power stations.

2. This Scientific Commentary seeks to inform policy decision-makers of the challenges that wind energy has brought to human communities

3. This Scientific Commentary deconstructs the complex technical issues that frequently obfuscate the matter of wind turbine noise.

4. This Scientific Commentary was prompted by the call for a Scoping Review on the current Onshore Wind Turbine Noise Assessment Guidance, on behalf of the Department of Business, Energy and Industrial Strategy (DBEIS).

5. The DBEIS Scoping Review on Onshore Wind Turbines specifically excludes any discussion on infrasound and low frequency noise, thus contradicting its stated objective.

6. The document known as ETSU-R-97 (*The assessment and rating of noise from wind farms),* published in 1996, is the core guideline of the wind turbine noise assessment guidance currently in practice in the UK, and on which DBEIS bases its public policy.

7. The UK Government, through DBEIS, relies on ETSU-R-97 in spite of the dubious and questionable nature of the "veracity or accuracy of any facts or statements"[62] contained in ETSU-R-97, as is self-acknowledged by the signatory authors in their initial disclaimer.

8. ETSU-R-97 chooses to ignore the infrasound and low frequency noise emissions from onshore and offshore wind turbines.

9. Medical expertise is conspicuously absent from the list of the Members of the Working Group responsible for ETSU-R-97, and yet, ETSU-R-97 is touted as appropriate for the protection of Public Health against wind turbine noise.

10. The noise limits suggested by ETSU-R-97 are based on:

    "Existing standards and guidance relating to noise emissions

    - *the need of society for renewable energy sources to reduce the emission of pollutants in pursuance of Government energy policy*
    - *the ability of manufacturers and developers to meet these noise limits*
    - *the researches of the Noise Working Group in the UK, Denmark, Holland and Germany*
    - *the professional experience of members of the Working Group in regulating noise emissions from wind turbines and other noise sources*
    - *the discussion of the issues at meetings of the Noise Working Group and with others with appropriate experience."*[63]

11. Unsurprisingly, given the absence of representatives of the medical community, noise limits suggested by ETSU-R-97 do not prioritize, or even conscientiously consider, the health and well-being of UK citizens.

12. The ultimate purpose of the DBEIS Scoping Review is, as yet, unclear.

[62] ETSU-R-97, page 0

[63] ETSU-R-97, Executive Summary, page iii

B. BACKGROUND

1. It has come to our attention that the Government of the United Kingdom, through its Department of Business, Energy and Industrial Strategy (DBEIS), has commissioned a Scoping Review on the current assessment guidance regarding onshore wind turbine noise.

2. IARO scientists welcomed and applauded this initiative taken by DBEIS.

3. Particularly since, in 2021 alone, IARO scientists were involved in the following Public Inquiries held in Ayrshire, Scotland: a. Rigghill Wind Power Plant (ongoing)

   ITPE Energies Acoustics Consulting, for the wind developer

   b. Arecleoch Wind Power Plant Extension (WIN-370-2), 7 March

   Hoare Lea Acoustics Consulting, for the wind developer

   c. Clauchrie Wind Power Plant (WIN-370-3), 10 May

   Hayes McKenzie Acoustics Consulting, for the wind developer

d. Rigghill Wind Power Plant Appeal (Ref: PPA-310-2034), 27 August ITPE Energies

Acoustics Consulting, for the wind developer

4. Upon closer inspection of the requirements and limitations imposed by DBEIS on their Scoping Review, it became clear that incongruities existed between its stated objective and the information that would actually be gathered, i.e., the conditions DBEIS imposed on its Scoping Review contradict the stated objectives.

5. Very specifically, where wind turbine 'noise' is concerned, the Scoping Review limits the topics to:

   a. Amplitude Modulation (AM), and

   b. Tonality.

6. *Question:* Why is the topic "Infrasound and Low Frequency Noise" not included?

7. DBEIS has also limited their Scoping Review to invited organisations only.

8. *Questions:* Why?

   In addition to the Wind Industry-related enterprises and professional acoustic consulting firms, what other organizations have been invited to participate in this Scoping Review?

   The populational groups most directly affected by the current wind turbine noise assessment guidance (i.e., human communities who now have wind power plants as neighbours) appear to have been summarily excluded from this Scoping Review. Why?

C. GOALS

9. Policy-making authorities are oftentimes unfamiliar with the issue of acoustics and/or acoustics and health.

10. The primary goal of IARO's Scientific Commentary to the DBEIS Scoping Review is to deconstruct the technical complexities associated with the matter at hand, and that contribute to the (wilful?) obfuscation of this issue.

11. It is the goal of this Scientific Commentary to facilitate the understanding of the competent decision-making authorities regarding the contradictions and incongruities self-imposed by DBEIS on its own Scoping Review.

12. In doing so, some aspects of the core document currently regulating wind turbine noise in the UK (ETSU-R-97) will be discussed.

D. DISCLAIMER

13.

a. The authors of this Scientific Commentary are not party to anti-technology sentiments.

b. Wind turbines are considered by the authors as welcome additions to modern technological societies.

c. The Scientific Commentary provided herein has one, and only one, agenda— that of pure scientific inquiry.

d. In no way can, or should, this Scientific Commentary be construed as a document arguing for or against the implementation of wind turbines, or any other industrial complexes.

e. There are no commercial, financial, or professional agreements (contractual or otherwise) between the authors of this report and any persons or parties involved in the wind turbine sector or persons or parties who stand against the implementation of wind turbines.

f. This Scientific Commentary was provided *pro bono*.

E. CONTEXTUALIZATION

14. It may be surprising to those reading this report that, all over the world, including the UK:

a. Citizens living in the vicinity of onshore wind power stations have been complaining of adverse health effects, also observed in pets and livestock;

b. Citizens living in the vicinity of onshore and offshore wind power stations have formed small, grass-roots groups in order to challenge the 'wind industry';

c. Numerous ongoing legal proceedings are opposing private citizens, or groups of private citizens, to the 'wind industry';

d. Many of the ongoing and concluded legal proceedings are subjected to nondisclosure agreements, or gag orders.

15. In the UK, the current situation that sees residential communities opposed to existing and planned wind power stations has been ongoing for three decades, since the operation of the first wind turbines in 1991 at Delabole in Cornwall—hub height: 32m, blade length: 17 m. In 2021, the Arecleoch wind turbines in Scotland have a hub height of 83 m, and a blade length of 69 m. Figure 1 is reproduced from industry literature.

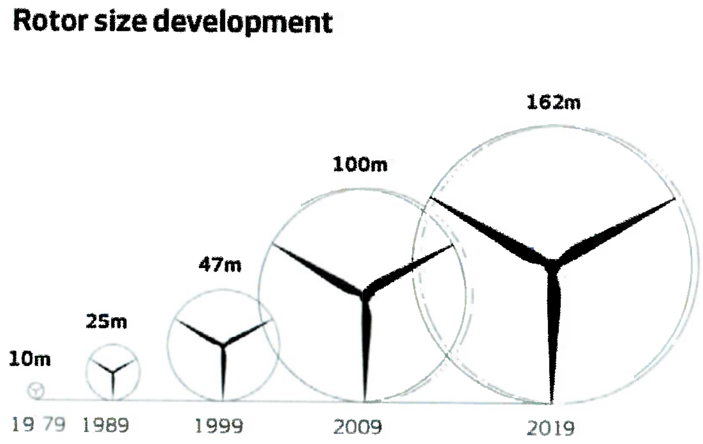

Figure 1. Evolution of the size of wind turbine rotor blades[64].

16. In addition to the stroboscopic effect (which, in the sole case of wind turbines, is termed 'shadow flicker') and the decreased visual amenity, wind turbines also produce 'noise.'

17. A part of the 'noise' produced by wind turbines is of a unique type, that is not properly contemplated in current assessment guidance: pulsed infrasound and low frequency noise.

18. The immediate and long-term effects of this unique type of 'noise' on human health are, for the most part, not investigated.

[64] Vestas Wind Systems A/S, 2019. "EnVentus Platform" Brochure. https://www.vestas.com/en/products/enventusplatform/enventus-platform

19. It would therefore seem appropriate and natural that the UK governmental agency responsible for "Energy and Industrial Strategy" would take a strong interest in this matter, particularly given their "Energy White Paper: Powering our net zero future."[65]

20. On the other hand, it would seem equally appropriate that the UK governmental agency responsible for the protection of Public Health should also take a strong interest in this matter.

F. DBEIS SCOPING REVIEW

21. It is worthwhile to review the wording used by DBEIS in the Introduction section of the Scoping Review on wind turbine noise assessment guidance[66].

> *"The purpose of the review is to determine whether the guidance adequately ensures that wind farm turbine noise is managed effectively and consistently in line with current Government policies on noise (...), accounts for contemporary technological and acoustical developments, and (if not), what updates may be necessary to achieve this."*

22. The first part of this statement is unequivocal—the purpose of this Scoping Review is to ensure that the current assessment guidance is "in line" with current Government policies on noise. Presumably, this means, in line with ETSU-R-97[67].

23. The second part is more surprising because it acknowledges the possibility that contemporary technological and acoustical developments *might not* be accounted for in the current assessment guidance.

24. Lastly, the purpose of this Scoping Review seems to be the gathering of information on what type of updates could be introduced into the existing assessment guideline to account for the hypothetical technological and acoustical developments.

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[65] https://www.gov.uk/government/publications/energy-white-paper-powering-our-net-zero-future
[66] https://www.smartsurvey.co.uk/s/ZJ1E81?fbclid=IwAR1MCDZDxYF5AndTiM5AgT3f6rUj

[67] ETSU-R-97: The assessment and rating of noise from wind farms. The Working Group on Noise from Wind Turbines, Final Report September 1996.

25. The recognition of the need to gather information is further corroborated by item 3) in the excerpt below:

> *"This survey is divided into three main parts:*
>
> *1) questions about topics addressed in the current UK wind turbine noise guidance,*
>
> *2) questions about wind turbine technology and wind farm design, and*
>
> *3) a request for any other evidence or suggestions that may be relevant to the intentions of this scoping review."*

---

26. The purpose of this information gathering exercise is explained as follows:

> *"[T]he current review will inform a decision on whether any future guidance development is required (...)."*

27. It is further added that:

> *"[N]o guidance development is being undertaken (...); but any potential subsequent development of guidance is likely to be accompanied by a consultation stage (...) However, please ensure you raise any key issues that you feel should be considered at this stage"* [bold in the original text].

28. In the meantime, as would be expected:

"This review and engagement does not affect any material considerations of the current UK onshore wind turbine noise assessment guidance within ongoing planning applications and decisions, which remain as referenced in the relevant authority policies." 29. Offshore wind turbines are excluded from this Scoping Review.

30. Lastly, the Introduction informs:

> *"Your responses to this engagement will be an important part of ensuring that the wind turbine noise assessment guidance in the UK is consistent with Government policies, and remains suitable."*

31. In Paragraph 21 above, a small portion of the statement of purpose of the Scoping Review was truncated, and is now reproduced below:

> *"The purpose of the review is to determine whether the guidance adequately ensures that wind farm turbine noise is managed effectively and consistently in line with current Government policies on noise and achieving 'Net Zero'[1]*

greenhouse gas emissions by 2050, accounts for contemporary technological and acoustical developments (...)" [our bold].

[1] Achieving the Government's ambitious 2050 Net Zero target will require significant increases in renewable electricity generation, and we will need to increase deployment across a range of technologies, including onshore wind. Our recent Energy White Paper: Powering our net zero future stated that we will need sustained growth in the capacity of onshore wind over the next decade, alongside solar PV and offshore wind."

32. A brief review of the above-mentioned 2050 Net Zero White Paper reveals a preponderance of discussion on *offshore* wind power stations, with only 2 entries for "onshore wind." Offshore wind power is excluded from the DBEIS Scoping Review.

G. DBEIS SURVEY QUESTIONS

33. Having laid out the stated purpose of this Scoping Review in Section E, it is now of interest to see what types of questions were included in this survey.

34. This survey can be taken online,[68] by invited organizations only.

35. Figure 2 shows the Definitions used in the survey.

36. "Amplitude Modulation" and "Tonality" are two features associated with 'noise' emitted by wind turbines—both exclusively imply the existence of *audible* disturbances.

37. Notably, there is no entry for "Infrasound" nor for "Low Frequency Noise," although the item associated with "Amplitude Modulation" may cover some aspects of the audible, low frequency noise emissions.

[68] https://www.smartsurvey.co.uk/s/ZJ1E81?fbclid=IwAR1MCDZDxYF5AndTiM5AgT3f6rUj

PLEASE READ THIS PAGE CAREFULLY BEFORE CONTINUING WITH THE SURVEY

Term	Meaning
Current UK wind turbine noise assessment guidance	*ETSU-R-97 The Assessment and Rating of Noise from Wind Farms (1996), the Institute of Acoustics Good Practice Guide to the Application of ETSU-R-97 (2013) and its six Supplementary Guidance Notes (2014)* It is acknowledged that further individual devolved UK administration noise guidance is also in place, both wind turbine specific and non-specific. It is also acknowledged that the SGNs to the IOA GPG do not officially form part of the guidance endorsed by all devolved administrations, due to the publication dates (specifically, the Northern Ireland Assembly and Scottish Government endorsements preceded the SGN publications). However, it is believed that the IOA GPG SGNs are widely viewed as representing best practice guidance around the UK.
Government policies on noise and Net Zero	*The UK devolved administration governmental policies on noise and achieving net zero targets for greenhouse gas emissions relevant in any UK nation to which your professional experience is applicable* If your experience encompasses more than one UK nation, please provide details of any divergence in your responses as they concern the context of the policies of each devolved administration, as appropriate.
Amplitude modulation	*A sound characteristic associated with the regular rotation of the wind turbine blades, sometimes described as 'swishing', 'whooshing', 'whoomphing', or 'thumping'*
Tonality	*A sound characteristic sometimes described as 'droning', 'humming', 'ringing', or 'whistling'*

Figure 2. Screen shot of the survey webpage-Definitions[2].

38. Following the questions related to identification of the participant in the survey, the pivotal question appears: see Figure 3.

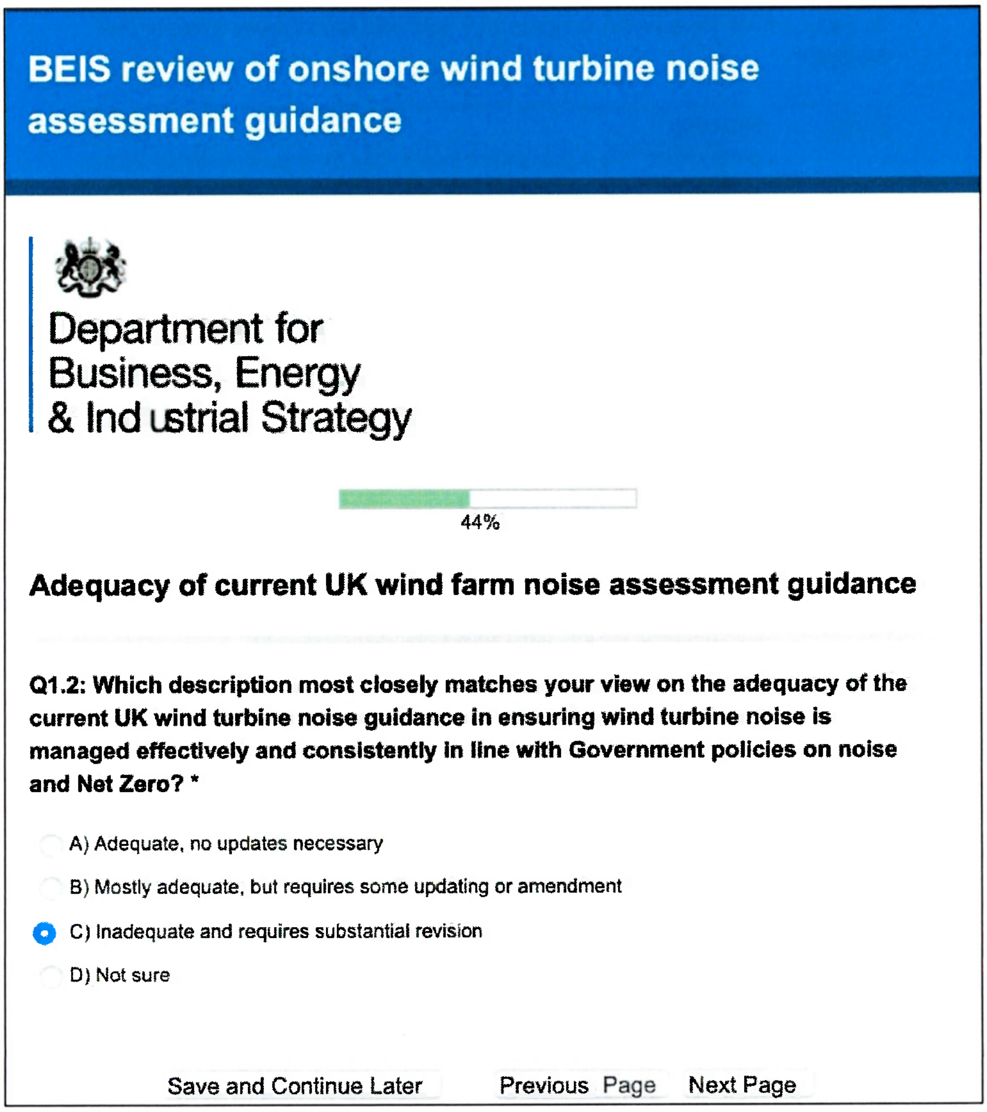


Figure 3. Screen shot of the survey webpage—Pivotal Question[2].

39. Figure 4 shows the next screen of the survey in which the participant is asked to choose from a list of topics associated with wind turbine noise assessment, indicating which topic would require updating.

Topics requiring updating

Q1.3: Which (if any) of the following topics relevant to the current UK wind turbine noise assessment guidance do you consider need to be updated? (Choose as many as applicable) *

- [x] Fundamental approach (holistic view of the guidance on managing wind turbine noise)
- [x] Baseline determination (pre-development environment)
- [x] Measurements of sound or meteorology
- [x] Consideration of atmospheric, meteorological, or topographical influences on sound
- [x] Evaluation of sound characteristics
- [x] Sound predictions
- [x] Noise impact assessment (including cumulative impact)
- [x] Noise controls (including noise limits, effects thresholds, and use of planning conditions)
- [x] Compliance determination and enforcement
- [x] Uncertainty
- [ ] Anything else not listed above (please specify in comments)

Figure 4. Screen shot of the survey webpage—Topics Requiring Updating[2].

40. The following screen in the survey lists these same topics and invites the participant to outline the updates believed to be required.

> **Q1.4: Please could you briefly outline the updates you believe need to be made to the current UK wind turbine noise assessment guidance, and identify any publicly accessible evidence you are aware of that would support or inform the updates indicated? (Please enter your responses under headings from the topics listed below that are most closely applicable to your suggestion)**

41. Lastly, specific questions are posed, as shown below:

> **Q2.1: Do you have any specific experience or research knowledge of the potential influence of wind farm or wind turbine design or age on sound emissions? ***

> **Q3.1: Please could you identify any publicly accessible evidence you are aware of that could be relevant to the development of any future UK wind turbine noise assessment guidance and is not already mentioned in your previous responses?**

Q3.2: Please could you briefly outline any suggestions you have for how any future UK wind turbine noise assessment guidance could be developed and maintained to provide a stable platform for development planning and assessment, while ensuring that it is kept up to date with robust scientific evidence?

H. EXCLUSION OF INFRASOUND & LOW FREQUENCY NOISE

42. IARO represents a group of scientists who, collectively, hold over 100 years of scientific experience in the field of infrasound and low frequency noise, and its effects of human health. Since 2016, our researchers have been recording and analysing acoustical data in and near homes located in the vicinity of onshore wind power stations, in the following countries (alphabetical): Australia, Canada, Denmark, England, France, Germany, Ireland, New Zealand, Northern Ireland,
Portugal, Scotland, Slovenia, and The Netherlands. Prior to 2016, all IARO scientists were already working either in acoustics alone or in acoustics and health.

43. All research conducted by IARO is part of the Citizen Science Initiative for Acoustic Characterization of Human Environments (CSI-ACHE), the research protocols for which have been approved by the New Zealand Ethics Committee (application number NZEC19_12).

44. In a nutshell, IARO provides citizens with continuous (weeks), high-resolution infrasound and low frequency noise recordings, during which time citizens log their symptoms in a diary.

45. Diaries are then time-matched with the recorded acoustic environment.

46. This methodology has been allowing IARO scientists to pin-point what type of acoustical disturbances are present when citizens claim to be most impacted by wind turbine 'noise.'

47. The ultimate goal of IARO Scientists is to contribute to the establishment of doseresponse relationships for infrasound and low frequency noise exposures, in both environmental and occupational settings.

48. The high-resolution methodology for recording acoustic environments as employed by IARO scientists is not prescribed by any guideline or legislative document.

49. IARO's methodology is, however, in compliance with the axioms of The Scientific Method and Evidence-based Medicine.

50. And now, some of those technical complexities arise.

Table 1 compares three major noise assessment parameters that clearly distinguish the methodology prescribed by ETSU-R-97 and the scientific methodology used by IARO Scientists.

Table 1: Comparison of noise assessment parameters used by ETSU-R-97 and IARO

Parameter	ETSU-R-97	IARO
Temporal resolution	*10-minute averages*	*1-second*
Frequency resolution	*1/3rd of an octave*	*1/36th of an octave*
Frequency weighting	*A-weighting*	*Unweighted*

51. Table 1 reflects a progression that is analogous to going from the hand-held magnifying glass to the table-top microscope.

Features that were previously unseen are now revealed and can be quantified.

52. IARO scientists have always found that images can greatly aid in the understanding of more complex technical issues. Figures 5, 6 and 7 provide a visual comprehension of the complexity of acoustics. A composite image with this data is provided at the end of this Commentary.

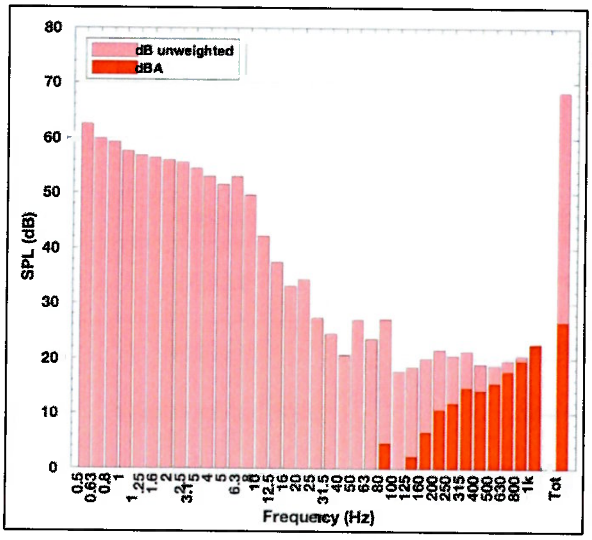
53. Figure 5A and 5B are not visually different.

In terms of ETSU-R-97 requirements (red bars), no significant difference exists between these environments. Moreover, in both, noise levels are below 30 dBA.

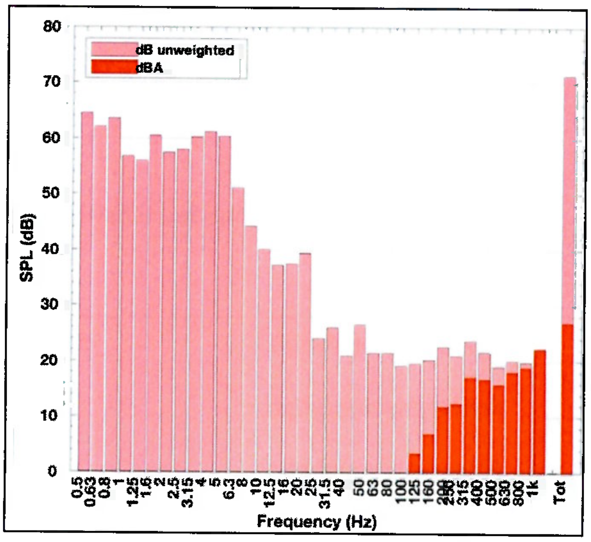
And yet, on July 22 (Fig 5A) the couple slept peacefully, while on July 29 (Fig 5B), they were unable to sleep, and were compelled to take medication.

Are they hallucinating? Are they suffering from some psychosomatic pathology? Is this evidence for the existence of a nocebo effect?[69]

[69] A psychosomatic disorder in which the patient believes s/he has contracted some illness, but no organic basis for illness exists; the opposite of the "placebo effect."



A



B

Figure 5. 1/3 octave band analyses of the acoustic environment within a bedroom of a home located near a wind power station. A: 22 July at 04:00, couple slept peacefully. B: 29 July at 03:20, couple required medication.

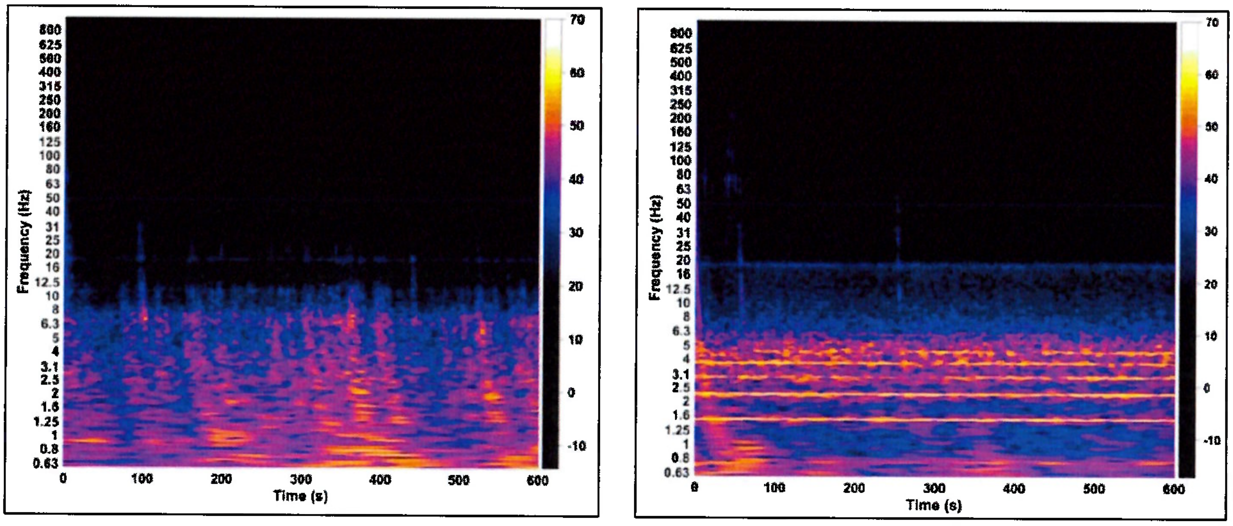
These images are analyses performed with a frequency resolution of 1/3rd of an octave (1/3rd octave band analysis), within the frequency range of 0.5—1000 Hz. Additionally, data is analysed over segments of 10-minute time averages.

The red bars reflect the 'noise' levels that are measured under ETSU-R-97 constraints, with the application of the A-frequency weighting filter, yielding the dBA (decibel-A) metric.

The pink bars reflect the 'noise' levels that are actually present in the bedroom, measured in unweighted (or linear) decibel units.

54. By observing the acoustic environment with methodologies that are free of the ETSU-R-97 constraints, a much different picture is obtained—one that exonerates citizens of suspicion of having developed psychosomatic disorders.

55. Figure 6 shows the exact same data as that presented in Figure 5, but with a higher resolution analysis.



A B

Figure 6. 1/36 octave band analyses of the acoustic environment within a bedroom of a home located near a wind power station. A: 22 July at 04:00, couple slept peacefully. B: 29 July at 03:20, couple required medication.

These images are analyses performed with a frequency resolution of 1/36th of an octave (instead of a 1/3rd octave band resolution), within the frequency range of 0.5—1000 Hz. The images reflect the same 10-minute segment as is shown in Figure 4, but instead of the 10minute time average, they show a second by second (600 seconds) breakdown of the environment.

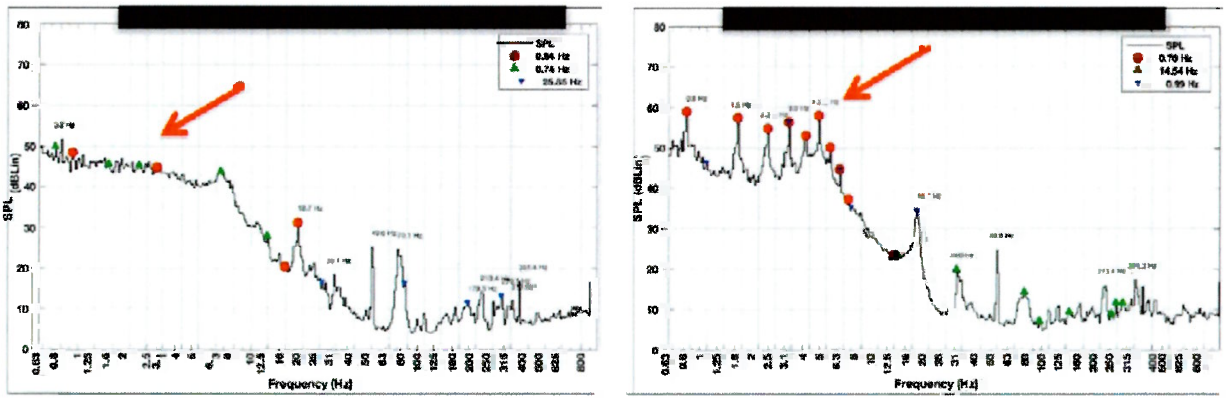
The colour-bar reflects the unweighted noise levels, at each 1/36th octave and at each second.

56. Figure 6B clearly exhibits straight horizontal lines, stretching throughout the 600second interval, with levels reaching up to 60 dB, and all occurring at frequencies below 5 Hz. This was on the sleepless morning of July 29th, when medication was required.

    These acoustic phenomena are not present in Figure 6A, which was the morning of July 22nd, when couple slept peacefully.

57. These horizontal lines correspond to the acoustic output of wind turbines. They can be mathematically matched to the technical specifications of each wind turbine make and model. They are called *wind turbine acoustic signatures*.

58. Another view of the same data might be helpful. Figure 7 shows the same numerical data as that used to construct the images presented in Figures 5 and 6. These images reflect the absence of elevated peaks of acoustic energy on the morning when the couple slept peacefully, and their presence on the sleepless morning when medication was required.



A B

Figure 7. Periodograms over a 10-minute average of the acoustic environment within a bedroom of a home located near a wind power station. A: 22 July at 04:00, couple slept peacefully. B: 29 July at 03:20, couple required medication. Arrows point to the absence (A) and presence (B) of the wind turbine acoustic signature.

59. Features that are not distinguishable with the "magnifying glass" (i.e., ETSU-R-97) become visible when using the "table-top microscope" (IARO scientific methodology).

60. By now, it should be clear to the readers of this report why IARO scientists welcomed and applauded the DBEIS initiative to consider reviewing the wind turbine noise assessment guidance.

61. Despite being outright precluded from the DBEIS Survey topics (see Fig. 2) "infrasound and low frequency noise" are inextricably associated with the acoustic output of wind turbines.

I. ETSU-R-97: A DISCLAIMER THAT VITIATES THE ENTIRE DOCUMENT

62. The 175-page document titled "The assessment & rating of noise from wind farms," known as ETSU-R-97, has an opening statement which is fully transcribed below:

> *"This report was drawn up under the direction of the Noise Working Group. While the information contained in this report is given in good faith, it is issued strictly on the basis that any person or entity relying on it does so entirely at their own risk, and without the benefit of any warranty or commitment whatsoever on the part of the individuals or organisations involved in the report as to the*

veracity or accuracy of any facts or statements contained in this report. The views and judgements expressed in this report are those of the authors and do not necessarily reflect those of ETSU, the Department of Trade and Industry or any of the other participating organisations."[70]

63. It is acknowledged that a certain level of protection against liability suits may be required for a document of this nature, and hence the following statement is understandable:

"...it is issued strictly on the basis that any person or entity relying on it does so entirely at their own risk..."

64. As Scientists, however, the second part of the ETSU-R-97 opening statement is astonishing:

"While the information contained in this report is given in good faith, it is issued strictly (...) without the benefit of any warranty or commitment whatsoever (...) as to the veracity or accuracy of any facts or statements contained in this report" (our bold).

65. What an extraordinary statement! It is very difficult for Scientists to read this statement and simply proceed with validating the remainder of the report.

66. Lest the readers of this Commentary be misguided into thinking that this type of wording is some sort of standard practice, IARO scientists would like to make the following very clear:

To the best of their knowledge to date, the IARO scientists that are signatories to this Scientific Commentary, stand behind the veracity and accuracy of all statements contained in this document.

67. It is shocking that a policy-decision document which has served as the core document for wind turbine noise assessments, with direct implications on Public Health, and where scientific evidence is of critical importance, is absent of any accountability or responsibility.

J. ETSU-R-97 IS UNRELATED TO PUBLIC HEALTH PROTECTION

[70] ETSU-R-97, Page 0

68. It might now be interesting to list the people and entities who knowingly co-signed a document of (self-acknowledged) questionable veracity and dubious accuracy[71]:

Members of the Noise Working Group:

Mr R Meir, Chairman	DTI
Dr M L Legerton, Secretary	ETSU
Dr M B Anderson	Renewable Energy Systems
Mr B Berry	National Physical Laboratory
Dr A Bullmore	Hoare Lea and Partners
Mr M Hayes	The Hayes McKenzie Partnership
Mr M Jiggins	Carrick District Council
Mr E Leeming	The Natural Power Company Ltd
Dr P Mu grove	National Wind Power Ltd
Mr D J Spode	North Cornwall District Council
Mr H A Thomas	Isle of Anglesey County Council
Ms E Tomalin	EcoGen Ltd
Mr M Trinick	Bond Pearce Solicitors
Dr J Warren	National Wind Power Ltd

69. *Questions*: Who represented the medical community?

If no medical expertise was relied upon, how is it that ETSU-R-97 has become the forefront document presumably contributing to the protection of Public Health, as far as wind turbine noise is concerned?

70. The answers to these questions become obvious in the first paragraph of the Executive Statement, transcribed below (our bold and italics):

"This document describes a framework for the measurement of wind farm noise and gives indicative noise levels thought to offer a reasonable degree of protection to wind farm neighbours, without placing unreasonable restrictions on wind farm development or adding unduly to the costs and administrative burdens on wind farm developers or local authorities. The suggested noise limits and their reasonableness have been evaluated with regard to regulating the development of wind energy in the public interest. They have been presented in a manner that makes them a suitable basis for noise-related planning conditions

[71] Two of the commercial enterprises represented in this Working Group are still closely involved in current wind turbine planning procedures (see Paragraph 3b and 3c).

or covenants within an agreement between a developer of a wind farm and the local authority" (Executive Summary, page iii).

71. ETSU-R-97 seems to be (yet another) example where an industrial sector is directly involved in the preparation of governmental 'guidelines' that shape policy-decisions and that minimize or outright ignore potentially harmful emissions generated by that particular industrial sector.

K. "WHAT YOU CAN'T HEAR CAN'T HURT YOU"

72. This is the outdated notion on which ETSU-R-97 is based: "what you can't hear can't hurt you."

73. It is this same outdated notion that explains why infrasound and low frequency noise is conspicuously excluded from the DBEIS Scoping Review.

74. Since infrasound is inaudible at the levels generated by wind turbines, it is considered by some to be irrelevant to human health.

75. In fact, those who 'complain about wind turbine noise' when levels are below the ETSU-R-97 mandated levels, are often ridiculed and labelled as suffering from the 'nocebo effect.' [8]

76. This outdated notion justifies the use of the A-frequency-weighting (yielding the dBA unit) (See Table 1).

77. It is also used to justify the claim that wind turbine acoustic signatures have no effect on health as they occur below the human hearing threshold.

L. CLOSING PERPLEXITIES

78. If the medical community was not represented in the preparation and publication of ETSU-R-97, how can the UK Government allow ETSU-R-97 be used to establish public policy with direct implications on Public Health?

79. What was the purpose of the DBEIS Scoping Survey, considering that a critical part of the problem was specifically excluded from discussion, namely, infrasound and low frequency noise?

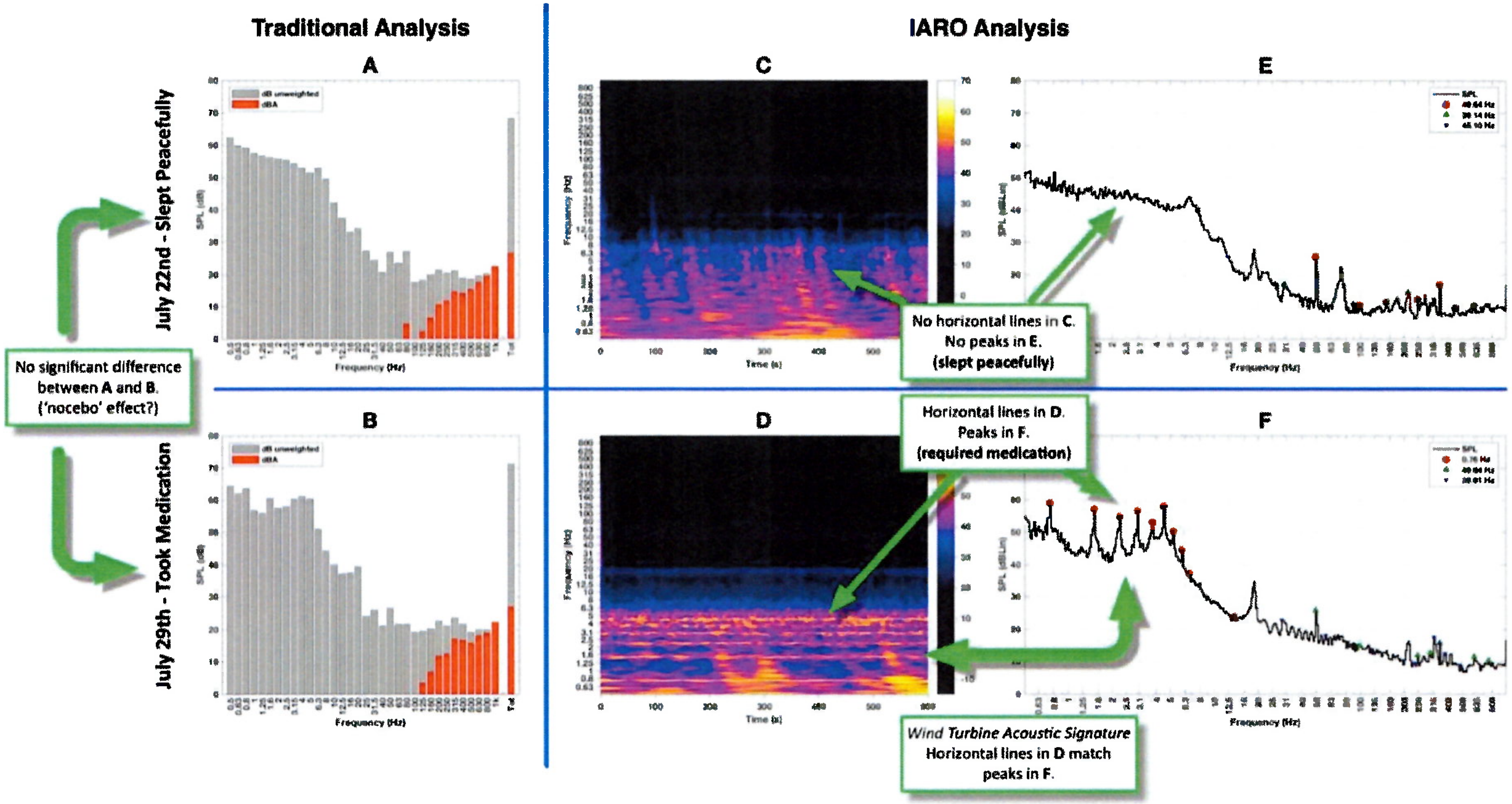
80. If offshore wind power plants are the focus (almost exclusively) of the currently imposed "2050 Net Zero target," why is the "2050 Net Zero target" being used by DBEIS to justify onshore wind turbine development?

81. If the "2050 Net Zero target" is of such paramount importance, why were offshore wind power plants specifically not included in the DBEIS survey? Both onshore and offshore wind turbines have the same type of acoustic signatures.

82. If the veracity and accuracy of *any* statement contained in ETSU-R-97 is questionable, as is self-acknowledged, how can it conscientiously be used to establish public policy?

83. Why does the UK Government, through DBEIS, rely on ETSU-R-97 for protecting the UK population against wind turbine noise?

84. These and several other critical issues, relevant for the well-being of the UK population, could have been opened for discussion with the DBEIS Scoping Survey.
Regrettably, they were not.



Composite Figure—Please see full legend on next page

Legend for the Composite Figure:

Comparison between the acoustic environments (10-minute recordings) in a bedroom of a home located close to wind power plants. On 22 July (at 04:00), the couple slept peacefully (A, C, E). On 29 July (at 03:20), medication was taken at 04:00 to 'deal with the noise' (B, D, F).

A and B

- Acoustic analysis using a 1/3rd octave resolution.
- Red bars indicate sound pressure levels in dBA, as required by ETSU-R-97.
- Overall noise levels are below 30 dBA and therefore, well within the ETSU-R-97 guideline.
- Grey bars indicate the sound pressure levels actually existent in the environment.
- No visual difference between A and B.

C and D

- Acoustic analysis using a 1/36th octave resolution.
- Straight horizontal lines are present in D—29 July, sleepless night
- No horizontal lines in C—22 July, slept peacefully
- Evident visual difference between C and D.

E and F

- Periodograms showing peak level.
- No peaks on July 22—slept peacefully.
- Prominent peaks on July 29—sleepless night requiring medication.

Takeaway message:

ETSU-R-97 requirements are insufficient to predict human health effects and are irrelevant for protecting Public Health against wind turbine noise immissions.

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Clinical Protocol for Evaluating Pathology Induced by Low Frequency Noise Exposure

Nuno A. A. Castelo Branco, M.D.
Senior Surgical Pathologist, R. Prof. Dias Amado, No. 5-1B, 1600-612 Lisbon, Portugal

Mariana Alves-Pereira, Ph.D.
Biomedical Engineer, Lusófona University, Campo Grande 376, 1749-024 Lisbon, Portugal

Augusto Martinho Pimenta, M.D.
Senior Neurologist, Julio de Matos Hospital, Av. do Brasil, 53, 1700-063, Lisbon, Portugal

José Reis Ferreira, M.D.
Senior Pneumologist, Clínica Doentes Pulmonares, Campo Grande, 4, 1700-092, Lisbon, Portugal

Summary

Segments of the general population who complain about infrasound & low frequency noise (ILFN) in their homes or in their workplaces continue to increase. These individuals often complain about similar sets of concurrent symptoms, and frequently attribute their ailments directly to ILFN exposure. Oftentimes, however, routine clinical evaluations of these individuals reveal no apparent dysfunction, and patients with persistent complaints are subsequently referred to psychology or psychiatry health professionals. The goal herein is to present an objective clinical protocol that scientifically evaluates these complaints, leading to the elimination of malingerers, and to the proper medical assistance of those developing ILFN-induced lesions.

PACS no. 43.40.Ng, 43.50.Qp, 43.80.Gx

Introduction

Since 1980, this team of scientists has studied the biological response to Infrasound & Low Frequency Noise (ILFN) exposure in both human populations [1-3] and laboratory animal models [4,5]. Over the decades, a valid clinical protocol has been established in order to ascertain a differential diagnosis for ILFN-exposed persons. The goal of this report is to list the medical diagnostic complementary tests relevant for evaluating ILFN-induced pathology. The rationale justifying each diagnostic test included in this ILFN clinical protocol will be but briefly described; extensive details can be found in the references provided.

2. Vibroacoustic Disease

The nosological entity triggered by excessive exposure to ILFN has been termed vibroacoustic disease (VAD) [1-3]. Despite the overwhelming antagonism with this nomenclature [6, for example], this time these authors have opted to use this specific name rather than "ILFN-induced pathology." VAD is a whole-body pathology characterized by proliferation of extra-cellular matrices (collagen and elastin) in the absence of an inflammatory process. VAD is a consequence of the disruption and restructuring of tissue and cellular components in order to maintain functional structural integrity in the presence of a mechanical agent of disease [further refs in 1]. The onset of VAD is insidious and frequently misdiagnosed. Individual ILFN exposure patterns dictate the time-evolution and ultimate severity of lesions, i.e., exposure times vs. recovery periods is of crucial importance, both for a prognostic view and for an appropriately detailed clinical history of ILFN exposure. Generally, ILFN exposure can be occupational or residential. With occupational exposures, recovery periods are usually certain, given the scheduled end of the workshift and the existence of weekends. Residential exposures, however, do not enjoy this type of recovery periods. The onset of VAD among individuals who are exposed to ILFN in their homes has been observed to be more rapid than those who are exposed to occupational ILFN. Over the past decades, there has been much controversy regarding several issues related to human health and noise exposure, such as, a) the role and range of the human auditory system in ILFN-rich environments; b) the physiological pathways responsible for inadequate quality of sleep, for hypersensibility and intolerance to sound, and for cardiovascular disease; and c) the parameters used for measuring ILFN, and for assessing health impacts on ILFN-exposed populations. These issues have been extensively addressed by this team of researchers, and are currently beyond the scope of this report. The clinical protocol herein defined will provide family physicians and epidemiologists with objective, useful and clinically valid data that could ensure appropriate medical assistance to potential VAD patients.

3. Clinical Protocol for ILFN Exposures

3.1. Fundamentals

Auditory effects of ILFN exposure differ from the classical picture of hearing loss due to acoustic trauma. In VAD, patients report of *hearing too much*, and commonly lower the volume of audio devices (as opposed to increasing the volume to hear better). Whether in occupational or environmental ILFN exposures, early symptoms frequently include mood disorders and sleep disturbances. As overall exposure time accumulates, physicians are often confronted with a myriad of complaints referring to a wide variety of organs and systems. If unfamiliar with VAD, extensive complementary diagnostic tests will be prescribed to confirm or exclude a clinical suspicion. Most of these medical examinations will disclose negative or borderline values in ILFNexposed patients, i.e. useless for a diagnosis. Generally, at this point, the clinician refers the patient to psychiatric care, with the likely suspicion of malingering or hypochondria. If, however, the physician suspects that ILFN may be playing a role in the patient's condition, the following complementary diagnostic tests are recommended for confirmation or exclusion of that hypothesis.

3.2. Echocardiogram

Thickening of the parietal pericardium was first observed in autopsy [7], then studied through echocardiography [8-10], and then confirmed through surgical pathology [11,12]. Pericardial thickening in the absence of diastolic dysfunction, and in the absence of an inflammatory process, is a hallmark response to ILFN exposure in humans. In VAD, pericardial echogenicity is visible with a GAIN setting of <45. See Fig. 1.

Figure 1 shows echocardiograms of Mr. R [13-15]. *Top image*: Gain set at 67. *Bottom image*: Gain set at 39.

Valve pathology may also be present, particularly in the more severe cases [8-10]. When thickened pericardia are observed through echocardiography, and no accompanying diastolic dysfunction exists, this indicates that significant ILFN exposure has taken place. Echo-imaging alone, however, is insufficient to establish a full VAD diagnosis. Firstly, because this organic manifestation is a *sign* of ILFN exposure, and not a nosological entity in itself. Secondly, no standardized methodology exists to numerically evaluate pericardial thickness. Hence, an undesirable element of subjectivity is introduced with this diagnostic test, making it susceptible to erroneous interpretations [16, for example] and/or deliberate manipulations. With the introduction of GAIN considerations, however, the degree of subjectivity of this imaging technique can be drastically reduced. Echocardiography is, therefore, the diagnostic method of choice for exposure confirmation and patient selection.

3.3. Brain MRI

This imaging test includes the evaluation of structural changes in brain tissues. Albeit nonspecific to VAD, brain tissue changes in ILFNexposed patients include: a) hyperintense foci in T2 of the subcortical and periventricular white matter, basal ganglia and brain stem, and b) cerebral atrophy and dilation of the perivascular Virchow-Robin spaces. The most frequent locations for these appearances are the sublenticular and periatrial areas, and semioval centers [17]. While these situations may be expected in older populations, they are not desirable among working populations within the 35-55 year age range. VAD patients often exhibit low tolerance to this examination, and frequently remain bed-ridden for the rest of the day.

3.4. P300 Event Related Evoked Potentials

This non-invasive and objective neurological test evaluates nerve conduction times of processes that occur in the cerebral cortex. The P3 and N2 components of Event Related Potentials (ERP) are related to decision processing and stimuli classification, respectively, and increased latencies in these components have been associated with cognitive deterioration [18]. Longer latencies and lower amplitudes of ERP are observed in ILFNexposed individuals [17]. VAD patients who present with the above described brain MRI lesions, also exhibit significant latencies of the endogenous N2 component, and significantly decreased amplitudes of the P3 component [17]. The presence of cortical lesions, confirmed through brain MRI, is associated with the changes seen in the P300 ERP values. Frontal topography and multipeaked appearances, as observed in these ILFN-exposed individuals, are similar to those found in the elderly and in patients with degenerative processes of the brain.

3.5. Brainstem Auditory Evoked Potentials

This is another non-invasive and objective neurological test. Here, nerve conduction times of processes occurring within the brainstem are evaluated. These can be altered due to demyelinization foci or expansive lesions. In ILFN-exposed individuals, brainstem auditory evoked potentials (BAEP) exhibit increased latencies in wave intervals III, IV and V [19]. Increased BAEP wave V interval latencies were correlated with hyperintense foci in T2 observed in the brainstem through MRI. VAD patients often develop balance disturbances, and these were associated with the existence of asymmetric values for the BAEP wave V interval latency, in both ears [20]. BAEP results suggest that some central dysfunction is occurring at the level of the brainstem. This is further corroborated by the results obtained in ILFN-exposed individuals through the next diagnostic test in this discussion.

3.6. PCO_2 respiratory drive evaluation

This evaluation is performed within the context of lung function tests. The neurological centers of the control of breathing are located in the brainstem. This control system modulates respiratory rate and respiratory (either inspiratory or expiratory) pressure depending on CO_2 concentration: as CO_2 concentration increases, so does the neurologically-controlled respiratory rate and respiratory pressure drive. In VAD patients, this increased respiratory rate and drive in the presence of increased CO_2 is only mildly observed [21]. The significance of this impaired partially autonomic reflex among ILFN-exposed individuals is not yet clearly understood, and raises many (more) questions regarding the pathophysiological mechanisms of this agent of disease. Nevertheless, it further corroborates the existence of brainstem lesions in ILFN-exposed humans. In respiratory functional tests, changes of metacholine sensitivity is common in VAD patients, probably related to the cellular changes in epithelial bronchial cells which present cellular cholinergic degranulation processes [1,4,22].

3.7. Bronchoscopy

This is a highly invasive examination, and is only recommended for forensic purposes within the context of legal proceedings. In VAD patients, vascular-like lesions are observed in both tracheal and bronchial trees, uniformly distributed bilaterally near the spurs [23]. Biopsies of these lesions were taken and studied with light and electron microscopy, revealing the same features observed before in ILFN-exposed human and animal samples, namely, organized proliferation of collagen and elastin in the absence of an inflammatory process [1,2]. Respiratory diseases (specifically, asthma-like conditions, and squamous cell carcinomas, particularly of the right lung) that develop among noise-exposed populations should be carefully considered in light of the morphological impact that ILFN has on respiratory tract structures [22].

3.8. Voice Acoustic Analysis

In a more recent area of study for VAD researchers, this non-invasive test evaluates changes in voice production as a consequence of physiological changes of the laryngeal anatomical structure system. Morphological changes of the respiratory tract structures, such as those seen in ILFN-exposed human and animal models, can alter several parameters associated with voice acoustics. The fundamental frequency among three vowels significantly increases with increasing ILFN exposure time [24,25]. Changes in other voice acoustic parameters, such as jitter and shimmer perturbation measures, harmonic-to-noise ratio, and maximal phonational frequency range, also exhibited changes but these are not yet fully understood. Bronchoscopy imaging of the vocal folds revealed the same, above-mentioned, vascular-like lesions as observed in the tracheal and bronchial trees [23]. This non-invasive, voice acoustic evaluation that seems to reflect a doseresponse pattern for VAD patients is poised to become an invaluable complementary diagnostic tool for ILFN-induced pathology

3.9. Hemostasis and Coagulation Parameters

In extreme stress environments, states of elevated hypercoagulability have been documented [26,27]. In ILFN-exposed individuals, spontaneous platelet aggregation was observed in the most severe cases while platelet aggregation values are abnormally high in all VAD patients. In ILFN-exposed persons the plasminogen activator inhibitor-1 (PAI-1) is significantly increased, even after several days post-ILFN exposure [27]. Increased PAI-1 is an indicator of fibronolysis inhibition and activation of coagulation, leading to situations of hypercoagulability.

3.10. Immunological Parameters

Autoimmune disorders, particularly collagenous diseases, are common among the more extensively ILFN-exposed individuals [1,9]. Lupus-prone animal models exposed to ILFN saw an earlier onset and higher mortality rate than the non-noiseexposed control group [28]. ILFN-exposed Wistar rats saw the pleural immune mechanisms highly impaired, when compared to non-exposed controls

[5]. In ILFN-exposed animals, splenic $CD4^+$, $CD8^+$, and IgM^+B lymphocyte populations were decreased when compared to non-exposed controls [29]. In VAD patients, the number of circulating $CD8^+$ and $CD4^+$ T lymphocytes was significantly increased when compared to non-noise-exposed controls [30]. Pericardial fragments of VAD patients observed through electron microscopy revealed remarkable amounts of cellular debris due to non-programmed (non-apoptotic) cellular death [1,11,12]. It is, therefore, unsurprising that VAD patients often develop lupus, vitiligo, and other autoimmune disorders [1]. Hence, complementary examinations should include assays for antinuclear and anti-mitochondrial antibodies, C-reactive protein, and systemic lupus erythematous.

3.11. Exposure Histories

To assess the probability of a patient's symptomatology being associated with excessive ILFN, a comprehensive noise exposure history must be taken. Not only will this aid diagnosis, but it will also provide valuable prognostic information. Noise exposure histories begin with fetal exposure that will depend on the mother's profession and residential conditions. Residential exposures during childhood are of fundamental importance given the cellular processes that occur only during this time of human physical and emotional growth. The relative position of bedrooms in relation to noisy streets, potentially concurrent with occupational exposures, and a variety of different types of recreational noise exposures, must all be taken into account in order to obtain an accurate clinical picture of the patient. The development of ailments in the individual's history should be viewed in light of the chronological exposure to noise. Each type of individual noise source also provides key information for ascertaining the extent of the risk factors for VAD to which the individual has been exposed. Documentation of the time spent away from the ILFN-rich environments (i.e., recovery periods) is crucial for characterizing the evolution of VAD.

4. Health Impact of ILFN Exposure

Over the past decade, the health impact of ILFN exposure has taken on a new life due to the worldwide energy crisis and the urgent implementation of numerous industrial wind turbines (IWT), as decreed by many governments. Since little regard was initially given to the ILFN generated by these devices, it was not long after their installation that families living in their vicinity began having complaints. Recognizing the problematic situation, several agencies and institutions worldwide began conducting studies and publishing papers with titles suggesting that health impacts were being evaluated among these residential populations. However, upon a closer examination, significant design flaws rendered

most of these studies useless [31, for example]. While this may not have been a concerted effort, it is however a consequence of the perpetuation of an historical fact: acousticians, usually with no medical background, are generally greatly involved in noise-impact study designs. Therefore, information on the "health impacts," as rudimentarily obtained through questionnaires or interviews, is often deemed sufficient in order to establish whether or not ILFN is, *de facto*, having an impact on the health of human populations. Objective clinical evaluations of families and animals living in the vicinity of IWT are not commonly performed. ILFN is a physical agent of disease, and infrasound (<20 Hz) is internationally classified as *non-ionizing radiation*. The type of toxicological effect and the evolution and onset of disease caused by ILFN exposure is partially analogous to that caused by radiation. As with radiation exposure, a) the onset of ILFN-induced disease greatly depends on time-exposure patterns; b) different wavelengths of the physical agent affect different organs and tissues; c) the individual need not perceive the agent of disease for a pathological effect to occur within the body; and d) prior exposure histories are a determining factor of key importance. These facts *must* condition the design of studies purporting to evaluate the health impacts of residential ILFN exposure; but currently, they do not. It is recognized that there is an added cost to conducting real clinical studies among ILFNexposed populations. The next obvious question, though, is: what is the added cost associated with continuing with the *status quo*. While this issue is way beyond the scope of this paper, it is nevertheless pertinent to recall episodes in humanity's recent history, having to do with asbestos, smoking and pesticides.

5. Looking Forward

In the interest of becoming a responsible and mature human society, activities that are deleterious to human health and wellbeing should not be hidden, obfuscated, or otherwise camouflaged. History unequivocally demonstrates the benefits of dealing outright with any potential human-health issue. It is recognized that the production of electrical energy has become the warp and woof of modern societies, and hence the urgency to procure new ways of harvesting energy that can be rapidly (and inexpensively) transformed into electrical energy. There need not be, however, such antagonistic, acrimonious and spiteful endeavors between ILFN disturbed families and *industry*, be it in of the energy, transportation, military, entertainment or manufacturing sectors of society. Having contextualized the issue, it is therefore of paramount importance that the clinical parameters used to evaluate the specific type of pathology caused by excessive ILFN exposure be the most appropriate for the job. Audiometry, electrocardiography, cortisol levels, and number of nighttime arousals are remarkably imprecise measures to clinically evaluate the adverse health impacts of noise exposure. Whether transverse or longitudinal epidemiological studies are planned, the clinical parameters required to ascertain the extent of ILFN-induced pathology have herein been outlined. It is hoped that this report will contribute to a symbiotic relationship between the ILFN-generating industries and world citizens.

Acknowledgement

VAD researchers profoundly and gratefully acknowledge the participation of all voluntary patients and *pro bono* scientists who have, over the decades, greatly contributed to this body of knowledge.

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[30] A.P. Castro, A.P. Águas, N.R. Grande, E. Monteiro, N.A.A. Castelo Branco: Increase in CD8+ and CD4+ T lymphocytes in patients with vibroacoustic disease. Aviation, Space & Environmental Medicine 70 (1999) A141-4.

[31] Executive Office of Energy and Environmental Affairs of the State of Massachusetts, USA: Wind turbine health impact study: Report of an independent expert panel.
January 2012.
www.mass.gov/eea/docs/dep/energy/wind/turbineimpact-study.pdf

Grosvenor Consultancy
Seskin Planning Application Reference 2460122.

Annex 5.

IARO Response to Applicant's Appendix 12.2 Operational Wind Turbine Noise Report.

15. The Health Effects of 72 Hours of Simulated Wind Turbine Infrasound: A Double-Blind Randomized Crossover Study in Noise-Sensitive, Healthy Adults - PMC (nih.gov).

Para 3.2.12.

3.2.12 Since the publication of the WSP BEIS report, the study that was granted funding by NHMRC (the National Health and Medical Research Council of Australia) was published in the Environmental Health Perspectives (EHP) journal which is published by the United States National Institute of Environmental Health. **The study (14) aimed to test the effect of exposure to 72 hours of infrasound (designed to simulate a wind turbine infrasound signature) exposure on human physiology, particularly sleep.** The study concluded that: 'Our findings did not support the idea that infrasound causes WTS1. High level, but inaudible, infrasound did not appear to perturb any physiological or psychological measure tested in these study participants.'

The response provided for this item is reproduced from a Report authored by IARO - International Acoustic Research Organization, within the context of the Rural Sheep Farm case in Scotland. The numbered footnotes are applicable to this report. Please note these foot notes do not directly cross reference to Grosvenor Consultancy's WTN submission in respect of the Seksin WPP proposal ref 2460122, but in some instances maybe be informative as supplementary evidence sources.

1. In the 2023 study by Marshall *et al.*,[72, 73] the objective is stated as follows:

[72] Marshall N, Cho G, Toelle BG, Tonin R, Bartlett DJ, *et al.* (2023) The Health Effects of 72 Hours of Simulated Wind Turbine Infrasound: A Double-Blind Randomised Crossover Study in Noise-Sensitive, Health Adults. *Environmental Health Perspectives*, 131(3): 1-10. https://pubmed.ncbi.nlm.nih.gov/36946580/

[73] Disclaimer included in the 2023 Marshall *et al.* paper: "All of the authors have superannuation accounts which are compulsory in Australia and these accounts may contain investments in both traditional and renewable energy, including wind turbines. R.T. is the founding principal of Renzo Tonin Associates who have previously worked as consultants for the NSW Department of Planning on several wind farms in NSW, Australia. None of the investigators have any other pecuniary interest or academic conflicts of interest in the outcomes of this study."

We aimed to test the effects of 72 h of infrasound (1.6–20 Hz at a sound level of ~ 90 dB pk re 20 microPa, [74, 4] *simulating a wind turbine infrasound signature) exposure on human physiology, particularly sleep.*

2. [75] In Medical Sciences, this type of study purports to investigate the <u>immediate effects</u> of exposure, as opposed to long-term effects:

Our principal hypothesis was that exposure to infrasound in healthy individuals, at a level of ~ 90 dB pk re 20 microPa compared with the sham infrasound, increases WASO [76] *—a measure of sleep disturbance—and worsens other measures of sleep quality, mood, WTS* [77] *symptoms, and other electrophysiological measures. In addition, as a positive control, we also tested whether audible traffic noise, a mixture of road (motorbike, truck, car) and aircraft noise (at a sound level of 40–50 dB LAeq; night and 70 dB LAFmax transient maxima) had an adverse impact on these same outcomes, when compared with sham infrasound.*[78]

3. The conclusions of this study were:

Our study found no evidence that 72 h of exposure to a sound level of ~ 90 dB pk re 20 microPa of simulated wind turbine infrasound in double-blind conditions perturbed any physiological or psychological variable. None of the 36 people exposed to infrasound developed what could be described as WTS. Our study is unique because it measured the effects of infrasound alone on sleep. This study suggests that the infrasound component of WTN [wind turbine noise] *is unlikely to be a cause of ill-health or sleep disruption, although this observation should be independently replicated.*

4. The dose presented to these subjects "simulating a wind turbine infrasound signature" was questioned by scientists from the International Acoustics Research Organisation (IARO—iaro.nz.org), and correspondence with co-author R. Tonin was exchanged (in May 2023) to ascertain what "simulated wind turbine infrasound" meant.

5. Regrettably, the material provided by co-author R. Tonin was regarded by IARO scientists as unsatisfactory, if "simulating a wind turbine infrasound signature" was the objective. The acoustic pattern used to simulate the wind turbine signal had a sawtooth profile, not the short-duration pulses of the wind turbine acoustic signatures, see Error! Reference source not found.. A sawtooth-shaped wave has a quick onset, a slow decay, and only locally oscillates the air. Wind turbine acoustic signatures hve a rapid onset and decay, and 'pump the air' (as

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[74] See Appendix 1—Medical Sciences: IV. How is noise quantified?

[75] See Appendix 2—Physics of Acoustics: I. What is Sound?

[76] WASO = Wakefulness After Sleep Onset is the total number of minutes that an individual is awake after having initially fallen asleep.

[77] WTS = Wind Turbine Syndrome. See: Pierpont N. (2009) Wind Turbine Syndrome: A Report on a Natural Experiment. K-Selected Books: Santa Fe, New Mexico, USA. https://www.researchgate.net/publication/265247204_Wind_Turbine_Syndrome_A_Report_on_a_Natural_Experiment

[78] Marshall N, Cho G, Toelle BG, Tonin R, Bartlett DJ, et al. (2023) The Health Effects of 72 Hours of Simulated Wind Turbine Infrasound: A Double-Blind Randomised Crossover Study in Noise-Sensitive, Health Adults. Environmental Health Perspectives, 131(3): 1-10. https://pubmed.ncbi.nlm.nih.gov/36946580/ [Footnotes contained in the original text are not included.]

proposed by Dr Stephan Kaula, Germany), rather than only causing the local oscillations that are typically seen in airborne, acoustic propagation phenomena.

6. Nevertheless, for the sake of scientific discussion, it will be temporarily accepted that the subjects of this study were actually presented with a properly simulated wind turbine infrasound signature.

7. The idea seems to have been to investigate immediate responses to the simulated wind turbine infrasound signature, but as measured by parameters that, perhaps, were not so relevant for assessing immediate responses.[79, 80, 81, 82]

8. Another questionable practice was the selection of the "healthy individuals" as study subjects. No evaluation appears to have been made regarding prior exposures [12] to infrasound and low frequency noise.

9. Marshall *et al.* explain the viewpoint that foundationally justifies their study:

People who suffer from WTS [Wind Turbine Syndrome [83]] *report that their symptoms begin quickly when they are exposed to infrasound from wind turbines and are then sustained. Our scientifically robust study provides evidence to address this claim. The Australian NHMRC* [National Health and Medical Research Council] *report that gave rise to our study made note of this "absence of evidence" rather than concluding an "evidence of absence" owing to the lack of any laboratory-controlled double-blind experiments of sufficient duration and intensity to hypothetically induce WTS in a human.*[84]

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[79] Mohr GC, Cole JJN, Guild E, von Gierke HE. (1965) Effects of low-frequency and infrasonic noise on man. *Aerospace Medicine*, 36: 817-24.

[80] Ponomarkov VI, Tysik A, Kudryavtseva VI, Barer AS. (1969) Biological action of intense wide-band noise on animals. *Problems of Space Biology* NASA TT F-529, 7(May): 307-9.

[81] Castelo Branco NAA, Gomes-Ferreira P, Monteiro E, Costa e Silva A, Reis Ferreira J, Alves-Pereira M. (2003) Respiratory epithelia in Wistar rats after 48 hours of continuous exposure to low frequency noise. *Journal of Pneumology, formerly Revista Portuguesa Pneumologia*, IX (6): 474-79. https://pubmed.ncbi.nlm.nih.gov/15190432/

[82] Castelo Branco NAA, Reis Ferreira J, Alves-Pereira M. (2007). Respiratory pathology in vibroacoustic disease: 25 years of research. *Journal of Pneumology, formerly Revista Portuguesa Pneumologia,* XIII (1): 129-135. https://pubmed.ncbi.nlm.nih.gov/17315094/ 12 Including, foetal, childhood and young adult exposures in residential, occupational, and leisurely settings— The parameter of prior exposures is of fundamental importance when investigating the biological effects of exposures to physical agents of disease, such as noise from wind turbines.

[83] Pierpont N. (2009) *Wind Turbine Syndrome: A Report on a Natural Experiment.* K-Selected Books: Santa Fe, New Mexico, USA. https://www.researchgate.net/publication/265247204_Wind_Turbine_Syndrome_A_Report_on_a_Natural_Experiment

[84] Marshall N, Cho G, Toelle BG, Tonin R, Bartlett DJ, *et al.* (2023) The Health Effects of 72 Hours of Simulated Wind Turbine Infrasound: A Double-Blind Randomised Crossover Study in Noise-Sensitive, Health Adults. *Environmental Health Perspectives*, 131(3): 1-10. https://pubmed.ncbi.nlm.nih.gov/36946580/ [Footnotes contained in the original text are not included.]

10. "Induce WTS in a human"? [85] As far as is understood by scientists, WTS is not commonly viewed as an immediate effect of the exposure to this agent of disease.[16]

[85] "The causes of this syndrome have been the subject of substantial international controversy. Proponents have contended that the symptoms that compose this syndrome are caused by low frequency subaudible infrasound generated by wind turbines. Critics have argued that these symptoms are psychological in origin and are attributable to nocebo effects. The Australian National Health and Medical Research Council Wind Farms and Human Health Reference Group concluded that the available evidence was not sufficient to

11. The expression "laboratory-controlled double-blind experiments of sufficient duration and intensity" as applied to the matter at hand is simultaneously unethical, dangerous, and unnecessary.[17, 18]

12. Is it the desire of the Australian NHMRC to expose subjects to a toxic agent—which is very difficult, if not impossible, to reproduce in laboratory settings—until some clearly severe health endpoint is observed? While tens of thousands of citizens are sitting in real-life laboratories being 'accused' of developing psychosomatic disorders?

13. Had this study been performed on 3 groups of people, differentiated by the extent of their prior exposures (mild, moderate, or extensive), and, abiding by appropriate selection criteria of the study population, then, perhaps, statistically useful numbers could have been obtained, and scientifically useful results could have been achieved. The inability to reproduce 'wind turbine infrasound' under laboratorial conditions, however, would still render this study as irremediably flawed, while its overall design could be deemed ethically questionable.

14. This methodology is considered to reflect sub-standard practices of Scientific Inquiry.

15. In conclusion, the effort expended by these authors to conduct this study is laudable (particularly given the position of the Australian NHMRC), even though, scientifically, within the realm of Medical Sciences and dose-response relationships, its results are inconsequential for the investigation into wind turbine noise and health.

establish which, if either, of these explanations is correct." See: Marshall N, Cho G, Toelle BG, Tonin R, Bartlett DJ, et al. (2023) The Health Effects of 72 Hours of Simulated Wind Turbine Infrasound: A Double-Blind Randomised Crossover Study in Noise-Sensitive, Health Adults. Environmental Health Perspectives, 131(3): 1-10. https://pubmed.ncbi.nlm.nih.gov/36946580/

16 Pierpont N. (2009) *Wind Turbine Syndrome: A Report on a Natural Experiment.* K-Selected Books: Santa Fe, New Mexico, USA. https://www.researchgate.net/publication/265247204_Wind_Turbine_Syndrome_A_Report_on_a_Natural_Experiment

17 What kind of "laboratory-controlled double-blind experiments of sufficient duration and intensity" were conducted for asbestos contamination leading to asbestosis? Or for issues related to second-hand smoking, use of glyphosates, etc?

18 Alves-Pereira M, Rapley B, Bakker H, Summers R. (2019) Acoustics and Biological Structures. In: Abiddine Fellah ZE, Ogam E. (Eds) *Acoustics of Materials*. IntechOpen: London. DOI: 10.5772/intechopen.82761.

Grosvenor Consultancy
Seskin Planning Application Reference 2460122.

Annex 6

Evidence in response to the Applicant's
Appendix 12.2 Operational Wind Turbine Noise Report.

Reference Para 3.2.7 Appeal Case reference *PPA-310-2028, Clydeport Hunterston Terminal Facility.*

Evidence also submitted to:

Conjoined public inquiry concerning:

WIN 370-4 Craiginmoddie Wind Farm, Dailly, South Ayrshire, KA26.
WIN 370-5 Carrick Wind Farm, Approximately 6 km South of Straiton, South Ayrshire, KA19.
WIN 370-6 Knockcronal Wind Farm, Knockcronal, Straiton, South Ayrshire, KA19.

TOPIC : WIND TURBINE NOISE.

ON BEHALF OF Save Straiton for Scotland.

Hunterston National Offshore Wind Turbine Test Facility.

Hearing Statement Rita Holmes.
Chair of Fairlie Community Council.

INTRODUCTION.

1. The National Offshore Wind Turbine Test Facility (NOWTTF) at Hunterston close to Fairlie in North Ayrshire was commissioned to test offshore turbines on shore. The initial planning consent for the operational testing was for a period of five years.

The two operational turbines at that time, were the largest wind turbines ever to be constructed on shore in the UK and were operational between December 2014 and October 2017. These comprised of a Siemens 6MW turbine and a 7.2MW Mitsubishi Sea Angel turbine to a maximum height of 198.5m. The turbines were commissioned and operated by SSE.

2. Witness Statement.

2.1. My name is Rita Holmes. I have lived in the Ayrshire village of Fairlie, on the west coast of Scotland, since 1972 and brought my two children up there. I have a Diploma in Education and taught in primary schools over 22 years. For the last three years of my career, I delivered the excellent Science programme for our school for Primary 1 to Primary 7 classes.

I have been fortunate enough to enjoy robust good health throughout my 75 years.
I am Chairwoman of Fairlie Community Council, and have been a member of it for 18 years.

I have been Chairwoman of Hunterston Site Stakeholder Group (HSSG) for the past 8 years and a member since 2005, when it was set up by the Nuclear Decommissioning Authority.

I am co-chair of the Nuclear Decommissioning Authority / Non Governmental Organisations Forum (NDA/NGO Forum) which was set up last year.
I have been for the past 10 years and continue to be a member of the Office of Nuclear Regulation/ Non Governmental Organisations Forum (ONR/NGO Forum) and the Department of Energy Security and Net Zero/ NGO Forum (DESNZ/NGO Forum.

I am Fairlie Community Council's representative on the Hunterston Parc Liaison Group, which is concerned with developments at Hunterston Parc. This is land, owned by Peel Ports, just south of our village. Our Community Council is one of the Statutory Consultees for the Hunterston area which is designated for industry, so we consider many major planning applications. It was on this land, at the redundant Marine Construction Site, that the National Offshore Wind turbine test facility was located. It lies 3.5km across water from our village. I personally did not oppose this development, as I saw it as helping with the way forward for renewable energy that would enable Scotland to move away from nuclear electricity generation. I became very interested in nuclear issues as we live about 5 kilometres from the two nuclear power stations, one, Hunterston B, now defuelling and Hunterston A which has been decommissioning for almost two decades now. My interest is primarily in Low Level Radiation and Health.

I am not a fan of nuclear power, but fully understand the need for safe and secure decommissioning and clean up, as well as the viable options. So, I was totally pro wind energy. I still appreciate its place in electricity generation, but I now do not support the push for larger more powerful wind turbines on land as I know the adverse effects that the non ionising radiation, i.e., Infrasound Low Frequency Noise had on my neighbours and me. My experience of the effects from the two huge wind turbines at Hunterston have made me realise that Wind Energy, like Nuclear Power has its severe and negative health impacts for those living within the range of the Infrasound Low Level Frequency sound pressure wave propagation from large scale wind turbines.

I have provided a personal impact statement at Para 6.1 below.

3. Background - SSE's NOWTTF Variation Application seeking to extend operation and testing for a further years 2 and subsequent Appeal Decision.

3.1 Despite the fact SSE gained a variation permission on appeal to Scottish Ministers (Date of appeal decision: 9 January 2018.) to continue operations for a further 2 years from the original consent expiry date of 14th October 2017, SSE did not conduct further testing, or operations after this date even though they had consent to continue operations to October 2019.

3.2 Hunterston S42 Appeal decision letter reference: PPA-3102028.

Site address: Clydeport Hunterston Terminal Facility, approximately 2.5 km south-west of Fairlie.

Extract:

"The development proposed: the erection of up to 3 wind turbines with a maximum tip height of 198.5 metres and ancillary infrastructure, including foundations, crane hard standings, access tracks, three temporary meteorological masts, transformers, underground cabling, substation, control building, welfare facilities and a temporary construction compound"

"That the site shall be used as a facility for the testing of a maximum of 3 off-shore wind turbines at any given time for a period of 5 years from the date of operation of the first turbine, prior notification of which commencement date of operation of the first turbine shall be

submitted in writing to North Ayrshire Council as Planning Authority; at the expiry of the 5 year period or 14th October, 2017.

3.3. The Reporter at paragraphs 29 to 44 considered submissions by local residents in respect of the reported adverse health impacts by affected local residents and concluded at Para 45:

I appreciate that some of those who complain about dizziness and other symptoms are extremely firm in their view that these symptoms are caused by the operation of at least one of the turbines on the appeal site. But the balance of evidence, including the literature reviews undertaken by the health authorities and the evidence from local survey and analysis, does not support complainants' views about the root cause of their symptoms. The potential effects of the Mitsubishi turbine operating in the future at full power (unlike its mode of operation, for instance, during the survey that I referred to at paragraph 39 above), are not clear. The balance of the evidence indicates to me that further turbine testing as sought in the appeal application should not be refused on the basis of adverse effects on the health of the local population. In the event that a causal link is established between turbine operation at the appeal site and such effects, this could be addressed through environmental protection and public health legislation. Consequently, even with a reasonable application of the precautionary principle, I do not consider that the evidence of adverse effects on the health of the local population is sufficient to justify or support refusal."

4. Does the Reporter's <u>recommendations and decision in reality</u>, honestly reflect the background and outcome of this case that led to the halting of testing and operations of both of the offshore turbines at around the time of the appeal decision in January 2018?

4.1 Let us carefully consider the evidence:

SSE's published intention for Continued Operation and Power Generation should the Variation Application be consented by either NAC planning or on appeal.

4.2 In consideration an important starting place is to reference a complete extract of the Hunterston Offshore Wind Turbine Test Facility - SSE Community Liaison Group - Meeting Notes held in Largs Library on 07/11/2016.

Agenda.

4.) Noise Concerns

Claire confirmed that the operational noise monitoring for the Siemens wind turbine was completed in December 2014. The document detailing the results of the noise monitoring was emailed out to the Liaison Group following the Liaison Meeting held in April 2015 and has been recently sent out again for information as requested.

Standard noise monitoring for the Mitsubishi wind turbine has not as yet fully commenced due to the intermittency of wind turbine operation and daytime only operation during the commissioning phase. Noise testing would typically be done in the evening times and at weekends to measure the noise levels from the machine at times when there is predicted to be less background noise.

Low frequency noise monitoring commenced on Thursday 20th October in Fairlie. This has been set up in response to a specific low frequency noise complaint raised by a local resident who *is concerned that the low frequency noise is making them dizzy and having an impact on their health and balance. The equipment for this testing is likely to be removed during w/c 14th November and we anticipate that the results of this survey will be available* in *December. It was noted that during the recent testing the Mitsubishi turbine had been operating on a pretty intermittent basis.*

SSE were keen to stress that the concerns raised about low frequency noise have been taken seriously which is why the noise monitoring was set up and carried out straight away. There was a discussion about low frequency noise in general and the many different potential sources. The group agreed to wait and see what the results from the testing showed before agreeing how they felt it would be best to take things forward.

He then explained that the current plan is to submit a Section 42 Application (S42) which is for a two year extension to the existing five year consent. This S42 would include detailed information showing a full appraisal of the last four years including; information on construction works, training to date, testing to date and a socio-economic appraisal. It would also include detailed information of the projections for the next two years including potential partnerships, testing training and socio-economic impacts.

Immediate plans would be for the Siemens machine to stay up and running and for testing to continue. Regarding the Mitsubishi turbine we can't confirm what the further plans are for the machine as yet but would look to do so within the S42 application.

Investigations are already underway for looking at partnerships and training possibilities for the next two years. These include meetings with North Ayrshire College and Strathclyde University who are both very interested in being involved with the facility.

Michael didn't deny that SSE could have been more pro-active at sharing the good news stories from the site but that the fact of it is that the site has performed very well as a test facility and if consented we would certainly look to be far more pro-active in our approach to sharing information.

4.3 If the S42 is consented SSE have also confirmed that their intention would be to look at submitting a Major Application for the site for a further 15-20 years.

5. **Why were the Hunterston turbines subsequently decommissioned by SSE?**

5.1 Extract from press release confirming the Hunterston turbines have commenced power generation dated 3 March 2014.

Hunterston Siemens turbine generating power.

3 March 2014

First power exported from Hunterston Offshore Wind Turbine Test Facility

https://www.scottish-enterprise-mediacentre.com/news/first-power-exported-from-hunterstonoffshore-wind-turbine-test-facility

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Part of: Energy
Region: West of Scotland

SSE Renewables reached a significant milestone after electricity was exported for the first time from its offshore wind turbine test facility at Hunterston, North Ayrshire.

The Siemens SWT-6.0-154 wind turbine, is 177 metres high, and incorporates the latest offshore turbine technology to generate six Megawatts (MW) of electricity.

The Hunterston site, on the North Ayrshire coast, has similar wind conditions to those found offshore, as well as access to the Grid and an adjacent jetty for facilitating component deliveries.

This makes it an ideal location for turbine manufacturers to test their latest turbine equipment before deploying it offshore.

Ian Flannagan, SSE's Project Construction Manager, said: "It's great to see the Siemens wind turbine generating electricity for the first time which is testament to the hard work and commitment shown by everyone involved in the project.

"We are busy preparing the site ahead of the second turbine, a Mitsubishi Sea Angel 7MW offshore wind model, arriving in a few months time."

Clark MacFarlane, Managing Director, Siemens Wind Power Offshore UK&I said: "We are delighted with the news of first power for our 6MW turbine at Hunterston. This is another important milestone for our next generation wind turbine technology.

"The SSE and Siemens team has worked extremely hard to get to this point and should feel proud of their achievement in delivering this important clean energy project."

The project, the UK's first onshore test site for offshore turbines, is being supported by Scottish Enterprise, the Department for Energy and Climate Change (DECC) and the Department of Business, Innovations and Skills (BIS).

UK Energy and Climate Minister, Greg Barker said: *"SSE Renewable's test site for offshore wind turbines is an exciting and innovative project. It will help the country take another step towards delivering £110 billion investment into our energy sector while helping to support local jobs."*

Notes to editors
Hunterston was identified for potential renewable energy supply chain development in the National Renewables Infrastructure Plan. The £20million funding of the project includes a commitment of up to £4.4million by Scottish Enterprise from the National Renewables Infrastructure Fund. Scottish Enterprise is developing one of the three test berths at the site.

5.2 Extract from Arcus Consultancy Services EIA submission to NAC on behalf of SSE Generation Limited in support of their variation application dated January 2017.

Para 2.2 Need:

The NOWTTF retains a strong need to continue to operate from the Site. The continuing of the testing of offshore wind turbines is vital to support and enable the offshore wind industry to develop. The current Siemens turbine on the Site, the SWT-7.0154, is on test for usage on the 588 MW Beatrice Offshore Farm in the Moray Firth, ***which is due to commence construction in 2017, and has influenced DONG Energy to purchase this turbine for the 1.2 GW Hornsea offshore wind farm in the North Sea. There is an imperative need for this testing to continue to ensure that the offshore wind energy industry continues to develop.***

The continued testing of the Mitsubishi turbine and further investment on the Site will also enable further understanding of offshore wind turbines, to enable turbine designs to be refined and development, as well as allowing for the training opportunities detailed above.

Scotland, through facilities such as the NOWTTF, is advanced in the research and understanding of offshore wind turbine development. This puts Scotland in a strong position with the potential to export this technology to other parts of the world, where the offshore wind industry is less developed. This underpins the economic benefits of the NOWTTF, at the national scale.

There is clear support through planning and energy policy, for the need for the offshore wind industry to develop, in order to combat climate change and due to its economic benefits. This underpins the case for the need for the Development as a material in determining this Section 42 Application.

There are however few opportunities for the testing of offshore wind turbines to occur, due to the need to replicate offshore conditions on a site that is accessible and serviceable. The NOWTTF represents one of these few opportunities, and where such sites occur, they must in principle be permitted so to allow for the testing of offshore wind turbines.

The importance of the NOWTTF nationally is likely to last well beyond the proposed extension of the operational time period for a further two years. *The extension of the operational period will however allow the Applicant to develop further options for the Site, so it is safeguarded over the longer term. This may also include* energy storage and new forms of technologies that will further support the Scottish energy industry, and the local and national economies.

5.4 **It is clear from the above statements that there was an intention for SSE to continue operations at the NOWTTF beyond the 2 year variation consent. In addition, this evidence also confirms that SSE were generating power which was being exported to the National Grid.**

5.5 Extracts SSE - FCC Community Liaison minutes of a meeting held on 27th March 2017.

1.) Project update SK - Existing planning permission expires October 2017. Siemens turbine commissioned and noise survey completed 2014. Mitsubishi turbine fully erected and connected to grid March 2015, not fully commissioned to date due to technical issues.

JL asked if the Mitsubishi Sea Angel technology is now redundant. SK SSE replied that it is true that Mitsubishi are not taking the 7MW Sea Angel turbine to market because of their partnership with Vestas, the technology is still important for later generation turbines though.

JR asked why the Siemens turbine is still being tested here if the 7MW version is already being deployed in offshore wind projects in Denmark and elsewhere and why other test sites which are offshore cannot be used instead.

SK explained that there is still a lot to learn operationally from the turbine for the SSE and UK application, for example Siemens are looking to test a UK grid compliance software update to comply with new UK grid code requirements. This will be extremely useful for SSE as it will allow us to anticipate what we will experience on the Beatrice turbines when they start to become operational next year.

SK added that an onshore location for offshore testing allowed safer and most cost effective testing of new technology. SK also advised that while the Siemens turbine is in the ownership and operational control of SSE the Mitsubishi turbine is owned by Mitsubishi and they are responsible for the testing of the machine. Although the technical data from the testing is for Mitsubishi, SSE does get sight of some operational information.

5.6 **The minutes of this meeting again also advise SSE's intentions to continue testing, yet this was curtailed despite the Reporter's favourable appeal decision granting consent to October 2019.**

6. Impact Statements from Fairlie Residents presented during the Planning Committee Application Meetings and subsequent statements at public inquiries.

6.1 Rita Holmes.

This is an impact statement about my experience of living in close proximity to the two large, high power output wind turbines, which were located at the Hunterston Marine Yard. It is a record of the consequential detrimental health I suffered during this time.

My name is Rita Holmes, I have been a resident of Fairlie since 1972, enjoying robust good health and well used to noise from the unloading activities at the coal terminal jetty which is 900 Metres due west of us. I never had cause to complain about audible noise from the wind turbines, so the noise from the wind turbines, which I refer to as causing my symptoms, was below 20Herz and inaudible. I also had my hearing and balance tested when I first experienced symptoms. Apart from a few frequencies in the extremely high and low range, my hearing was fine and balance also.

I have never, before or after, experienced anything as awful as the effects from the two Hunterston wind turbines. It was tantamount to inescapable torture. Thankfully, they have now gone, as, during Covid 19, I would not have been able to escape. We never knew when the Mitsubishi Sea Angel would be operational, so in effect, there was no way of planning to be away from home, when it was operational. So, I took every opportunity to be away from home, staying overnight in the Central Hotel, visiting friends when I had meetings in London or Manchester and staying with relatives. My home became unliveable in, when the wind turbines were turning. However, at least, I knew that my ill health was due to the wind turbines, many people did not and were left wondering what on earth was wrong with them. I did go to my doctor and tell him about the effects and how it definitely was the wind turbines.

I did phone and write to Health Protection Scotland (now Public Health Scotland) and despite them telling me that my symptoms might well be from ILFN they assured me that there was no evidence in the literature to prove this. I have since looked at the papers and studies on ILFN and wind turbines and I found empirical evidence from all around the world . So no help from PHS, no help from Ayrshire and Arran Health Board who advised North Ayrshire Council and no help from the GP practice. Our GP advised in writing that their insurance did not cover them if they got involved.

I did not have to see the turbines to know they were turning, I felt the effects of them turning immediately. I also knew, without seeing them, when they had stopped. When they turned I was ill, when they stopped I was fine and it had nothing to do with me being anti wind energy, or a NIMBY, in fact I am the opposite and do not mind them aesthetically. I know without any doubt whatsoever, that my symptoms were due to the wind turbines when they turned.

As soon as the wind turbine was switched on, I would experience a single wave of nausea....like morning sickness for those who have had that. I would feel that my balance wasn`t right and that I was walking differently, feeling like co ordination was out of sync and that without concentration I could crumple to the ground. Unlike my next door neighbour, I actually didn`t collapse or fall. At its worst, when SSE was ramping both turbines up in power together, I could not walk, talk or think properly. The centre of my brain felt like a drill was whizzing away inside it and that I had to escape and get away from it. I remember thinking this is what whales must feel like when they beach themselves trying to escape. My neighbour was with me at the time. She was chatting and about to go off on holiday so getting some books from me. We both knew instantly they had started up and she had to resort to getting downstairs on her bottom as I clung to the handrail.

I drove us into Largs, 5km away and we made emergency appointments to see a doctor. But, what can your doctor do for wind turbine symptoms...offer anti nausea pills, sympathy but I did ask that I could register by phone when I was being affected. <u>The doctor also told me that Ayrshire and Arran Health Board`s claim at a North Ayrshire Planning Committee meeting that there was no epidemiological evidence was irrelevant and invalid as there was no code for GPs to register wind turbine symptoms for the Health Board statistics.</u>

Nobody should have to unnecessarily suffer, as I and others did. I say unnecessarily because the size, power output and location are all important factors which need to be taken into account by developers and Planning Authorities, in order to avoid torture to residents. The effects of the two wind turbines at Hunterston could be felt as far away as the north end of Largs which is approximately 10km from Hunterston. Fortunately, for various reasons, the Mitsubishi Sea Angel did not "turn" for any extended period and the Siemens for the latter part of the time had a broken blade so was too dangerous to turn. Also there were periods with no wind so they did not turn.

Please note that I use the term "turn" and not "operate" as the Company SSE tried to discredit my evidence by claiming, that on two occasions I had complained of detrimental effects, when the wind turbines were "non operational". It emerged on investigation, that "non operational" did not mean that they were not turning. <u>The wind turbines had been "idling". In fact, merely allowing the blades to idle in the wind was enough to produce ILFN, Infrasound Low Frequency Noise which can play havoc with the neurological system.</u> The effects of ILFN from these large high power wind turbines were something one would not wish to happen to any other human being or living creature, so to hear that another community or person might have to put up with ill health due to large turbines near them fills me with fear for those people and anger at a system that allows the injustice of it, due to the lack of understanding from those with no experience of the severe effects and developers and their consultant acousticians who lie about the dangers from ILFN.

What I and others experienced was tantamount to torture and against our Human Rights. There was nothing that we could do to stop it, because there are no regulations that safeguard us against wind turbine noise at the ILFN level. Current noise regulations only deal with frequencies that are audible, i.e. above 20Hertz. What I discovered was that although the doctor was sympathetic, GP `s insurance does not cover them for getting involved in anything to do with this. Also, the claim made by Ayrshire and Arran Health Board that epidemiological studies showed no increase in wind turbine effects was invalid as, according to my GP, there is no code available for GPs to input statistics regarding this.

So, basically, once a development is approved and built don't expect help from anybody, not from your GP, or NHS or PHS and don't expect Planning Conditions to make a difference as the length of time between you reporting a statutory nuisance and a response can be up to 21 days.

Rita Holmes (Chairwoman Fairlie Community Council) June 2017.

6.2 Karen Brodie.

This is a copy of my complaint regarding Hunterston Sea Turbine test centre.

"I am writing to you to raise a concern over the two test wind turbines, the Mitsubishi Sea Angel turbine and the Siemens turbine.

I live in Millport on the Isle of Cumbrae and I have been unwell for over a year with dizziness which (becomes quite severe at times), nausea, sleeplessness, poor coordination, the feeling of collapse, heart palpitations. These debilitating health effects I now believe to come from the low frequency noise produced by the two wind turbines. I have been seen by the consultant at Crosshouse Hospital, ENT department for a year now and I still don't have an official diagnosis as the doctor is not able to tell me why I have these severe symptoms. I have had both MRI and CT scans which have all come back clear.

Please note that when I am off the island and away from the turbines or when they are switched off, my symptoms are greatly reduced and some of the, i.e., the feeling of collapse, disappear altogether.

I understand that there are many people who are suffering the same symptoms as myself. This issue must now have to be addresses as an Environmental Health problem.

As I do not buy the Largs & Millport Weekly News due to its inaccurate and awful writing, I was unaware of the fact that people in the village of Fairlie and some people in Largs were suffering the same symptoms as myself. As I stated previously, I have been attending my GP for some 18 months after having a very bad fall due to a dizzy spell. The symptoms became much worse as I had just moved to the other side of Millport Town. I now believe that I was in the line of the infrasound noise and this has affected my health, in having severe dizziness and vertigo attacks. Increased levels of Tinnitus, disturbed sleep, feeling of gravitational pull to the ground, which some call 'a feeling of collapse'. Sometimes my brain feels like it's turned to jelly and floating around my skull. I was referred to ENT at Crosshouse hospital 13 months ago. I have had a MRI scan which came back clear and a CT scan which also came back clear. I have not been given a diagnosis as yet as the Consultant wants more tests and monitoring done.

I understand that these two turbines are designed to gather wind energy out to sea I am not sure why they are being tested in such close proximity to towns and villages I also understand that Mitsubishi are not taking the 7MW Sea Angel turbine to market, because of problems with the turbine and a new model has been designed.

However, as these are TEST turbines, it is important the health issues that are being raised are used as part of the tests and these turbines should now cease and further testing should stop.

I am not against Green Energy, I am very much in support of cleaner energy, but only when it is positioned in the right place and not affecting health in close areas.

I want my health back, it has been a hideous time feeling so unwell with all of these symptoms and the consultant not being able to give me a diagnosis a year on.

I trust that this email will be taken seriously!

Yours sincerely,

Karen Brodie" 28th October 2020.

The test turbines were removed well before the extended testing date ceased. Mitsubishi took their turbine down extremely quickly for fear of being sued when they were aware so many people were affected by these turbines. The Siemens turbine did not operate due to a broken blade, it was blown up the following year, never repaired, again due to the adverse health impacts on local people.

The UK government stated on 21st October that Off shore wind energy was the way to go, Scotland has plenty viable coastal waters to sustain this kind of energy collection.

6.3 Email from Fairlie resident [redacted] dated 6th January 2021.
Subject: Hunterston

Thank You kindly for getting in touch regarding the offshore wind turbines sited at Hunterston in Fairlie North Ayrshire .

Unfortunately I have deleted all my emails and statements with regards to these offshore wind turbines.

What I can do is tell you that over the course of the years whilst these offshore wind turbines were in operation (producing electricity) or idling , I suffered the most awful side affects relating to infrasound.

I had headaches, palpitations, nausea and general lack of energy . I phoned sse countless times whilst I was experiencing these symptoms and asked them to stop the operations . I had a visit to my home by 2 SSE workers. A very strange encounter indeed as still to this day the meeting served no purpose. My friend was in attendance at this meeting so I am guessing the 2 SSE representatives didn't actually fulfil their visit .

I have stood up and given a full account of my health affects at a North Ayrshire Planning meeting to halt SSE from extending the offshore wind turbine facility from extending their contract.

This information regarding the NAC planning meeting should all be on record .

As a footnote I would like to add that I am not against wind turbines BUT I am against any wind farm that has planning to be sited near anybody's home , village , town , school and beauty spots where there is abundant flora and fauna.

I am now in good health and have never experienced these awful side affects since the removal of the two offshore wind turbines that were sited at Hunterston

And I wish you all the luck in Scotland and I hope you win this fight as your health will be in danger if these people are not stopped .
Kind Regards [redacted]
[redacted]

6.4 Statement in respect of the Determination of SSE's Variation Application extending the operational consent of the 2 Hunterston Turbines for a further 2 years.

(1 Siemens @ 6MW & 1 Mitsubishi @ 7MW. Height 200M to blade tip)

Dated: 18/08/2017

Ref: PA-3102028

(Contact details redacted)[redacted]

Dear Sir or Madam,

I wish to object to SSE getting another two years of operation. I would prefer that operation stopped immediately as my life has been ruined since they started operating.

As far back as 2014, I complained to my GP about symptoms and blamed the Siemens turbine. (The Mitsubishi was not operating then.)

However, what was bad is much worse now that the Mitsubishi has started operating and when both rotate at the same time it is horrendous.

As I am aware that SSE`s submission is only up until 1st July 2017, I feel that I need to bring to your attention that there are more formal complaints that have not been included in their Summary of complaints document.

I have lodged formal complaints with NAC Environmental Health and also informed my GP. These have been added to my medical files.

My first official complaint to SSE was made to an 0800 number, Sat 1st July, which I had managed to google online.

SSE returned my call nearly two weeks later. I spoke with Chris Bell of SSE at great length, describing my symptoms.

On Monday 22nd May I made an emergency appointment with my GP as I was suffering from palpitations (a new side effect for me) The Mitsubishi had been operating from Thurs 18th May through to Monday 22nd May intermittently but persistent.

On Wednesday 19th July, I called SSE at around 08:10 to make a formal complaint with regard to my severe adverse health effects that morning.

Around 08:35am, I had to call my GP for an emergency appointment as my heart was beating too fast. I collapsed in the doctor`s surgery.

Now I am going through testing for my heart. One of the tests will be wearing a heart trace whilst the turbine is in operation.

I have completed the first part of the test wearing the heart trace while the turbine is non operational. I have kept a list of dates and symptoms I have suffered and I have lodged these with [redacted] NAC EHO and my local GP.

My symptoms are as follows, nausea, sharp ear pain in one or both ears, shallow breathing and heart palpitations. These symptoms disappear when the wind turbine stops, albeit it takes me longer and longer to recover.

I have logged these dates with NAC as complaints. Wed.14th June, apart from the last three.

Thur 15th June,
Fri 16th June,
Sat 1st July,
8th July,
Sun 2nd July,
Fri 14th July
Sat 15th July,
Tues 18th July
Wed 19th July.
Thur 20th July
Fri 28th July
Sat 29th July

The turbines have not operated for almost three weeks and it has been bliss. I understand, as well as anybody, that this is hard to believe, that someone can be affected by low frequency infrasound, but I have no control over these symptoms when the turbines operate. I am a normal, healthy person who is rendered unfit with these adverse health effects .

Yours sincerely,

[redacted]

7. Examination of Hunterston Appeal Decision letter in respect of reported health impacts by local residents (a small sample of which I have referenced above).

7.1 In the context of concerns regarding potential Health Impacts, it is notable that in the Hunterston Variation Appeal decision dated 9 January 2018, Reporter Mike Croft broadly concurs with submissions by Health Protection Scotland HPS and the National Health Service (NHS) stating;

"Consequently, even with a reasonable application of the precautionary principle, I do not consider that the evidence of adverse effects on the health of the local population is sufficient to justify or support refusal".

7.2 Relevant comments from the decision letter are copied below:

(b) whether evidence of adverse effects on the health of the local population is sufficient to justify or support refusal.

> *34. However, most of the evidence I have received from professional sources lends limited support, at most, for that view. I have the views of Health Protection Scotland (HPS), dated July 2017. As HPS's function within the National Health Service (NHS) is to help protect the Scottish public from environmental hazards, I am bound to accord its views very considerable weight.*
>
> *35. HPS considered four independent systematic literature reviews, including literature on infrasound/low frequency noise and amplitude modulation. It noted that all the reviews conclude that there is sufficient evidence to confirm a clear association between wind turbine noise and annoyance, and that such annoyance is related to, but not necessarily causally linked to, levels of anxiety, sleep disturbance and stress. Feelings of annoyance about wind turbines are also affected by a wide range of factors that are not related to health outcomes.*
> *Apart from this, HPS found that none of the reviews found sufficient evidence to confirm a causal relationship between wind turbine noise and the type of health complaints cited by local residents.*
>
> *36. HPS considers that the balance of the objectively reviewed scientific evidence does not support there being a direct causal link between the symptoms described by local residents and the operation of nearby wind turbines. It does not exclude the possibility that there might be some sort of relationship between wind turbine noise exposure and symptoms in individual cases. But its view on balance is that the strength and consistency of the existing scientific consensus suggests this to be unlikely.*
>
> *37. NHS Ayrshire & Arran concludes that, <u>although the international literature suggests that wind farms can lead to concerns from the public, these concerns about health impact are not supported by good quality research</u>.*

7.3 However, the Hunterston Reporter in reaching his decision, relied largely on the literature reviews undertaken by NHS Ayrshire & Arran and HPS, who reportedly '*considered four independent systematic literature reviews*' to reach his conclusions.

7.4 These literature reviews and supporting information have been subsequently reviewed by Professor Mariana Alves - Pereria then submitted as evidence at the Rigghill Appeal.

Ref: PPA-310-2034 Appendix K Commentary on *"Wind turbine noise and human health impacts in Fairlie, North Ayrshire" produced by Health Protection Scotland, July 2017*, Authored by Mariana Alves-Pereira, Ph.D.

This document is also considered to be relevant to respond to the information submitted by the applicant's acousticians at this conjoined inquiry.

7.5 Professor Alves- Pereira's conclusions are copied below: *T. Conclusions and Recommendations .*

*81. The institutions that, in Scotland, are mandated to protect human health against environmental hazards **self-report a lack of expertise** in this scientific field when the environmental hazard is infrasound and/ or low frequency noise.*

*82. As a result, **they are unable to carry out and implement** their obligations which include surveilling and monitoring environmental hazards.*

*83. Consequently, Scottish citizens with environmental health complaints that are suspected of being related to excessive exposure infrasound and low frequency noise (whatever the source) **go ignored, and often even ridiculed.***

*84. Since it is the health of Scottish citizens that is at play here, and since HPS/PHS has admitted to its lack of expertise of this subject, this would be my first suggestion to the appropriately competent decision-makers—**a fairly inexpensive first step that could provide invaluable epidemiological data (if properly done):***

*Implement a **mandatory notification rule for all Medical Practitioners (General Practitioners in particular)** so that all patients exhibiting specific signs and symptoms suspected of being related to 'noise' exposure could be formally counted and associated with a specific geographic location and/or occupation.*

7.6 I have noted that in the Craginmoddie -TNEI Operational Noise Report March 2023.

Para 3.2.7 & Para 3.2.8 states:

The Reporter concluded that:

- *The literature reviews by bodies with very significant responsibilities for the health of local people found insufficient evidence to confirm a causal relationship between wind turbine noise and the type of health complaints cited by some local residents;*

- *The NHS's assessment is that concerns about health impact are not supported by good quality research; and*

- *Although given the opportunity, the Community Council failed to provide evidence that can properly be set against the general tenor of the scientific evidence.*

7.7 In response to the Reporter's comment that;

• Although given the opportunity, the Community Council failed to provide evidence that can properly be set against the general tenor of the scientific evidence.

I would like to state, it is a bit much to expect an underfunded and under resourced Community Council, which did all it could to make the North Ayrshire Environmental Health Officer, the local doctors, Health Protection Scotland and Ayrshire and Arran Health Board aware of the problems and also referred them to research documents and the WHO Report, which supported claims about detriment to health from ILFN.

All this, whilst being pushed from pillar to post, seeking help, as well as battling Wind Industry misinformation.

7.8 I also note that Para 3.2.7 Craiginmoddie WF Operational Noise Report states:

In addition, he also considered LFN surveys undertaken by the Appellant and the Local Authority, both of which demonstrated compliance with planning conditions and did not identify any problems attributable to the turbine operations; some periods with highest levels of low frequency noise were in fact recorded when the turbines were not operating.

In response, this evidence was flawed there were periods when SSE stated the turbines were not operating, but I personally went to the control cabin and spoke to the technician who confirmed he had started low speed operations of the Mitsubishi Sea Angel turbine.

There is sound evidence that given the significant lengths of the blades of large scale turbines, blade resonance is a source of ILFN sound pressure waves, especially when the blades are not rotating at optimum speed.

Indeed as Mr William Leslie Huson BSc (Hons) MSc CPhys MInstP MIoA MAAS confirms within his Expert Witness Statement:

"The issue associated with the larger wind turbines is that they emit resonant infrasound tones in the presence of wind even when they are not rotating".

I do know, that when one of the Hunterston wind turbines " turned" I was ill. When both turned, I felt worse, i.e. the symptoms were more numerous and more severe. When they did not "turn" I was symptom free. The one occasion they were ramped up to half their potential output, i.e. 4.2MW, I was severely physically and neurologically impaired and had to leave my house and the area, (as did my neighbour.)

I told SSE, that I and others locally, were being made ill by the noise. I was told by one of the Scottish engineers, that they had, in the past, been out on the beach in front of our houses to listen, and the noise wasn`t too bad. I said I wasn`t bothered by the audible noise, but the frequencies below the threshold of human hearing.

I said that I had been woken up about 6:55am experiencing a single wave of nausea and on getting up, I had problems with walking and balance. The Scottish engineer said that, his team had not got to site, until just before 8:30am and that the Mitsubishi wind turbine had just been turned on then. However, the Japanese engineer, when they looked at him for his response, said that he had switched the turbine on just before 7am, to let the blades move freely and the oil in the system to warm up. This astounded them.

I also said that many in the community had been alerted by a constant rolling thunderous noise which went on overnight on the 2nd February of that year, it was dark so nobody knew if the wind turbines were turning or not. People reported on facebook that they felt very odd, their chests felt compressed during that long episode. I was told by the engineers that the Mitsubishi wind turbine was not operational that night. However, on referring to records, we subsequently found that it had been indeed been operating at that time.

Mr Huson expert witness evidence also advises:

However, it has been postulated by Kelly (1982) that lightweight building structures can be excited by infrasound pressure from wind turbines and can be one of the major causal agents responsible for the annoyance of nearby residents. Part of the conclusions in Kelly's paper follows: "In this paper we have presented evidence to support the hypothesis that one of the major causal agents responsible for the annoyance of nearby residents by wind turbine noise is the excitation of highly resonant structural and air volume modes by the coherent, low frequency sound radiated by large wind turbines.

Further, there is evidence that the strong resonances found in the acoustic pressure field within rooms actually measured indicates a coupling of subaudible energy to human body resonances at 5, 12 and 17-25 Hz, resulting in a sensation of whole-body vibration. The audible sounds indoors associated with the impulsive excitation of the structure appear to be due to the coupling of energy from the higher frequency discrete bands in the impulse to higher frequency room resonances related to the air volume itself."

Simply, I know when I was physically impacted and when I was not. To say otherwise, is questioning my integrity and personal and professional reputation.

7.9 It is also of extreme concern that Para 3.1 of the Conjoined Inquiry document Operational Noise - Statement of Agreed Matters Date: 21st March 2023 states:

3.1 We note the WSP BEIS report considered the topics of infrasound and low frequency noise and the advice contained therein. Whilst it may be feasible to measure infrasound from wind turbines9, the current weight of evidence (see WSP BEIS report) indicates that wind turbine infrasound has no adverse effects on human health at typical exposure levels and that it is not necessary to consider wind turbine infrasound when determining development applications. Furthermore, assessment on the basis of 'A' weighted sound levels (the approach in the ETSU-R-97 assessment methodology) provides sufficient control over the potential impact of low frequency noise.

7.10 Also the statement at Para 4.22 of the Craiginmoddie Hearing Statement - Noise:

The WSP BEIS report (CD012.015) considered a number of studies which investigated claimed links between adverse health symptoms and infrasound emissions from wind turbines. The report notes on page 116 that:

*Overall, the findings from the existing evidence base indicate that infrasound from wind turbines at typical exposure levels has no direct adverse effects on physical or mental health, and reported symptoms of ill-health are more likely to be *psychogenic in origin.*

Note: Oxford Dictionary definition of *psychogenic - having a psychological origin or cause rather than a physical one.

It is abundantly clear that the extremely worrying continual denial and denigration of harm of the significant debilitating health impacts from large scale wind turbines **is** putting at risk the health and welfare of a increasing number of adversely affected residents.

Notably, a important question raised within the INWG's critique of the WSP report states:

<u>On what basis should medically unqualified acousticians, (as are the authors of the WSP BIES report) opinions on the health and wellbeing of affected residents, become accepted as statement of fact, on which large scale planning decisions are made?</u>

The 3 applications this conjoined inquiry is considering, for a total of 34 x 200m and 2 x 180m high wind turbines, each with a proposed generating capacity of 6.5MW unacceptably close to homes and recreational facilities, based on our experience at Hunterston with just 2 comparable turbines is alarming. Especially given these proposed developments are to be located in an extensive area between the operational wind turbines at Hadyard Hill, Tralorg and Assel Valley in the west and Dersalloch to the North East, forming a cumulative array of wind turbines extending for approximately 25 -30km.

8. Conclusion.

8.1. I confirm my personal evidence is based on my experience, which I consider is essential to inform this Inquiry and to counter misleading information on wind turbine noise, submitted by the applicants.

Although I will not be directly affected by these proposals, I am compelled by my free will to state my experience of living in close proximity to the Hunterston turbines. This is the only recorded physical evidence of the actual impact on health on those living close to turbines of this size and power in the UK. It also demonstrates the only physical evidence of the return to full health once the turbines were demolished.

8.2. It is worth mentioning that when I was getting nowhere with any public authorities or governments bodies, I decided that, if any Body/Group had an interest in ILFN research, it must be COMARE. Firstly, I was told COMARE did not have AGNIR`s remit, (that was incorrect), then that there was no money for this type of ILFN research as there were too many other priorities. I am telling you this, to illustrate, the dereliction of duty of care by public health and government officials in the UK; declining to act or further knowledge and research in this field, given the evidence available by the direct health impacts on the residents of Fairlie as a result of the operation and demolition of the Hunterston turbines.

8.3. Should the Reporters be minded to recommend approval to Scottish Ministers, then it is crucial my evidence forms part of the published record, raising my fully justified concerns for the future health and welfare of those forced to live in close proximity to turbines of this size and power.

8.4. Finally, given our knowledge and personal experience, I consider it would be irresponsible to consent these developments close to the homes of residents. We, in Fairlie and Millport were adversely affected by two such turbines, this conjoined inquiry application is considering allowing thirty six such turbines close to hundreds of homes.

Comment:

This evidence submitted to the Conjoined Inquiry is equally applicable and relevant to the Seskin Wind Farm proposal and is resubmitted with consent to Carlow County Council in respect of Case No 2460122.

END.

Independent Noise Working Group

Wind Turbine Amplitude Modulation &

Planning Control Study

Work Package 1 – The Fundamentals of Amplitude Modulation of Wind Turbine Noise

Author: John V Yelland MA DPhil (Oxon) MInstP FIET AMASA MIOA

This document is based partly on a paper presented at the Institute of Acoustics Annual Conference held at Harrogate on 15 October 2015

Contents

Note: footnotes are superscripted; bibliographic references are within square brackets.

1 Introduction

The wind industry, and successive Governments much in thrall of it, after years of suffering of noise nuisance by many wind farm neighbours, and under pressure from those neighbours and concerned acousticians, physicists, medical consultants and engineers, have finally acknowledged the seriousness of the issue of Excessive Amplitude Modulation (EAM).

Normally amplitude modulation is a relatively benign characteristic of wind turbine noise. It is the periodic 2 - 3 dB(A) variation[86] in the level of the audible noise emitted by the turbine blades, modulated at the blade pass frequency (BPF) by a quasi-sinusoidal envelope. Its cause is well understood and its characteristics are quantitatively consistent with that understanding.

Unfortunately increasing numbers of wind farm neighbours in many countries now suffer from a rather different wind turbine noise characteristic which is far from benign, which has come to be called "excessive amplitude modulation" (EAM). Now that this has been acknowledged as a problem both by Governments and by the wind industry it is essential that its causes and effects are correctly and objectively determined. A group of acousticians with long experience in working with and for the wind industry (the IOA AMWG) is leading a consultation exercise on AM; its outcome is awaited with interest. The acousticians of the Independent Noise Working Group (INWG) are concerned by the narrowly defined terms of reference of the IOA AMWG consultation, which appear to have impeded the exposure of important evidence concerning the true spectrum of EAM, and thus of wind turbine noise as now frequently experienced by many wind farm neighbours.

This paper explores aspects of AM and EAM relating to their definition, causes and measurement. The high incidence and harmful effects of EAM are reported in other INWG papers.

2 The Characteristics of AM and EAM

2.1 Amplitude Modulation is Always Present

The principal source of audible noise from an ideal wind turbine is aerodynamic noise from the blades. As they rotate the distance between them and a static observer varies at the frequency at which the blades pass the turbine tower. This variation causes a quasisinusoidal modulation of the aerodynamic noise in both frequency and amplitude, usually referred to respectively as the Doppler effect and convective amplification, and creates the characteristic "swish" of wind turbine blade noise. The modulation depth varies as a function of the

[86] When dB differences are quoted the descriptor (A) is redundant, but its retention can serve as a reminder that measurements in question are A-weighted. This is important because an unweighted sound pressure level (SPL) relates to true sound power, whereas an A-weighted SPL relates only to its perceived audibility. Whilst these two quantities are very similar at frequencies around 1 kHz the unweighted SPL at 20 Hz, for example, is 50 dB higher than the A-weighted SPL at 20 Hz.

observer's orientation to and distance from the turbine; indeed if the observer were, rather unrealistically, on the rotor axis of a turbine, with no wind shear, no ground reflection and a wind-transparent turbine tower, there would be no modulation. Off the rotor axis, at realistic positions for noise sensitive receptors, operational turbines always emit noise that is modulated in both amplitude and frequency.

ETSU R 97 [1] (ETSU) described AM long ago (in 1997), ascribing to it a modulation depth of 2 - 3 dB. This is consistent with the predictions of the well-established BPM [2] aerofoil noise model. Such "normal" AM is thus an intrinsic property of the noise emitted by operational wind turbines and is always present.

2.2 Excessive Amplitude Modulation – when Swish Turns to Thump

Amplitude modulation is excessive when the "modulation depth" of the time series envelope exceeds the maximum of the 2 – 3 dB range reported in ETSU; compared with normal AM the peaks of EAM are narrower, with modulation depths up to 30 dB(A) reported. The trough amplitudes show no change at the onset of AM. The waveform thus changes radically, but over a relatively small part of the blade pass period. An example of a high (25 dB(A)) modulation depth time series chart from Huson [3] is shown in Figure 1.

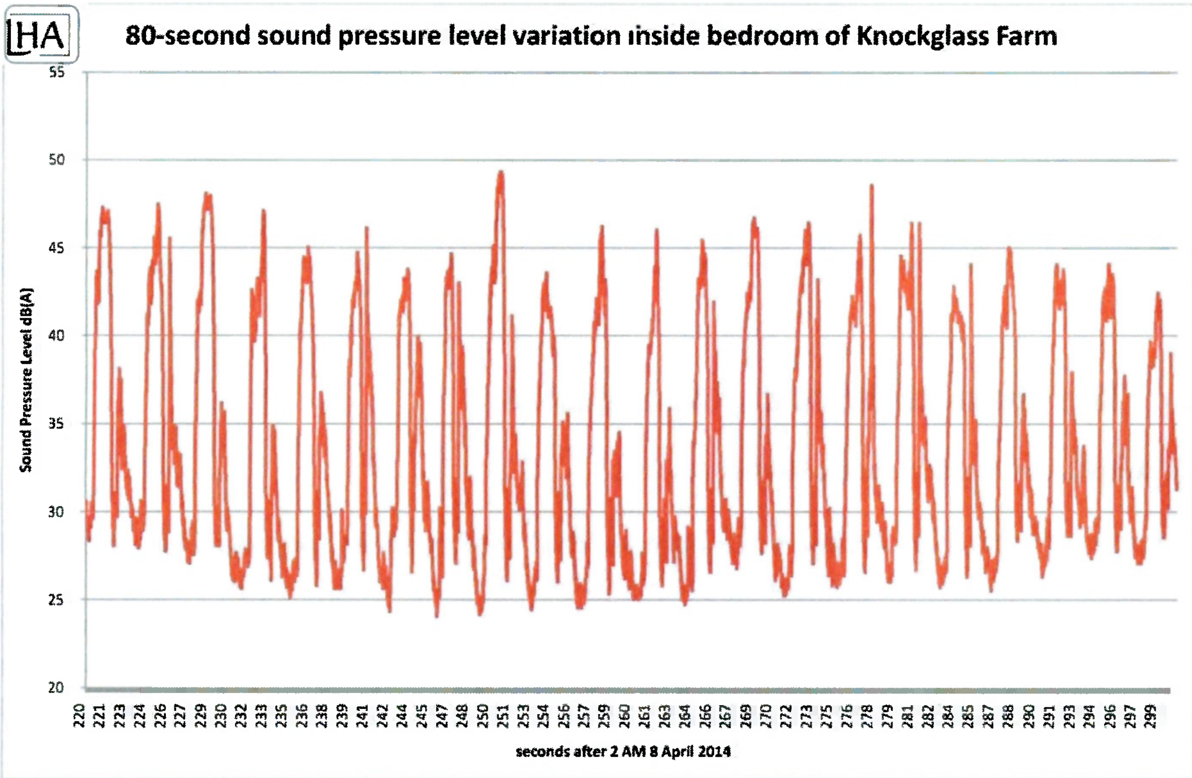


Figure 1: High levels of EAM (up to 25 dB(A)) at Knockglass Farm. Credit: Huson [1].

This is an interesting example as the AM frequency is relatively low, corresponding to the rotor frequency rather that the BPF. Much of the increase in modulation "depth" may well be due not to modulation of aerodynamic noise frequencies but to tones at turbine blade or tower resonant frequencies.

True AM as defined in other engineering disciplines would have the troughs descending as much as the peaks ascending; in the present case, where the trough level does not descend when the peak level ascends, it is more logical to refer to modulation height than modulation depth, as I do in all that follows.

The use of the term "modulation" in the acronym EAM was unfortunate as it pre-judged the spectral content of EAM at a time when it was little understood. In signal processing terms a modulated waveform is typically the product of a carrier frequency signal multiplied by a normally much lower modulation frequency or band of frequencies. EAM however is the sum of incoherent noise, modulated both in frequency and in amplitude, together with high levels of very low frequency tones. "Modulation" should therefore be understood in its lay definition rather than in any technical definition; use of the term does not suppress the very low frequencies from wind turbine noise, although it does appear to have suppressed serious consideration thereof by the wind industry or its acousticians.

The RenewableUK AM research report [4] ("the RUK report") states that EAM is entirely due to increased aerodynamic noise from the turbines blades which can stall at blade zenith ("12 o'clock") in high wind shear. I will show below that this can explain only a small part of the greater observed modulation heights; the major contribution comes from noise well below 100 Hz. I will also show that the RUK report and the IOA AMWG discussion document [5] largely derived from it repeatedly exclude any consideration of acoustic emissions at frequencies below 100 Hz. The RUK report includes no measurements below 100 Hz to support the exclusion however. In truth the greatest observed modulation heights are fairly easily explained by consideration of the very low frequency emissions which are a consequence of the structural dynamics of large modern wind turbines rather than aerodynamic noise from the blades. These very low frequency emissions are well known [6,7,8,9,10] to turbine manufacturers, but by reason of mechanical fatigue issues rather than noise nuisance.

2.3 The Normal Wind Turbine Noise Spectrum

The major part of the aurally perceived (i.e. A-weighted) acoustic emissions from normally operating turbines falls within the frequency range 100 Hz to 4 kHz, as seen in the logarithmic A-weighted trace (blue) of Figure 2, which is plotted from data in an independent test report [11] by Windtest gmbh for a typical modern turbine, the RePower (now Senvion) MM92. The major part of the acoustic power however falls below 4 Hz, as seen in the unweighted traces (linear, green and logarithmic, red) of figure 2; 4 Hz is well below the threshold of hearing. The A-weighted trace reflects the perceived loudness of the turbine, and thus its annoyance value to a listener, whereas the two unweighted traces reflect the true power level of the sound, and therefore give an indication of the likelyhood of any potential health hazard. This distinction is highly significant because the nature of complaints about wind turbine noise clearly indicate that wind turbine noise disturbs the human vestibular function rather than the human auditory function. See the report of INWG Work Package 3.2 [12] and the many referenced documents therein for further information.

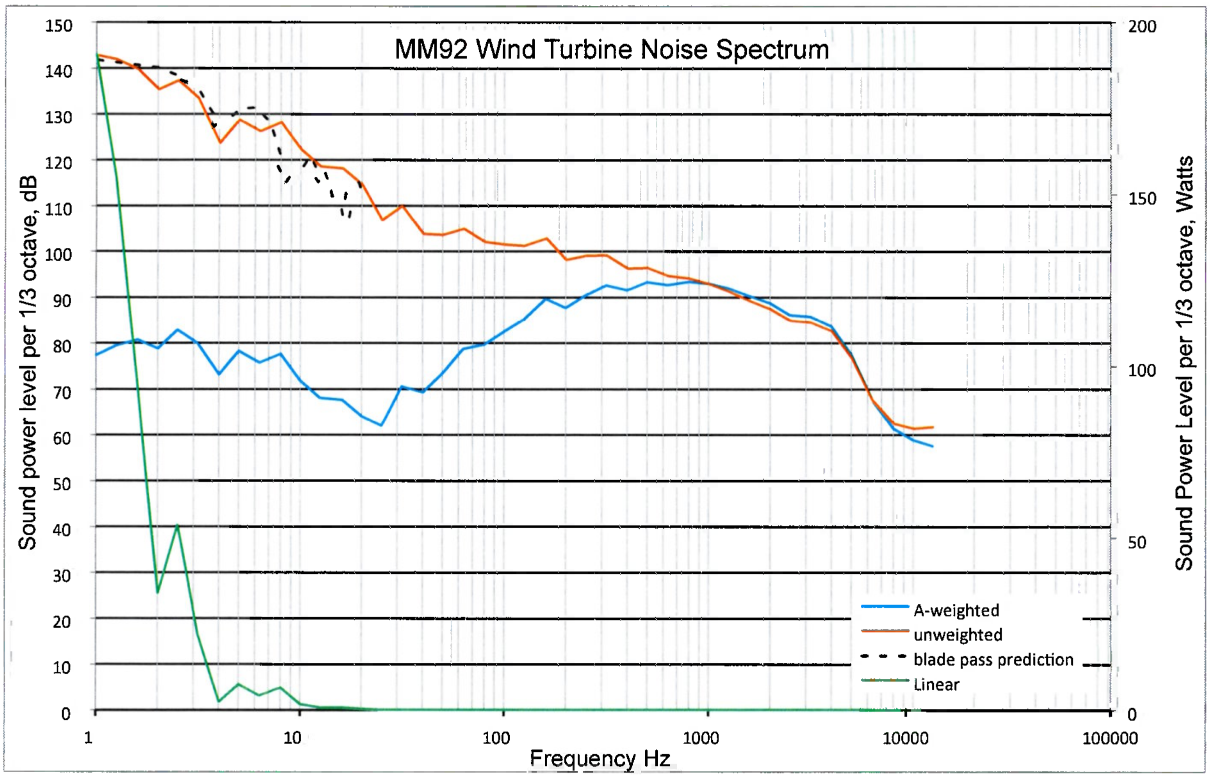


Figure 2: Noise emission power data to IEC 61400-11 from measurements on a RePower MM92 wind turbine, 1 Hz to 12.5 kHz, by Windtest gmbh.

Examining figure 2 in detail it is seen that the A-weighted spectrum appears to have a gradient discontinuity at around 20 Hz. This is because the because the data provided below 20 Hz does not state what weighting curve (if any) was used, so I have assumed no weighting. The standard A-weighting curve is defined down to 10 Hz, so this assumption may be incorrect, and may therefore have caused understatement of the unweighted noise power level below 10 Hz. The essential point to grasp is just how much power, rather than how much perceived loudness, is in the 1 - 20 Hz frequency band compared with that in the 20 Hz to 12,500 Hz frequency band; to illustrate this the linear green trace is plotted on the linear scale to the right of the chart. The answers are 99.94% and 0.06% respectively, of a total of 572 W. The total noise power below 20 Hz is. Irrespective of the mounting evidence of damage to both human and non human species, the magnitude of this ratio, 1,726, suggests that it is most unwise to ignore the existence of the acoustic energy below 20 Hz just because that frequency defines a nominal lower limit of human hearing.

The reason offered in ETSU for setting the night time noise limit at 43 dB(A), as opposed to the outdoor limit of 35 dB(A), is the assumption of 8 dB sound attenuation in passage through an open window. This assumption is valid at normal audio frequencies but certainly does not apply at very low frequencies; even with windows closed there is usually little or no attenuation from outdoors to indoors, and sometimes amplification due to room resonances. It is therefore not surprising that the majority of noise complaints relate to sleep deprivation indoors, and not to annoying noise levels outdoors.

2.4 Aerodynamic Blade Noise

The cause of aerodynamic blade noise is turbulence towards the trailing edges of the blades; noise and turbulence are closely related. If the blades are "free-wheeling", i.e. rotating at an angle of attack of 0^o without generating any torque on the rotor or therefore any electrical power, turbulence, and thus noise generation, is confined to the trailing edge of the blade and is relatively low. But maximum power generation is normally sought whenever the wind speed is not sufficient for the turbine to generate its installed power output, which is typically for about 90 % of the operating time.

For maximum power the angle of attack of the blades is adjusted close to maximum torque (equivalent to maximum lift from an aircraft's wing), at which point the airflow on the leeward side of the blade has started to detach as shown in Figure 3; this is close to stall. The emission noise power levels at integer wind speeds should then be those given in a turbine's test report, and the modulation height will indeed be around the 2 – 3 dB reported in ETSU.

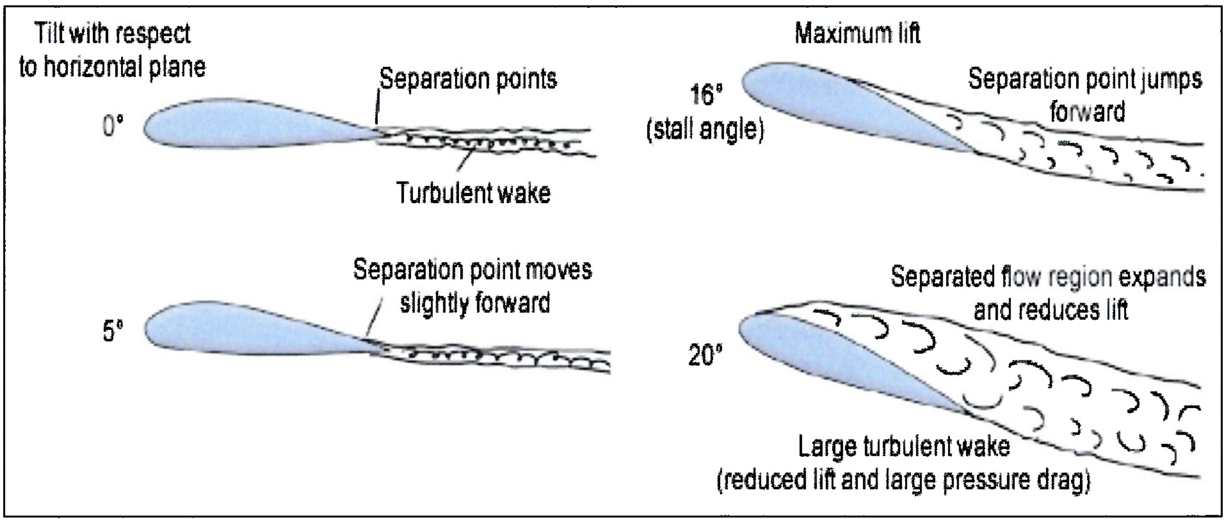


Figure 3: Aerofoils at increasing angles of attack (credit: NASA).

The turbine operational regime described above is assumed to prevail by ETSU, by the IOA Good Practice Guide [13] ("IOAGPG") thereto and until recently by the entire wind industry. Indeed it does usually prevail during daytime hours, but during evenings and at night time, because wind shear is greater, the higher noise levels of EAM are commonplace, as is explained in the following paragraphs.

As turbulence occurs on the trailing edge and adjacent leeward side of the blade the aerodynamic noise is directional, and more downwind propagation exceeds upwind propagation.

3 The Causes of EAM

3.1 Wind Shear

In order to understand one of the causes of EAM it is necessary to understand wind shear, which is the change of wind velocity with height above ground. The long established equation for wind shear, as given in ETSU, is:

$$\frac{V}{V} \quad \frac{\log \frac{h}{z}}{\log \frac{h}{z}} =$$

where V_1 and V_2 are the heights above ground of two different wind velocities at corresponding different heights above ground level h_1 and h_2; z_0 is the "roughness length" of the ground, and varies from a millimetre for smooth water to 0.3 m for forest.

The chart in Figure 4 shows average daytime values of wind shear for terrains of different roughness length, all normalised to a wind speed of 10 m/s at 10 m reference height. Wind shear is considerably greater in the evening and at night because of nocturnal temperature inversion. During the daytime the sun heats the land, which in turn heats the air in direct contact with it. This reduces the air density, so it rises over the colder air above it. The local turbulence disrupts laminar air flow. In contrast, the ground cools at night as it radiates heat instead of receiving it. Thus it cools the air in immediate contact with it, which stays low, and in turn cools the air above it, etc. This establishes a positive temperature gradient and a stable atmosphere. This encourages laminar air flow, and therefore greater wind shear, as there is no vertical turbulence to provide horizontal friction between layers.

Greater wind shear also results in greater atmospheric refraction, which "steers" (i.e. curves the propagation path of) the turbine noise downwards in the downwind direction, thus increasing downwind immission noise levels. Furthermore in higher than normal wind shear the ratio between hub height wind speed and receptor height wind speed, and therefore the ratio of turbine noise to background noise, will also be higher than normal. Thus wind turbine noise, even without any consideration of EAM, is a more serious problem during evenings and at night time than during the daytime. Again it is no surprise that most wind turbine noise complaints are about sleep disturbance at night, and rarely about excessive noise during the daytime.

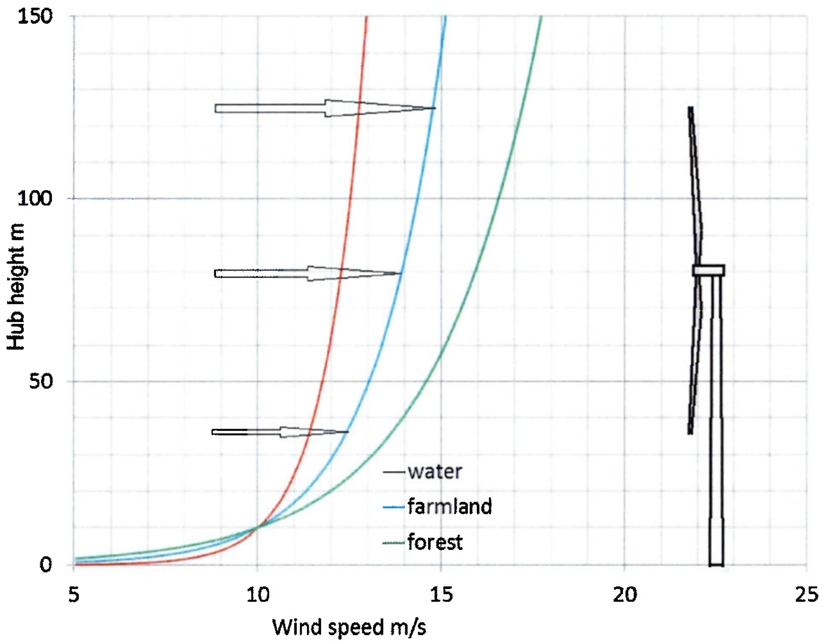


Figure 4: Wind shear: 125 m turbine on various terrains.

Figure 5: Noise contours; range of colour scale is 12 dB.

3.2 Transient Stall at Blade Zenith

As stated above the blade pitch of a turbine is normally adjusted for optimum energy conversion at the hub height wind speed. High wind shear creates EAM because, in the higher wind speed that pertains at blade zenith for a given hub height wind speed, the blade may not move fast enough to "keep up with" the wind; it therefore stalls. Figure 5 (from Oerlemans, pdf page 21 in the RUK report) shows the measured noise source distribution of a modern large wind turbine. It is seen that nearly all the noise comes from each downward sweep of a blade (the noise level increases by 12 dB from blue to red). The noise measurement however is A-weighted, which greatly understates any very low frequency noise power content. Nevertheless there is still some evidence of both blade/tower interaction at blade nadir and near stall at, or just after, blade zenith.

In deep stall the air flow is detached and turbulent over the whole of the leeward side of the blade. As the average wavelength of the noise is related to the extent to which the turbulence spreads across the blade this lowers the peak noise frequency by several octaves as well as considerably increasing its amplitude; see Figure 9.

Blade stall at zenith can quantitatively explain a 3 dB increase in the aerodynamic noise on stall, and the downwards frequency shift, but, notwithstanding repeated claims to the contrary in the RUK report, it cannot explain modulation heights up to 30 dB in measured noise level, also cited by Oerlemans in the RUK report.

The errors in the RUK report in this respect are explained in detail in §4.2 below.

3.3 Transient Stall Pressure Pulses at Blade Zenith

When a blade stalls and loses the force of the wind it also rebounds due to its elasticity (see Figures 6 and 7), generating a sound pressure pulse at the BPF. Because of the impulsive nature of the rebound its harmonics reach up into the lower part of the audio spectrum, i.e. above 20 Hz. When the BPF is close to a blade resonance frequency, or a subharmonic thereof, the blade oscillation can build in amplitude. Thus transient stall generates very low frequency noise as well as increasing the level of aerodynamic noise. Because of the vast area of a modern turbine blade the acoustic power of the very low frequency noise can be considerable. Its directivity differs from that of the aerodynamic noise; the blade acts as a dipole source, propagating equally upwind and downwind, although the wind shear still enhances the downwind propagation.

The higher nocturnal wind shear can thus increase peak wind turbine noise at night by three different mechanisms. In addition to the higher aerodynamic noise emission levels from the turbines from transient blade stall and higher noise immission levels at homes due to wind shear enhanced noise propagation there will also be very low frequency noise due to blade rebound and possible resonance.

Although blade stall has been described as transient most aerofoils have a hysteresis loop in their stall characteristic, in the case of turbine blades exacerbated by their considerable elasticity. The duration of stall is therefore a significant part of the blade passing period, as at zenith the vertical velocity component of the blade motion obviously passes through a minimum of zero.

Figure 6: Unstressed but considerably curved blades awaiting shipment.

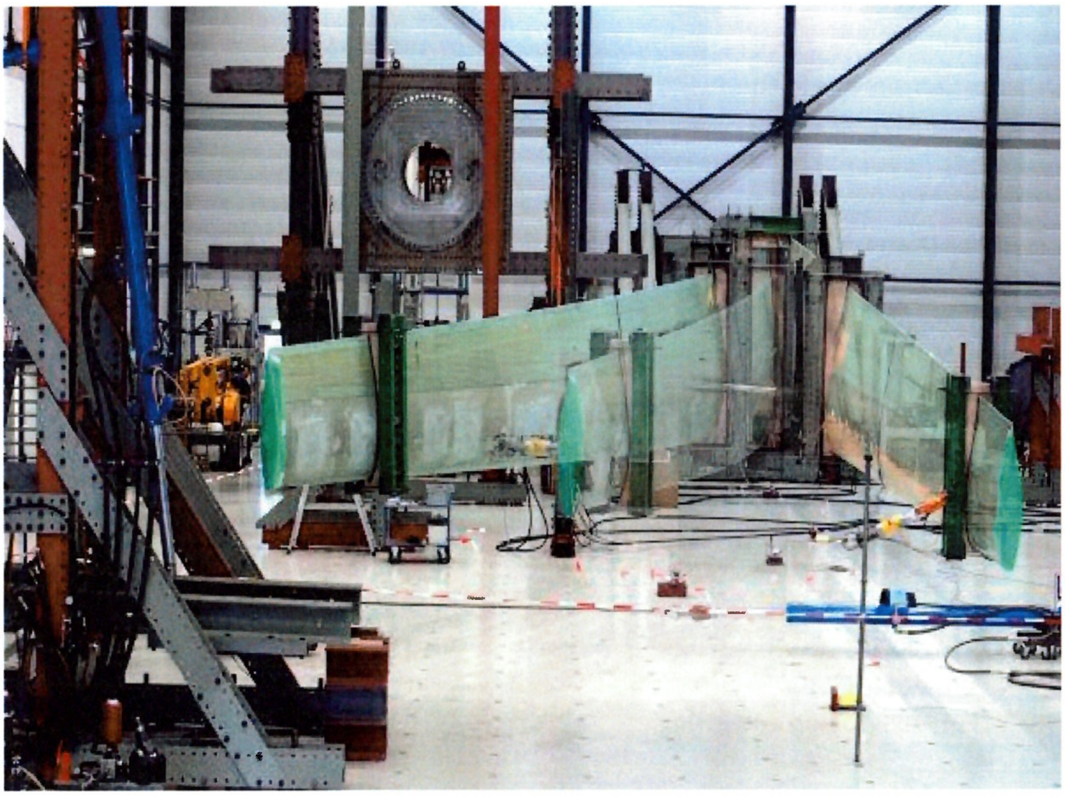


Figure 7: Triple exposure of a blade undergoing bending test.

3.4 Wind Turbine Evolution – from Large to Very Large, from Stiff to Soft

The smaller wind turbines of the 1990s were designed with sufficient rigidity not to vibrate; today's turbines are designed with less material and more subtlety in order to control and survive resonant vibration rather than to eliminate it by rigidity.

The relevant variables are the several resonant mode frequencies of the turbine components (the blades and the tower) and the frequencies of the periodic forces that risk exciting those resonant modes. Of the latter there are five:

- The rotational frequency of the rotor, f_r. Any static or dynamic imbalance in the blade weight or weight distribution will result in a rotating radial force at the hub, which can excite tower resonances.
- The BPF ($3f_r$ for a three bladed turbine, which is now almost universally the case, particularly for the larger AM prone turbines which have given rise to noise complaints). The reduction in the wind force on the tower when a blade is passing it can excite tower resonances.
- Again at the BPF, but at blade zenith, the blade rebound impulse on stall as described above in §3.3.
- The Kármán vortex shedding frequency of the tower, which is proportional to the wind speed and inversely proportional to the tower diameter.
- Similarly, the vortex shedding frequency of the blades, as acknowledged for example by Oerlemans in the RUK report [4].

Towers with a fundamental resonance frequency f_t higher than the BPF are referred to as "stiff", whilst those with f_t between the f_r and the $3f_r$ are referred to as "soft-stiff" or just "soft". If f_t is lower than f_r the tower is referred to as "soft-soft". Burton et al. comment [14] (on page 379 of the referenced book): *"The principal benefits of stiff towers are modest – they allow the turbine to run up to speed without passing through resonance, **and tend to radiate less sound**"* (my emphasis).

Simply scaling a turbine design by a factor of two would increase the rotor swept **area**, and therefore the power generation capacity, by a factor of four. The **volume**, and therefore the mass and much of the cost of materials used in the construction of the turbine, would increase by a factor of eight. Thus a simple scaling by two would, perhaps surprisingly, approximately double the materials cost per MW generation capacity. As the major purpose of increased turbine size is cost reduction per MW generation capacity modern wind turbines are, in relative terms, much more lightly built than their earlier brethren and therefore much more prone to resonance and vibration.

Turning again to Figure 2, a most unusual feature of the chart (perhaps unique for published data) is its coverage of a bandwidth down to 1 Hz. The blue trace is the usual 1/3 octave A-weighted noise emission power from SPL measurements at the rated turbine output power. The red trace is the same data with the A-weighting removed. The dashed black trace is the Fourier transform of a tower pass pressure impulse of arbitrary amplitude, that I have modelled at the BPF with a rise, dwell and fall time consistent with the manufacturer's published turbine dimensions. The BPF of the turbine is less than 1 Hz, so the fundamental at the BPF is not visible, but its amplitude is probably higher than that of any of its harmonics. It can be seen that the spectrum shape matches the measured values below 20 Hz reasonably well. Although the MM92 is an upwind turbine the nacelle overhang is relatively small, and at full power the wind-strained blades pass fairly close to the tower, so there is significant interaction therewith.

The green trace shows exactly the same unweighted data as the red trace, but plotted on a linear scale rather than a logarithmic (dB) scale. This provides a pictorial representation of where the noise power is at its highest level: below 10 Hz. The two ordinate values at which the logarithmic and linear plots coincide are 0 dB and 140 dB. The measurements were made in daytime wind shear so relate to turbines noise with normal AM, but without EAM.

3.5 Vortex Shedding from Wind Turbine Towers

Wind blowing past a cylinder (not necessarily a circular cylinder, but any bluff object) can create vortices which are shed alternately on each side of the cylinder. A common small scale experience of this is the whistling of overhead wires in a strong breeze; the alternating shedding of vortices applies an alternating force to the wire along its length, causing it to oscillate. The same applies to a tall factory chimney, where the effect can be more serious. The tower of a large modern wind turbine has resonant frequencies typically around 1 Hz or less.

Vortex-induced vibration (VIV) is well understood and well documented in journals of fluid dynamics and structural mechanics. If the vortex shedding frequency matches the resonant frequency of a structure the oscillations can destroy it. Wind turbine manufacturers are well aware of VIV; their concerns until recently have related only to fatigue and the structural integrity of the turbines rather than their noise emissions. A purely illustrative example of the power of VIV can be found here [15].

A frequently seen solution to VIV is the fitting of a helical "spoiler" around the outside of a chimney. This deflects the airflow upwards on one side of the chimney and downwards on the other side, thus avoiding the formation of vertical cylindrical vortices. Spoilers are not fitted to wind turbine towers, possibly for aesthetic reasons, but the towers do often have damping devices fitted internally to control resonance [13].

The unplanned shutdown from full power of Macarthur wind farm (140 x 3 MW Vestas V112 turbines) provided Huson [16] with clear evidence of wind turbine resonances by vortex shedding. When recording infrasound and low frequency noise from the turbines, the rapid shutdown caused the total loss of the aerodynamic noise signal from the turbines, but the tower/blade infrasound tones decreased by only a few dB. In such a case tower and/or blade structural resonances would seem to be the only plausible explanation of the tones.

3.6 Blade – Tower Interaction

The regular passing of the tower by the turbine blades can also cause a tower to oscillate at one of its resonant frequencies. Dwelling at any resonant frequencies of modern turbines is avoided when increasing or decreasing the rotor rotation rate, so whilst this mechanism can be a powerful source of infrasound it could in principle be mitigated, for the benefit of the turbine operator and the wind farm neighbour alike.

Much has been made by the wind industry of the reduction in turbine noise that was achieved by the transition from downwind designs to the now almost universal upwind designs. The problem with downwind turbines was that the blades passed through the wind shadow of the tower, producing an infrasound or very low frequency pulse at the BPF. This did cause the relatively small early downwind turbines to be very noisy for their size. Replacing the blade-passing-through-wind-shadow-of-tower event by the tower-passingthrough-wind-shadow-of-blade event of upwind turbines whilst solving one problem created another; the latter event can and does cause tower oscillation. I have observed this myself on several occasions when half way up the inside of the Ecotricity 1.5 MW Enercon turbine at Swaffham, Norfolk, at amplitudes I estimated to be up to about 40 cm. On other similarly windy occasions the amplitude of the swaying was only a few cm, presumably because the vortex shedding frequency was less close to a tower resonance frequency. I saw no internal damping devices in the tower of this turbine.

3.7 Vortex Shedding from Blades

Finally turbine blades, like turbine towers, can be caused to resonate by vortex shedding; as they are usually made of glass fibre composites they are highly elastic, as is seen in Figures 5 and 6. Blade vortex shedding causing a 30 dB EAM modulation height is reported in the AIAA paper cited by Oerlemans as his ref. [21] in the RUK report.

4 The RUK Report

4.1 A Note on the Academic Status of Authors and Publications

When decision makers are not specialists in the science on which their decisions should be based it is essential that they are aware of the academic status and any beneficial interests of the people and publications from which they take their guidance. This is particularly relevant when the technology is complex and the potential financial gains of its promoters are high, as in the present case. The RUK report was commissioned by the wind industry lobby organisation RenewableUK, which in its own words is the *"leading renewable energy trade association working to grow your business"*, so makes no claim to be an impartial academic institution. My own opinion of the RUK report is that it is technically unsound and highly misleading. Its authors work in or largely for the wind industry. I have found no evidence that the report has been peer reviewed, in spite of its statement (page 372) that *"it will be peer-reviewed by other specialists working in the field."* The three work package reports by Bullmore and Cand of Hoare Lea state on their audit sheets that the authors have reviewed each other's papers; this is not peer review. Cand in particular is identified as an author of four of the six UK produced work packages listed on pdf page 2 of the RUK report and his *"considerable contribution"* is gratefully acknowledged in one of the remaining two.

Conference papers are frequently referenced in the RUK report; these are rarely peerreviewed. It is only for the learned journals that independent peer reviews are required; the review process is managed by the journal and is usually anonymous. By way of example, a leading peer-reviewed international journal in acoustics is that of the Acoustical Society of America (JASA). According to the American Institute of Physics *"Since 1929 The Journal of the Acoustical Society of America has been the leading source of theoretical and experimental research results in the broad interdisciplinary study of sound."*

The claim of "peer reviews" by an author's colleagues who rely on the same customer base and belong to the same professional institution as the author is worthless and serves only to demean the author and the institution.

4.2 "WP A1 - An explanation for enhanced amplitude modulation of wind turbine noise"

In the following three sections I question the validity or relevance of three of the papers in the RUK report. The first carries the logo of the Dutch NRL which, though a commercial concern, not a government laboratory, is well respected and long established in aerospace research. I understand that Oerlemans, the paper's lead author, works for Siemens Wind Power, a major wind turbine manufacturer.

The paper is concerned with transient aerodynamic stall at blade zenith, which occurs when wind shear is high and the angle of attack of the blades is optimised for the wind speed pertaining at hub height, as explained in §3.2 above. It seeks to demonstrate that EAM can be quantitatively explained by blade stall at zenith; it appears to me that the demonstration, whilst plausible in principle, is arithmetically flawed.

Oerlemans states (on pdf page 4):

"The simulation results [using the BPM model] *show that, as long as the flow over the blades is attached* [meaning laminar], *wind shear has practically no effect on amplitude modulation. However, strong wind shear can lead to local stall during the upper part of the revolution. This can yield noise characteristics which are very similar to those of EAM. Thus, it can be concluded that local stall is a* ***plausible explanation*** *for EAM."*

On pdf page 19 Oerlemans reviews three reports of measured stall induced noise increases:

"In Ref. [19] stall was found to result in a 10 dB increase in broadband noise. In Ref. [18] the noise increase due to stall appeared to be ***somewhat lower*** *than 10 dB, but in Ref. [21] noise increases up to 20 dB (light stall) or 30 dB (deep stall) were found in a certain frequency range. All in all, it seems reasonable to assume an increase of 10 dB in overall sound level, although the actual value may depend on the airfoil. Thus, the prediction method should exhibit a sudden noise increase of about 10 dB when stall occurs."*

I do not agree that it is *"reasonable to assume an increase of 10 dB"* based on reported EAM heights of 10, 20 and 30 dB. In terms of SPL 30 dB is one hundred times greater than 10 dB.

I was unable to find in Oerlemans' ref. [19] any reference to a 10 dB increase in broadband noise on stall, or indeed any measurement data that I felt was relevant to the matter in hand.

Oerlemans' ref. [18] is about rotor noise from hovering helicopters, which does have something in common with wind turbine noise. From page 35 of the referenced document, *"The tip vortex generated by the upstream airfoil at an angle of attack, au = 8°, caused the 30 and 70% chord fluctuating surface pressures to increase on the order of* ***20 to 30 db at low frequencies with smaller increases obtained at high frequencies. These large increases were associated with airfoil leading edge-stall*** *as confirmed by flow visualization with tufts."* This is considerably higher than 10 dB, not *"somewhat low*er"; furthermore the quoted figures are surface pressure measurements, not far field SPL measurements, so of little quantitative relevance.

The device under test was NACA 0012 aerofoil with a 23 cm chord. The objective of the referenced document was to:

"...define the noise characteristics associated with the interaction of a stationary tip vortex and a downstream stationary airfoil. This model test geometry simulated, in its simplest form, the tip vortex-blade interaction which occurs on single rotor helicopters during hover".

This is a different cause of stall from wind shear, but I see no obvious reason why the noise increase on stall should differ markedly. The authors state that *"The stall noise was qualitatively of a* ***buffeting low-frequency*** *nature".* Scaling the frequency to fit the chord length of a typical turbine blade will scale the frequency proportionally lower

Oerlemans' Ref. [21] (my reference [17]) are to a paper given at the 30th American Institute of Aeronautics and Astronautics conference in 2009; it reports wind tunnel measurements, again on NACA 0012 aerofoils. The high levels of EAM (30 dB) to which Oerlemans refers occurred at frequencies around 100 Hz and are ascribed by the authors to vortex shedding. The aerofoil chord lengths in this case were around 10 cm, so scaling the 100 Hz frequency to current wind turbine blade dimensions would scale the stall noise frequencies down to a few Hz, which eliminates aerodynamic noise as a source of the 30 dB of EAM.

Having read Oerlemans' references [18, 19 and 21] I consider that, to merit the adjective *"plausible"*, a quantitative explanation of EAM should account for his highest quoted stall noise increase of 30 dB, not just his lowest quoted increase of 10 dB. Reference to noise measurements of wind turbines rather than of scaled down aerofoils in wind tunnels would perhaps be useful; I refer again to figure 1, where the maximum EAM height is 25 dB.

Oerlemans shows (pdf page 20) that typical measured AM heights of 2 – 3 dB, as described in ETSU, are indeed comparable with those predicted by the referenced BPM model. He then observes that the BPM model includes a module for stalled air flow, from which he predicts a noise increase on stall of about 3 dB. The waveform provided by Bowdler to Oerlemans (figure 4, pdf page 30 of the RUK report) shows such an increase, and this is moreover an increase in the peak level without any associated decrease in trough levels, as would be expected from an event which only occurs at blade zenith. It does not however explain even the reported EAM heights of 10 dB, let alone 25 or 30 dB. Oerlemans continues (pdf page 20):

"...7 dB is added to the spectral levels calculated using the BPM code, in order to obtain the desired 10 dB overall noise increase."

Yet he later (on pdf page 25) repeats his initial conclusion that:

*"...if local stall occurs, the resulting noise characteristics can be very similar to the EAM characteristics mentioned above, depending on the size of the stall region. Thus, it can be concluded that local stall is a **plausible explanation** for EAM."*

In summary, the objective was to demonstrate that the proven and well established BPM model supports the hypothesis that stall-at-blade-zenith can account for observed levels of EAM. But in truth the model predicts only a doubling of the modulation height on stall (from 3 dB to 6 dB), not an increase to 30 dB. So the target was lowered from 30 dB to 10 dB and the BPM prediction of 3 dB was increased by a declared but nevertheless arbitrary unjustified 7dB to achieve even that lowered target. Thus the paper offers no *"plausible explanation"*, even though it purports to do so, for the levels of EAM measured and reported in Oerlemans' references or indeed those measured and reported for example by Cooper, Huson, Stigwood and many others at wind farms around the world.

4.3 "WP B1 - The measurement and definition of amplitude modulation(s)"

This paper addresses a problem which in my view does not exist: the search for an automated process to determine whether or not the amplitude modulation height of a time series waveform is of acceptable magnitude. Taking figure 1 as a sample of EAM, albeit a fairly extreme example, it is abundantly clear that there is a typical modulation height of around 20 dB, peaking to 25 dB. All that is required to determine the modulation height is the eye and a ruler; all that is required to verify that the signal is indeed from a wind turbine and not some other source is the ear, for which purpose sound is recorded along with the LAeq.

There is no legitimate benefit to be derived from the use of complex and opaque signal processing techniques to derive a "metric" from a time series signal with clear and stable periodicity. It is noticeable that all the methods proposed by the IOA AMWG understate the modulation height when compared with the simple observation of the time series signal, as is demonstrated by Large in INWG Work Package 7 [18]. Whatever method is used transparency is essential, and must include independent evaluation of the final method chosen by the IOA INWG and the release of the source code for the MatLab software proposed by the IOA AMWG for the signal processing, not forgetting that the latter is in fact entirely redundant.

4.4 "WP B2 - Development of an AM dose-response relationship"

This paper describes the Salford listening room test commissioned by RUK. The listening room has a surprising inclusion in its sound reproduction system: **a high pass filter with a corner frequency of 140 Hz and 20 dB attenuation at 100 Hz** (see figure 8 reproduced from the RUK report, pdf page 229). The filtering out of all frequencies below 100 Hz in the measurement of EAM will completely remove any and all of the turbine noise signals from the sources described above in §3.3 to §3.7, along with some of the downward shifted frequency content of the aerodynamic noise in stall. This equipment was used to replay real wind farm noise recordings for volunteers to rate the degree of annoyance they caused. The RUK report, wind industry developers and their IOA AMWG acousticians repeatedly assert that the noise of EAM is all aerodynamic and has little content below 100 Hz; this would seem to make the 100 Hz filter redundant. No spectral measurements have been published in the RUK report to support this assertion; indeed independent measurements, such as reproduced in figure 1 above, demonstrate the contrary. I must therefore conclude that this paper, whatever its intention, serves to obfuscate rather than to illuminate the matter that the RUK report purports to address.

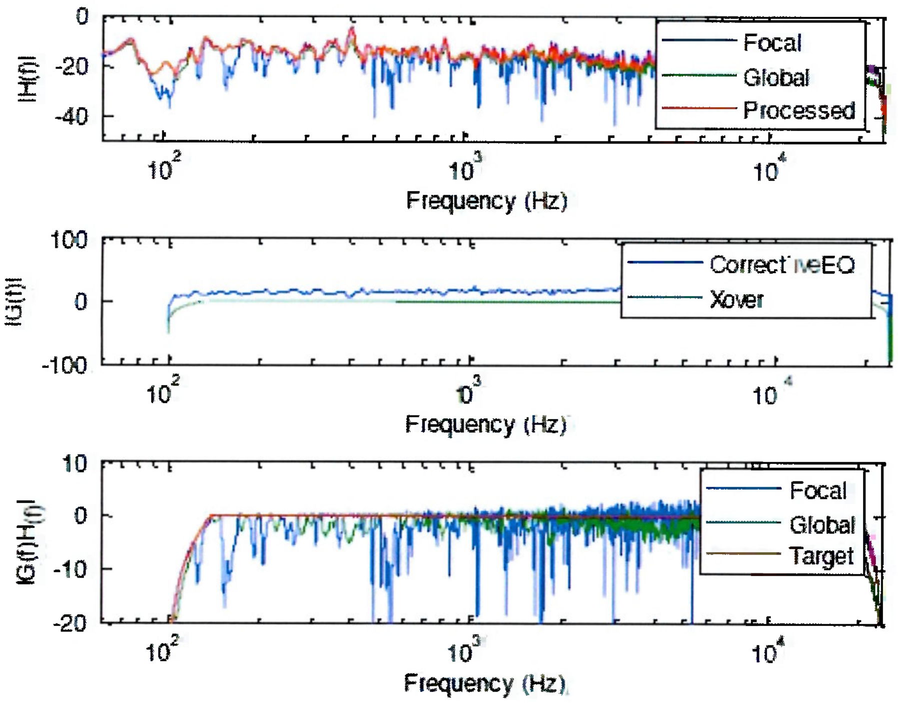


Figure 8: Salford listening test progressively filters out frequencies below 140 Hz.

The three traces in figure 8 are respectively the raw recorded signal IH(f), the response function of the filter IG(f) which the authors refer to as "the correction applied", and the resulting spectrum, the product of IH(f) and IG(f), which has clearly been stripped of any signal below 100 Hz.

4.5 "WP C - Collation and analysis of existing acoustic recordings - Hoare Lea Acoustics"

It was noted in §3.6 above that much effort has been expended by the wind industry to downplay the significance of wind turbine low frequency and infrasound emissions. For example in WP C, §2.1.5 on page 272 of the RUK report [4] Cand states:

"These considerations are complicated to a degree by the historical presence of infrasound in downwind turbine designs due to blade flow/tower interaction effects, which have now been effectively designed out of modern turbines through the use of upwind designs. The abovereferenced studies, as well as more recent research [4] presented in 2011, have confirmed that there is no significant level of infrasound emitted from modern wind turbines."

Cand's reference [4] (and my reference [19]) is to a paper by commissioned and coauthored by Australian wind energy developer Pacific Hydro. It is based on wind turbine noise measurements using G-weighting, a rarely used weighting curve which, like A weighting, purports to model the frequency response curve of the ear, only at infrasound rather than audio frequencies. At 10 Hz its weighting is zero, but the ear's sensitivity and therefore the G-weighting curve, descend rapidly below 10 Hz,; at a typical blade pass frequencies around 0.6 Hz the Z-weighting curve is close to - 50 dB, which is the same as the A-weighting curve at 20 Hz. At 0.25 Hz, the corresponding rotor rotation frequency, the G-weighting curve is not even defined, but extrapolates to – 96 dB. G-weighting is scarcely more relevant than A-weighting, as both assume that the human auditory response is the only relevant criterion.

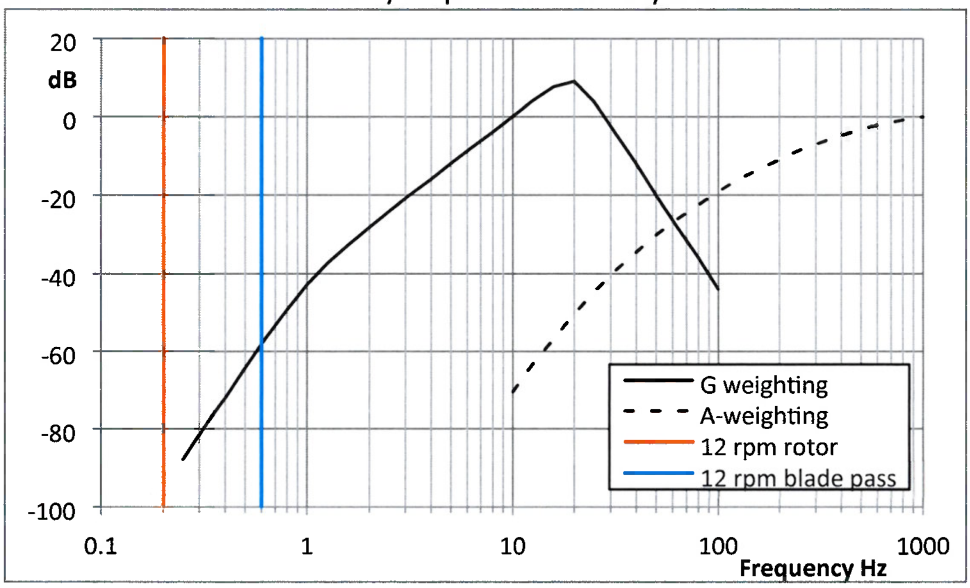


Figure 3: G-weighting and A -weighting curves with 12 rpm rotor and blade pass frequencies.

5 Measurement Problems

5.1 Why Always Use A-weighting Even When the Problem may not be Audible Sound?

The precise mechanism of the potential health hazards presented by turbine noise is outside the scope of this paper, but it should be understood here that, whilst the sound of normal AM turbine noise, with its normal 2 – 3 dB of AM, can cause annoyance, EAM differs from AM it that it can present a health hazard. This is a fundamental distinction between the effects of AM and EAM, and a fundamental reason why the appropriate measure of EAM is given by the true sound pressure level measured as dB re 20 µPa. By way of illustration, for the ear to perceive sound at 20 Hz and sound at 2 kHz to be of equal loudness the sound pressure level at 20 Hz needs to be 50 dB higher than the sound pressure level at 2 kHz. Below 10 Hz the A-weighting function is not even defined.

The common objective is, or should be, the determination of the levels at which wind turbine noise becomes:

(a) annoying to an extent that should be considered in the planning balance, or
(b) a potential health hazard, in which case the application/appeal should fail notwithstanding any other planning considerations.

It is important to use tools appropriate to each task. One tool which is clearly unsuitable for (b) is the A-weighting curve, which over rather more than 50 years has become entrenched, and often mandated, in environmental and industrial noise regulation. The original objective of the A-weighting curve was to reproduce the sensitivity of the average human ear over the audible frequency spectrum (defined as 20 Hz to 20 kHz) at low sound levels. It achieves that function well, but only at low sound levels; it is not suitable for, and was never intended for, the present purpose, where unacceptable levels of low and very low frequency sound may be present at high levels. The fundamental frequencies involved are the turbine rotation frequency, the blade pass frequency, and blade and tower resonant frequencies. All of these, and many harmonics thereof, fall below 20 Hz, where the A-weighting curve is not even defined.

The use of A-weighting reduces the sound level measurement – but not of course the sound level - by 50 dB at 20 Hz. At these low frequencies G-weighting is equally inappropriate as it too reduces measurements, by 50 to 100 dB at blade pass frequencies. Any weighting is inappropriate. As even the straightforward unweighted measurement of sound power level is referred to as "Z-weighting" the concept of weighting is obviously well entrenched in the acoustic mind set; inaudible pulsing pressure waves around 1 Hz however are far better understood in terms of physics rather than acoustics.

5.2 Use of a 100 Hz High Pass Filter Causes Understatement of EAM

The IOA AMWG Discussion Document [20], in order to *"filter out noise in the ambient environment occurring at frequencies below 100 Hz (which tends to be influenced by wind noise mainly)"* proposes the use of a 100 Hz high pass filter for AM compliance measurements. Inspection of the source spectra of Figure 9, all three of which are from wind energy industry publications, shows stall noise frequencies peaking at around 100Hz, compared with about 400 to 800 Hz in laminar flow. Thus, notwithstanding the contribution from very low frequencies due to blade rebound or resonance, the measured peak amplitude of EAM in stall will understate the true amplitude by around 3 dB, or even if (inappropriately) using A-weighting, by around a dB. The trough amplitude however will lose very little in the high pass filter (HPF), so the use of the 100 Hz HPF will cause significant understatement of the modulation height.

ETSU (page 31) considers frequencies down to 20 Hz in contemplation of the noise from the far smaller turbines current at the time of its drafting:

"It should be noted that low frequency noise, for example, from ventilation systems, can disturb rest and sleep even at low intensity. Where noise is continuous, the equivalent noise level should not exceed 30dB(A) indoors, if negative effects on sleep are to be avoided. In the presence of a large proportion of low frequency noise a still lower guideline value is recommended. It should be noted that adverse effect of noise partly depends on the nature of the source." [WHO]

The comments with respect to low frequency noise reflect the effect of using an A-weighted sound pressure level. If most of the acoustic energy was concentrated at a very low frequency, then high levels of acoustic energy might exist but an A-weighted level may still only be 30dB(A). As an example, the A-weighting network applies a correction of 50dB at a frequency of 20Hz. Therefore, a level of 80dB at 20Hz would meet this 30dB(A) requirement.

The IOAGPG endorses the use of ISO 9613-2 for wind farm immission noise level prediction and of IEC 61400-11 for turbine noise measurement. Both these standards require measurements only down to 45 Hz, a seemingly perverse movement upwards in frequency from 20 Hz over a 16 year period during which turbine noise emissions decreased considerably in frequency due to the increase in turbine dimensions. That the lower frequency limit should be raised even further to 100 Hz for EAM noise measurements, which clearly have a significant content below 100 Hz, seems yet more perverse.

5.3 The Den Brook Amplitude Modulation Measurement Methodology

Bass [21], of international wind farm developer Renewable Energy Systems (RES), claims that the Den Brook EAM measurement methodology is *"not fit for purpose"*:

"The above analysis has clearly demonstrated that the AM Test Method is not a good indicator of the presence of 'greater than expected' AM in samples of acoustic data, having a false

positive rate of 67 - 83 %. Given that the sole purpose of such a test is to discriminate between those samples which do, and those which do not, contain 'greater than expected' AM, this high rate of false positives demonstrates that the test is not 'fit for purpose'."

§4.3.2 and §4.5.2 of the IOA AM consultation document [5] echo Bass, referring to a high rate of false positives in the Den Brook time series methodology for measurement of EAM, and to Bass's report of the measurement of a large number of "false positives" at two typical wind farm sites – typical except that they were in fact rural locations devoid of wind turbines. This, he considers, is evidence of a failure of the Den Brook methodology. A simple argument; if you have all those false positives indicating excessive AM even without any turbines present then how can one possibly rely on the data with turbines present? But this argument has a fundamental and elementary flaw. It is easier to explain the flaw by starting at the beginning rather than working backwards from Bass's erroneous conclusion.

Suppose there is a constant background noise level of B = 25 dB(A) and wind turbine noise of 40 dB(A) with 3 dB of AM: T = (40 ± 1.5) dB(A). Because dB scales are logarithmic the sum S of B and T is not given by S = B + T, but instead by

$$S = 10 \log (10^{B/10} + 10^{T/10}) = 40.14 \pm 1.45 \text{ dB(A)}$$

as should be well known to all acousticians. Thus the addition of the constant 25 dB(A) background noise marginally increases the average and noise level and actually **reduces** the AM index. Now let us add ± 1.5 dB of AM to the background noise:

$$S = 10 \log (10^{B/10} + 10^{T/10}) = 40.14 \pm 1.50000 \text{ dB(A)}.$$

That the total AM is again ± 1.5 dB should be no surprise, as both signals had the same ± 1.5 dB level of AM. That adding 25 dB(A) of background noise only adds 0.14 dB to the total noise level should be no surprise either. In summary the background noise has little effect on the turbine noise when it is 15 dB below it, which is likely to be the case, especially when compliance measurements are made indoors rather than outdoors and in high wind shear conditions, which is after all where and when the noise levels that give rise to the majority of complaints are experienced – in homes at night.

The ear's AGC (automatic gain control) system, one of the reasons for measuring sound levels in dB, has a gain compression mechanism which allows the ear to accommodate a huge range of sound power levels. It also enables the well-known property of sound masking. Very simply, a dB change in SPL at 40 dB(A) is far greater than a dB change in SPL at 25 dB(A). At the turbine-free wind farms surveyed by Bass there is no wind turbine noise to mask the background noise, so of course a 3 dB change in background noise will be detected without turbine noise, but it would have masked if there was turbine noise. By its variable nature background noise will always produce "false positives" in the absence of turbine noise – more accurately, they are real, but irrelevant positives.

The argument proposed and published by Bass fails because linear arithmetic and logarithmic arithmetic are different.

5.4 Loss of Frequency Information

I have shown in §4.2 above that stall at blade zenith can only explain increased aerodynamic noise on stall for EAM heights up to about 6 dB; it is also clear that further increases in EAM heights up to 30 dB can only be explained by the presence of much lower frequency acoustic emissions due to the structural dynamics of the turbine components. The IOA AMWG state that all EAM of any height is fully explained by increased blade aerodynamic noise above 100 Hz. This question is easily resolved by measurement, and it is most extraordinary that the IOA AMWG has not reported, and therefore presumably has not made, any such measurements. The word "infrasound" appears 15 times in the RUK report, but always in the context of asserting its non-existence in wind turbine noise.

The measurement system used by the IOA AMWG, because any standard SLM (sound level meter) rectifies and integrates the signal from the microphone, destroys all the original frequency information in the microphone signal. The INWG is therefore undertaking a series of measurements of turbine noise spectra at sites notorious for troublesome EAM heights, as theory should always be proved by measurement, in part to give confidence to those unable to understand the theory. Representatives of the IOA AMWG will be invited to participate in those measurements.

5.5 Indoors or Outdoors

I address here the question of whether EAM compliance measurements should be made indoors or outdoors. The IOA AMWG discussion document proposes outdoors, and justifies this proposal (§3.3 of [5]) by the statement:

"...measurements are made outdoors for consistency with other procedures for measuring wind turbine noise (such as ETSU-R-97)."

In truth AM compliance measurements have little relationship to ETSU background noise measurements. The descriptor proposed by the AMWG is LA_{eq}, whereas ETSU refers exclusively to LA_{90}. Furthermore EAM is an area where ETSU offers no guidance; there is therefore nothing to be consistent with.

It has also been suggested that access indoors may be refused by residents; it is however most unlikely that residents suffering from a serious wind turbine noise problem would not cooperate with attempts to resolve that problem.

The advantages of indoor measurement are threefold:

(a) Wind noise is significantly reduced, particularly at low frequencies, making the turbine noise measurements less contaminated and therefore more reliable. The higher outdoor background noise would of course raise the troughs in the EAM trace far more than it raised the peaks, thus understating the EAM modulation index.

(b) The 8 dB attenuation from outdoors to indoors through an open window assumed by ETSU when setting the 43 dB(A) night time limit does not apply at low frequencies; as discussed in §2.3 above it is certain to be reduced at frequencies below 100 Hz and at lower frequencies is often replaced by amplification due to room resonances.

(c) The resident can be provided with a pushbutton to timestamp the sound recording on occasions when the noise is considered unacceptable, which greatly reduces the subsequent labour of data analysis by directing the person analysing the data to its relevant high EAM content.

Finally what good reason can there possibly be for measuring the noise level in a very different place from that where the noise level is giving rise to complaints?

It is puzzling that the IOA AMWG has changed its Terms of Reference by adding to the definition of AM the words ***"as observed outdoors".*** Referring to (b) above it is seen that this could allow indoor noise levels 8 dB above the ETSU 35 dB(A) limit on which the ETSU night time 43 dB(A) limit is based.

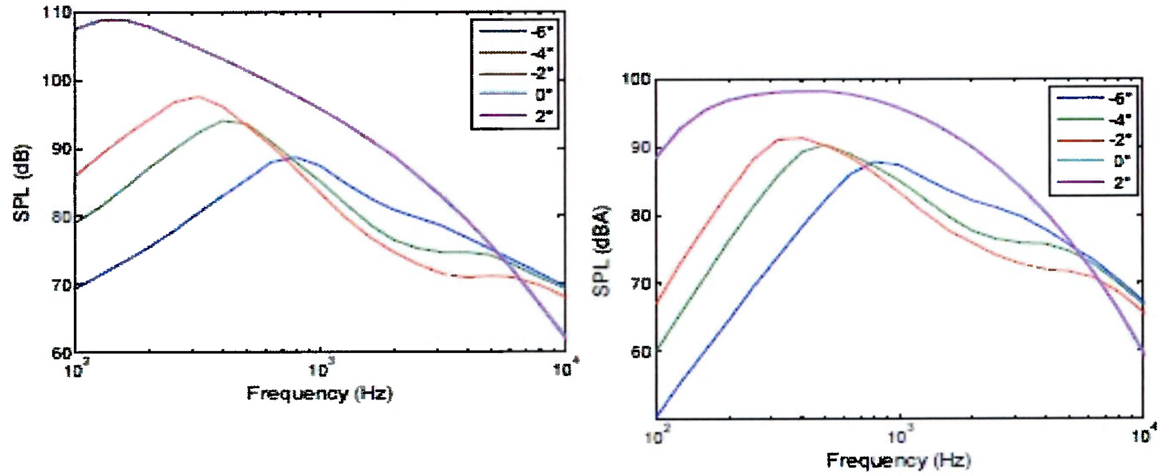
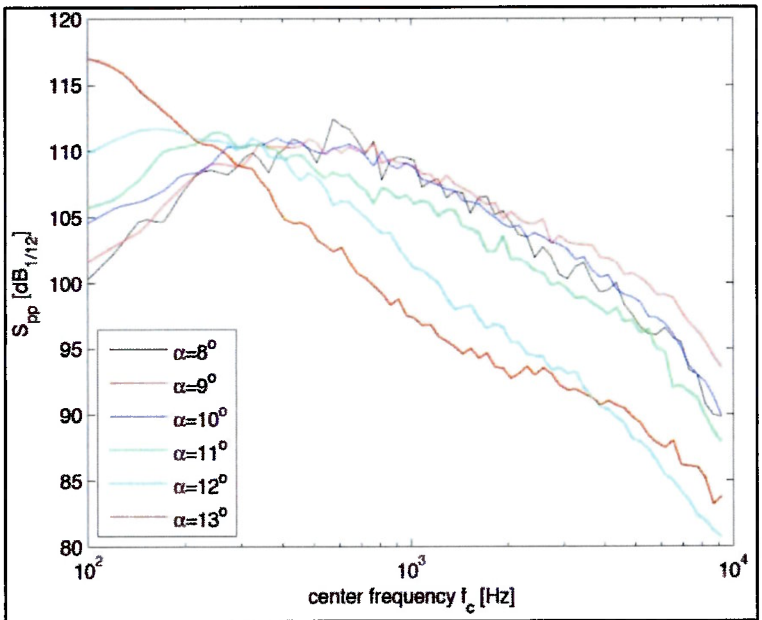


Figure 13: Source spectra for blade section in dB (left) and dBA (right) as a function of relative angle of attack (0° corresponds to the stall angle). The lines for 0° and 2° are practically on top of each other.



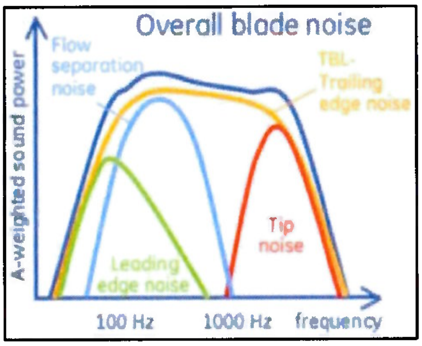


Figure 10: Change of aerodynamic noise spectrum with angle of attack; top, from the RUK report, Oerlemans, page 34; left, from the RUK report, H A Madsen et al., p. 492; right, from presentation by J Bass to EWEA Noise Meeting December 2012.

6 Conclusion

6.1 Understatement of the Modulation Index

Figure 9 shows, from three different wind industry publications, how blade stall at zenith increases the level of aerodynamic noise whilst reducing its frequency. All the charts have what appears to be the IOA INWG's rigid lower frequency limit of 100 Hz. The purple trace in the top left-hand chart is Oerlemans' predicted spectrum of aerodynamic noise in stall. Compare this with the red trace of my figure 2 for a similar turbine; it is seen that the SPL increases by 20 dB per decade as the frequency decreases from 100 Hz to 1 Hz. The comparison permits two observations.

- It cannot reasonably be assumed that the four stall traces of figure 9 all drop suddenly to an insignificant level at and below 100 Hz, yet the IOA AMWG effectively make that assumption by filtering out all noise below 100 Hz. This will cause a significant understatement of the EAM height. The increase in noise amplitude on stall will indeed show as an increase in EAM height, but cutting off all that part of the spectrum shifted below 100 Hz will spuriously and significantly reduce the EAM height.
- Aerodynamic noise from the blades is clearly not the only source of noise in play, as it does not explain the much higher energy part of the turbine spectrum, with or without EAM, below 100 Hz, as shown in figure 2 above but not shown or discussed in the RUK report [4] or in the IOA AMWG discussion document [5] derived from it.

6.2 The Increasing Inadequacy of ETSU

Turbines emit significant audible noise, against which current planning guidance (ETSU and the IOAGPG) provides a limited degree of protection to wind farm neighbours, and claims no better. ETSU opens thus (page iii):

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

I have observed that it is ETSU that is the primary constraint on the design of most commercial wind farms, the for which the NIAs usually predict noise immission levels within a small fraction of a dB of ETSU maximum noise limits; indeed if more turbines could be accommodated on a given site without exceeding those limits it would be commercially inept not to accommodate them. But it is now clear, from increasing numbers of noise complaints, that in many cases either the protection provided by the guidance is inadequate or compliance with the guidance is inadequate. The latter can only be due to questions of conscience and/or competence on the part of both developers and LPAs. I have represented many potential wind farm neighbours in appeals where I have exposed developers' NIAs as, in the words of one of the Inspectors, "deeply flawed" [22], and I have also seen gross but genuine errors due to the inadequate expertise of authors. One of the *"administrative burdens"* which many LPAs have failed to discharge is the verification of the competence of developers' NIAs, either by consulting their environmental health officers who lack the necessary education and experience or by using external consultants who largely work for the wind industry.

The adequacy and scientific rigour of ETSU has been questioned ever since its publication in 1997, not least by ETSU itself (page 2):

"The report was drafted in the light of the best information available at the time. However it is acknowledged that as more experience and information become available and as circumstances develop it may become necessary to revise and improve the contents of this report. The Noise Working Group therefore suggests this report and its recommendations are ***reviewed in two years' time****."*

That review is now 16 years overdue, and in the 18 years since the publication of ETSU wind turbines have considerably increased size and power. An inevitable consequence of this is the increase in amplitude and the decrease in frequency of turbine noise emissions. It is no longer credible for wind industry acousticians to claim that there is no noise problem from wind turbines, and in particular it is no longer credible to deny the emission of low frequencies noise and infrasound from today's wind turbines.

6.3 Annoyance or Health Impairment?

There are two rather different concerns raised by the IOA AMWG discussion document and the RUK report on which it is based. The boundary between the concerns is not abrupt, and is also uncertain because of the paucity of spectral measurements, but the dividing parameter is frequency, with the division probably somewhere near 20 Hz; it is the effect of turbine noise on the human species that changes with frequency.

Very low frequency noise can impair health without the hearer necessarily being aware of an annoying level of audibility, whereas the aerodynamic noise principally causes annoyance – although this too, if of sufficient degree, can ultimately impair health. Very low frequency noise, unless perceived as audible noise, cannot directly cause annoyance.

6.4 The Nocebo Effect

The wind industry response to the rapidly increasing numbers of noise complaints has been to invoke the "nocebo effect", which rhymes convincingly with placebo, and is in a sense its converse. According to the OED a placebo is "A substance that has no therapeutic effect, used as a control in testing new drugs". It also describes harmless but ineffective therapies used to placate patients whose problem is psychological rather than physiological. My OED has no entry for "nocebo"; the Journal *"Nature Medicine"* reports 16,579 titles which include the word placebo but only 35 which include "nocebo". Nevertheless the industry's nocebo-based claim is that negative propaganda about wind turbine noise causes many wind farm neighbours to think the noise is adversely affecting their health and disturbing their sleep when it is in fact innocuous. The industry also invokes psycho-acoustics to suggest that a dislike of the appearance of turbines translates to a dislike of their noise.

The reality is that all the information the general public have had from the wind industry and, until the summer of 2015, from Government, has been extremely positive. The printed and broadcast media, and particularly the BBC, still remain largely supportive of wind energy. When criticisms are made they relate to visual effects, damage to the economy and to security of supply, threat to endangered species, etc. Only rarely does the technically more complex topic of noise receive media attention; it is however usually the wind farm neighbours primary concern, but they do not often object to wind farm noise until they hear or otherwise perceive it. As the density of wind farms increases many potential wind farm neighbours will have heard noise, and the testimonies of neighbours, from other wind farms before they become involved in resistance to a planning application in their own immediate locality but even this does not fit the definition of nocebo unless the neighbours' testimonies are deemed to be false.

Figure 11: Some of the 1,600 aborted mink pups.
Credit: Mark Duchamp, WCFN.

There are several species besides man that appear to have suffered adverse health effects from wind turbine noise. It is unlikely that a non-human species would be aware of any propaganda from either side of the wind energy debate, and unlikely that it would take exception to the appearance of wind turbines, and then translate that exception to a dislike of turbine noise.

A 2013 Polish study [23] in the Polish Journal of Veterinary Sciences Vol. 16, No. 4 (2013), 679–686 of the effect of a single 2 MW turbine on domestic geese farming concluded with:

"Geese from the gaggle which was kept at a distance of 50 m from the turbine, grew slower, gained less body weight (by 10 %) and had a higher concentration of cortisol in blood, compared to birds reared 500 meters away from the wind plant. It was also noted that even the distance of 500 meters cannot be considered a safe one; this was confirmed by the results of infrasound measurement and cortisol concentration in blood, which exceeded the control values."

As this peer-reviewed study was done in the interest of commercial goose farming by veterinary science researchers it cannot be portrayed as scaremongering by wind farm opponents.

An equally compelling case is Kaj Bank Olesen's mink farm in Denmark. At the end of 2013 four 140 m high Vestas turbines, the nearest 320 m from the mink sheds, became operational. Overnight the mink became highly aggressive and fought amongst themselves, with some females even killing their own pups. The farmer complained, and the operators terminated the turbine test run. The behaviour of the mink immediately returned to normal. The operators then declared that the problem was not of their making and operated the turbines again; the problem returned immediately, and was accompanied by an extremely high rate of deformities, stillbirths and abortions (see figure 10). The most common deformity was the absence of eyeballs. The Danish Government are holding what seems to be a very lengthy enquiry into the case, but it is of interest that there seems to have been an unofficial moratorium for onshore turbines in Denmark in throughout 2015.

A third, more recent case[24] is that of Yann Joly, a French dairy farmer, who has instructed Me Philippe Bodereau of Cabinet Bodereau Avocats, Arras to take legal action against GDF (Gaz de France) because an adjacent 24 turbine wind farm has caused a 50% reduction in the milk yield of his herd.

There are other cases: a goat farmer in Taiwan, who has gradually lost the majority of his herd since turbines became operational; eggs without yolks in Australia. The wind industry may dismiss all these examples as anecdotal, but when many anecdotes tell the same story the anecdotes become evidence. It would be most unwise to assume that man can cope with an unnatural noise spectrum that many other species evidently cannot cope with.

6.5 The Need for Objective Research and Evaluation

I reproduce below the abstract of the opening paper, "Some pitfalls to be avoided in a wind turbine noise research program", by the internationally renowned acoustician Prof. Paul Schomer, chair of the wind turbine noise session at the 169th Meeting of the Acoustical Society of America in May 2015:

"The Acoustical Society of America has created a public policy position relative to the acoustic emissions from wind turbines. This position calls for research that definitively will show if problems exist, and if so, who is affected, how are they affected, and why. ***Much of the research to date is based on assumptions, frequently contrary to fact or unproven****. That is not the kind of research that the ASA desires. The money spent on this questionable research should have been directed towards definitive research such as that envisioned by ASA. This paper talks about some of the previous research and elucidates on their assumptions with the purpose of preventing mistaken test designs like these in the future, and with the purpose of improving the research program to be developed by ASA."*

Prof. Schomer is a Fellow of and the Standards Director of the ASA. The wind energy industry is global, not national, and his comments apply at least equally to the UK, where most of the "research" has been done by the industry itself or by acousticians predominantly if not exclusively contracted to it. The resulting conflicts of interest, even when declared, have been ignored by the UK Government, as also are papers and reports by highly competent and appropriately qualified "interested parties" whose interest lies not in financial reward but in the welfare of wind farm neighbours.

Wind industry acousticians state on the one hand that:

"This paper outlines a research project [the RUK report] *designed to improve our understanding of the phenomenon known as 'amplitude modulation' (AM).* ***There is little peerreviewed, published research into the causes of AM…"***

And on the other hand that:

"RenewableUK are ***strongly of the view that the frequency*** *and severity of AM are such that there is no need for a planning condition to control its emission…"*

These two comments might reasonably be supposed to have been made respectively before and after the successful execution of the proposed and much needed research project. They are however **consecutive paragraphs** in the wind industry paper (Bass et al., [25]) announcing the commencement of the RUK research project. It is therefore difficult to see the second quotation as anything other than a declaration of bias at the outset of the "research project" to which the first quotation refers.

6.6 Enough is Enough; Early Resolution of the EAM Problem is Essential

The design of most commercial wind farms is constrained by the ETSU noise limits; indeed if more turbines could be accommodated without exceeding those limits it would be commercially inept not to accommodate them. Provided that only normal levels of amplitude modulation are present, and that the noise prediction is fully compliant with planning guidance and best practice, noise nuisance should be minimal and health hazard zero. But when modulation heights are over 3 dB very low frequency noise may be (and, at heights over 6 dB, will be) implicated. The wind industry assumption that *"what you cannot hear cannot harm you"* is then no more valid than an assumption that the inability of the human eye to detect ultraviolet radiation somehow provides immunity to sunburn from it.

Wind industry developers and their acousticians have long asserted that wind turbines produce no significant levels of infrasound. By way of example Leventhall of the IOA NWG is quoted in numerous wind farm NIAs thus:

"I can state quite categorically that there is ***no significant infrasound from current designs of wind turbines****. To say that there is an infrasound problem is one of the hares which objectors to wind farms like to run. There will not be any effects from infrasound from the turbines."*

The UK Government (the Northern Ireland Assembly), like many wind farm victims, expresses a very different view [26]:

"The Committee therefore recommends that the Department should ***review the use of the ETSU-97 guidelines on an urgent basis****, with a view to adopting* ***more modern and robust guidance*** *for measurement of wind turbine noise, with particular reference to current guidelines from the World Health Organisation."*

*"The Committee recommends that the Department should bear responsibility for ensuring that arrangements be put in place for on-going long-term monitoring of wind turbine noise. 30. Following on from this, the Committee has heard evidence from local residents who are concerned about potentially **harmful low-frequency noise** emitting from wind turbines.*

*The Committee therefore recommends that the Department, working with local universities, should commission **independent research to measure and determine the impact of lowfrequency noise** on those residents living in close proximity to individual turbines and wind farms in Northern Ireland."*

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Commentary on
"Wind turbine noise and human health impacts in Fairlie, North Ayrshire" produced by Health Protection Scotland, July 2017.

by
Mariana Alves-Pereira, Ph.D. August, 2021

Document included in the Closing Submission to the Planning Application Appeal, Public Inquiry regarding the Arecleoch Wind Power Plant Extension.
[WIN 370-2 and RIGGHILL WIND POWER STATION PPA-310-2034 (PLANNING PERMISSION APPEAL) 20/00248/PPM (NORTH AYRSHIRE COUNCIL)]

A. Introduction

1.

I have been asked to provide a commentary on the document produced in July 2017, by Health Protection Scotland (HPS), today Public Health Scotland (PHS) (Doc1). I have also been asked to include a review of three emails, exchanged between Mr. Paul Brennan (Environmental Health Officer, North Ayrshire Council) and Ms. Joy Tomlinson (Interim Director of Public Health, National Health Services of Ayrshire and Arran) on 27 May—5 June, 2020 (Doc2).

2.

My area of expertise is the biological response to infrasound and low frequency noise exposure, in which I began working in 1988, integrated in a multidisciplinary team of medical scientists within the Portuguese Air Force. Although a copy of my CV as well as a list of Publications has already been submitted to the Reporters of this Appeal Hearing, I would like to reiterate my knowledge base for this subject matter: I hold a Bachelor of Science degree in Physics from the State University of New York at Stony Brook, a Master in Science degree in Biomedical Engineering from Drexel University in Philadelphia, PA., and a Doctorate degree in Environmental Sciences from the Nova University of Lisbon, Portugal.

B. Goal

3.

The documents I have been asked to scrutinize make reference to several scientific papers in which very complex matters are discussed in detail. It is my objective to facilitate the understanding of the more relevant scientific complexities to the Reporters of this Appeal Hearing.

C. 2017 HPS Document "Wind turbine noise and human health impacts in Fairlie, North Ayrshire" – Part 1

4.

This document (Doc1) is authored by Dr. Colin Ramsay, MBChB, MSc, MBA, DRCOG, FFPH. As I understand it, this means that Dr. Ramsey is a medical doctor, with a specialization in Obstetrics and Gynecology, a Master of Science degree (in Epidemiology, presumably), a Master's degree in Business Administration, and he is a Fellow of the Faculty of Public Health.[87] Figure 1 shows an excerpt of Dr. Ramsay's LinkedIn profile, detailing his expertise as an HPS Consultant Epidemiologist in Environmental Public Health, for the past 22 years.

[87] https://www.researchgate.net/profile/Colin-Ramsay

Experience

Health Protection Scotland
22 yrs 7 mos

Consultant Epidemiologist in Environmental Public Health
Feb 1999 – Present · 22 yrs 7 mos

Development of the Environmental Public Health Programme of Health Protection Scotland to address issues relating to the adverse impacts on health of exposure to environmental hazards and assessing the burden of ill health associated with exposure to environmental factors generally.
Provision of support to a wide range of stakeholders in relation to risk assessment, risk management, risk communication, with respect to the health impacts of exposure to environmental hazards.

Consultant Epidemiologist, Environmental Public Health
Feb 1999 – Present · 22 yrs 7 mos
Meridian House, 5 Cadogan Street, Glasgow G2 6QE

Responsible for the Environmental Public Health (EPH) programme of Health Protection Scotland (HPS) involving the provision of expert advice and support to NHS Boards, Local Authorities, Scottish Government and other stakeholders on risk assesment, risk management and risk communication related to environmental hazards and their health impacts. The programme also includes surveillance of environmental hazards and health impacts; supporting the local response to environmental incidents posing a risk to public health and assessing the impact of environmental factors generally on health.

Figure 1. LinkedIn profile of Dr. Colin Ramsay (excerpt).[88]

5.

In 2017, the residents of Fairlie, North Ayrshire submitted several research publications to the National Health Services of Ayrshire and Arran, regarding the potential for deleterious health effects due to the existence of industrial wind turbines in the vicinity of residential areas. These research publications (items) were reviewed by Dr. Ramsay on behalf of HPS, and an "HPS Assessment" was provided for each one, under the following guidelines:

> "HPS considered each of these items in terms of their contribution to the evidence on the potential association between exposure to noise generated by (industrial) wind turbines and adverse human health impacts. An assessment is provided based on a critical appraisal of the methods, findings and conclusions drawn" (p. 3).

6.

At this point, I would like to point out to the Reporters of this Appeal Hearing two examples of the "HPS Assessment."

a)

Regarding item 7) *Infrasound levels near windfarms and in other environments (2013)*:

> "Due to the technical nature of the subject matter, HPS cannot assess the technical competence of this study" (p. 10).

---

[88] https://www.linkedin.com/in/colin-ramsay-52021171/

b)

Regarding item 8) *Low frequency noise from large wind turbines (2011)*:

> "[T]he technical nature of the subject matter is outside HPS expertise" (p. 10).

7.

Since HPS claims to not have the expertise to evaluate studies concerning the measurement of infrasound and low frequency noise, I searched the charter of HPS to determine if this public institution is, *de facto*, mandated to possess such expertise.

D. Charter of Health Protection Scotland and Public Health Scotland

8.

The charter of responsibilities for HPS is given in its website (see Fig. 2).

9.

It is now relevant to point out to the Reporters of this Appeal Hearing that, in Medical Sciences, agents of disease are classified into 4 different categories:

- Biological
- Chemical
- Physical
- Psychosocial

Infrasound and low frequency noise (ILFN) fall into the category of *physical* agents of disease.

10.

All infectious diseases generally fall under the category of *biological* agents of disease, while ILFN falls under the umbrella of "environmental hazards" (Fig. 2), which encompasses all categories of agents of disease.

Responsibilities

We plan and deliver effective and specialist national services which co-ordinate, strengthen and support activities aimed at protecting the people of Scotland from infectious and environmental hazards.

We do this by providing advice, support and information to the following groups:

- health professionals
- national and local government
- the general public
- a number of other bodies that play a part in protecting health

Our functions include:

- surveillance and monitoring the hazards and exposures affecting people and the impact they have on their health
- co-ordination of national health protection programmes, for example, immunisation and antimicrobial resistance
- expert advice and horizon scanning
- effective preparation and response to outbreaks and incidents
- enabling good professional practice
- supporting the ongoing development of a confident and competent health protection workforce
- support commissioning specialist/reference lab services
- research and innovation to provide evidence for action

Figure 2. Responsibilities of Health Protection Scotland (excerpt).[89]

11.

In 2017, it was the responsibility of HPS to:

> "[P]lan and deliver effective and specialist national services...aimed at protecting the people of Scotland from...environmental hazards."

It was claimed that one of HPS functions included:

> "[S]urveillance and monitoring the hazards and exposures affecting people and the impact they have on their health"

12.

Today, HPS has become a department within PHS (see Fig. 3) that:

> "[W]ill continue to provide effective and specialist national services to protect the people of Scotland from .... environmental hazards,"

while PHS will:

> "[P]rovide advice, support and information to health professionals, national and local government, the general public and other bodies that lay a part in protecting health."

---

[89] https://www.hps.scot.nhs.uk/about-us/

Specific roles of PHS regarding "environmental hazards such as flooding, air, water and land contamination" include:

> "[S]urveillance and monitoring of hazards and exposures."

Overview of how we work to protect health

Health Protection Scotland will continue to provide effective and specialist national services to protect the people of Scotland from infectious and environmental hazards, including COVID-19, from within Public Health Scotland.

We will provide advice, support and information to health professionals, national and local government, the general public and other bodies that play a part in protecting health.

Environmental hazards

We also provide specialist operational support and advice to stakeholders around environmenta hazards such as flooding, air, water and land contamination. This includes:

- Advice during acute incidents and also for chronic exposures resulting from incidents that extend over a longer period of time
- Surveillance and monitoring of hazards and exposures
- Fostering a new post-Brexit UK-wide collaborative approach to the surveillance of communicable diseases and health problems associated with environmental hazards, including training and the development of a shared strategy

Figure 3. Operational information of Public Health Scotland (excerpt).[90]

13.
It should, therefore, be clear to the Reporters of this Appeal Hearing that there is an incongruence between HPS' self-reported lack of expertise and HPS' mandated responsibilities.

14.
This situation seems to carry over into PHS, since Doc2 (emails between Mr. Brennan and Ms. Tomlinson) informs:

> "[T]he review carried out by Health Protection Scotland (dated July 2017) is still considered to be an accurate assessment of the balance of evidence on this topic at this time" (Email from Ms. Tomlinson to Mr. Brennan, 05 June 2020).

[90] https://publichealthscotland.scot/our-areas-of-work/protecting-our-health/overview-of-how-we-work-toprotect-health/

E. Unanswered Questions – Part 1

15.
If HPS is responsible for "surveillance and monitoring the hazards and exposures affecting people and the impact they have on their health" how, then, does it self-report the absence of expertise when the potentially hazardous environmental exposure is ILFN?

16.
Could it be that ILFN exposure is not considered potentially hazardous by HPS/PHS?

If so, would such a position make any scientific sense, given what is known to date on this subject matter? (See Section O)

F. Example of a study deemed "sound and reliable" by HPS in 2017

17.
Returning to Doc1, let us now look at an item where the HPS Assessment was 'favorable'. This item will be used to touch upon several aspects of the subject matter at hand; some of these may be a bit more technical, others merely require common sense.

Regarding item 5) *Health effects related to wind turbine noise exposure: A systematic review (2014)* (p. 6), this was the corresponding HPS Assessment:

> "The paper is judged to be methodologically sound and reliable in terms of the conclusions drawn. The findings add to the existing body of epidemiological evidence on the relationship between exposure to wind turbine noise and adverse health effects" (p. 8).

18.
For the benefit of the Reporters of this Appeal Hearing, let us, then, examine, what type of research publication this is: a systematic review. This means that a search was performed on all the published papers on health effects and wind turbine noise exposure, after which, in the words of Dr. Ramsay:

> "Of 1231 relevant studies initially identified and then screened, 36 were suitable for inclusion in the final review" (p.6).

Scrutiny of these 36 studies revealed, in Dr. Ramsay's words:

> "[The authors] note a lack of studies investigating specific aspects of WT generated infrasound and health effects; none of the finally selected studies specifically investigated *"the relationship of health effects and exposure to low frequency noise or infrasound."* The authors considered that *"it remains unknown if exposure to*

infrasound from wind turbines does cause adverse health effects or if these potential health effects are the result of psychological mechanisms"" [author's italics] (p. 7).

19.
This means that the research publication that was deemed "sound and reliable" by HPS, one in which "the findings add to the existing body of epidemiological evidence on the relationship between exposure to wind turbine noise and adverse health effects," admits that none of the 36 studies that were included in the systematic review covered infrasound and low frequency noise health effects.

Is this not incongruent?

20.
Another incongruence emerges with the acknowledgement that:

> "Noise annoyance is not usually studied directly as a health outcome" (p. 7);

And yet, it is accepted that:

> "There was evidence of a threshold effect with a reduction in reported annoyance with noise levels below 35 dB(A) (...) The main conclusions are that there is sufficient evidence to confirm that wind turbines noise increases the risk of annoyance and sleep disturbance; with risk increasing as noise exposure increased (a positive doseresponse relationship)" (p. 7).

21.
It is, to me, extraordinary that despite the acknowledgement that "noise annoyance" is not a usually studied health outcome, the use of "noise annoyance" is nevertheless accepted by a medical practitioner as a *bona fide* parameter to assess health effects caused by exposure to a physical agent of disease.

Usually, it is the professional acousticians who insist on the notion that "noise annoyance" is an objective measure of human health, but medical practitioners are expected to know better.

G. Why is it that "noise annoyance" <u>cannot</u> be considered a measure of health outcome, under the axioms of The Scientific Method and Evidence-based Medicine?

22.

a) The term "noise annoyance" first emerged in the 1960's and 1970's, mostly associated with airport noise. It used to be called "noise nuisance." But, the term "nuisance" has legal implications, including liability of the party responsible for producing the nuisance, while "annoyance," of course, does not...

b) Noise annoyance is a *subjective* parameter, meaning it varies with subjective issues of the individual. As Dr. Ramsay pointed out in his assessment of the "sound and reliable" systematic review:

> "By contrast, economic benefit (derived from the presence of wind turbines) was "*negatively associated with annoyance*"" [author's italics] (p.7).

23.
When dealing with a *physical* agent of disease, dose-response relationships can only be achieved if proper and relevant clinical measures can be associated with quantified doses of the agent of disease. "Noise annoyance" is not a clinical measure. Again, this is usually something that has to be explained to professional acousticians, but not to medical practitioners.

24.
In Dr. Ramsay's defence, his acceptance of the dBA metric to quantify acoustical energy generated by industrial wind turbines is understandable although, yet again, highly unscientific.

H. Why dose-response relationships using the dBA metric for quantifying acoustic energy is an unscientific proposition when IFLN is a concern.

25.
To the Reporters of this Appeal Hearing, this is where some of the aforementioned technical complexity arises. I have often found that pictures are helpful aids in explaining complex issues.

26.
Figure 4 shows two noise graphs reflecting a 10-min average of the acoustic environment, recorded inside the master bedroom of a home located in the vicinity of a wind power station. (A) was recorded on 29 July 2020 at 04:00, and (B) was recorded on 22 July 2020, at 04:00.

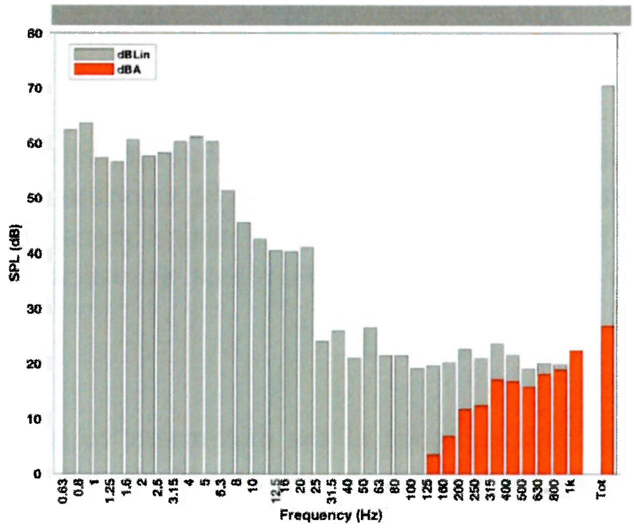
These images are the end product of the mandated guidelines for the assessment of "noise pollution," and are called 1/3rd octave band analyses. The red bars reflect the acoustic energy measured in dBA, as mandated by guidelines. The grey bars reflect the acoustic energy actually present in the environment, measured in dB-Linear (without the mandated Aweighted frequency filter).

27.
As is clearly visible to any layperson, the red bars merely reflect a minute portion of the entire acoustical environment.

What is also clearly visible to any layperson is the visual similarity between 4A and 4B.

Why, then, am I providing both them to you?

A



B

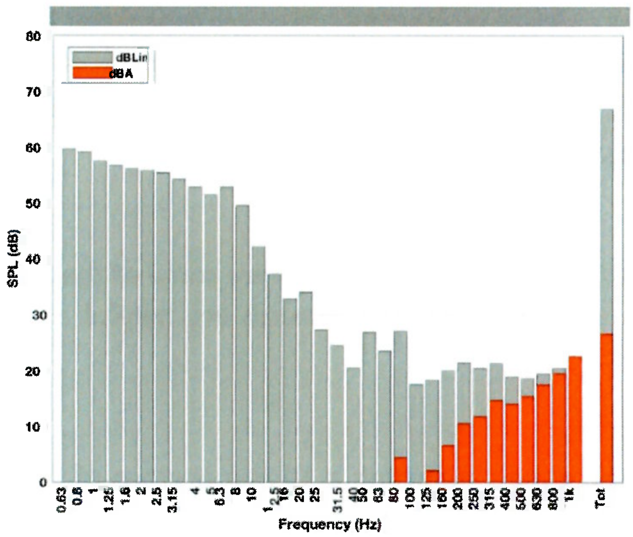


Figure 4. Ten-minute average of the acoustic environment inside the master bedroom of a home located in the vicinity of a wind power station (in Europe), analyzed in 1/3rd octave bands, and using the dBA metric (red bars) as well as the dBLin metric (grey bars).

(A) 29 July at 04:00.
(B) 22 July at 04:00.

The red bars, in dBA, reflect what legislation mandates be measured within the context of "noise pollution."

The grey bars reflect the amount of acoustical energy that is present in the environment, but not account for by the dBA metric.

Overall, there appears to be very little difference between A and B, and a significant difference between the acoustic energy represented by the red bars when compared to that represented by the grey bars.[91]

This is the type of information obtained under mandated guidelines (such as ETSU-R-97).

28.
On July 29, at 05:00, the man living in this home was compelled to take medication (benzodiazepines) because of 'the noise.'

On the morning of July 22, the couple slept peacefully until 07:00.

But there is practically no difference in these two environments (Fig 4A and B)!

Can it be *'all in their heads'?*

Please see Figure 5.

29.
Figure 5 shows the *exact same numerical data* as in Figure 4: (A) 10-minute segment recorded on 29 July 2020 at 04:00 and (B) 10-minute segment recorded on 22 July 2020 at 04:00.

What's the difference?

> **a)** Figure 5 is looking at the numerical data with a 1-second time resolution (each image covers a 600-second period of time) instead of the mandated 10-min time average (Fig. 4), and
>
> **b)** Figure 5 reflects a frequency resolution of 1/36th of an octave, instead of the mandated 1/3rd of an octave (Fig.4).

30.
For the layperson (and also, perhaps, for the medical practitioners), this is analogous to transitioning from a magnifying glass to a microscope.

And now, a clear difference can be seen when comparing Figs 5A and 5B: Figure 5A has horizontal lines crossing the entire image and Figure 5B does not.

So, maybe it is not *'all in their heads'*...

31.
What are these lines?

These horizontal lines (Fig 5A) reflect the peaks of pulsed, airborne pressure waves that are emitted from industrial wind turbines. This series of peaks is called the wind turbine acoustic

[91] This data is part of ongoing judicial proceedings, and is therefore kept anonymous.

signature, and it mathematically matches the blade-pass-frequency of the model of the industrial wind turbine that is used in this particular wind power station.

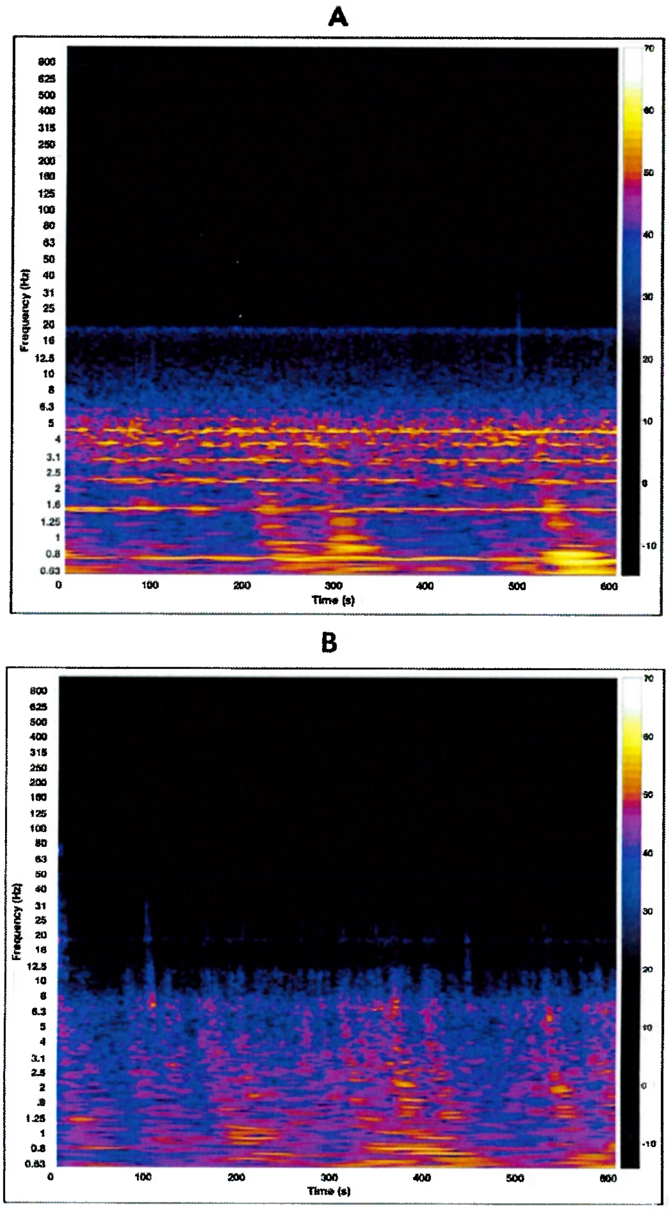


Figure 5. Acoustic environment inside the master bedroom of the home located in the vicinity of a wind power station (in Europe), analyzed in *1/36th octave bands*, spanning 10 minutes with *1-second temporal resolution* (600 seconds), and using the dBLin metric only (color-coded scale on the right).

(A) 29 July at 04:00.
(B) 22 July at 04:00.

However, image (A) now exhibits straight horizontal lines that are continuously present for the entire 10-min period, while in image (B), these lines are absent. (see text)[92]

This is the same exact numerical data as shown in Figure 4.

32.
For the information of the Reporters of this Appeal Hearing (and for any medical practitioners who can take a deeper interest in this subject matter), dose-response relationships for 'noise' emitted by industrial wind turbines *cannot* rely on the dBA metric, 1/3rd octave band analyses and 10-min time averages to characterize the physical agent of disease.

In Figure 4, we are looking at the acoustic environment through a magnifying glass.

In Figure 5, we have switched to a microscope and identified acoustic phenomena that was previously undetectable.

I. Psychosomatic origins of symptoms developed by people living near wind power stations

33.
Figures 4 and 5 now allow the Reporters of this Appeal Hearing to understand a very important situation, as pointed out in the words of Dr. Ramsay referring to the 2014 "sound and reliable" systematic review (see Parag. 18 above):

> "The authors considered that "*it remains unknown if exposure to infrasound from wind turbines does cause adverse health effects or if these potential health effects are the result of psychological mechanisms*" [author's italics] (p. 7).

By looking at Figure 4, and knowing that in situation A someone got sick and in situation B (exceedingly similar to situation A), no one felt ill, then, a psychosomatic origin for the symptoms of the people living in situation A could be plausible to the uniformed.

34.
In Medical Sciences, differential diagnoses can be achieved through the prescription of complementary medical diagnostic tests.

35.
Here again, some technical complexities arise.

[92] This data is part of ongoing judicial proceedings, and is therefore kept anonymous.

A psychosomatic illness means that the symptoms reported by the patient in conjunction with the signs observed by the medical practitioner can lead the latter to hypothesize that there may be no organic basis for the patient's symptoms... meaning, *'maybe it's all in their heads'*.

Example:
Pseudocyesis, or false pregnancy. This is the condition where the human female exhibits all the signs of pregnancy, and yet, there is no foetus.

> Question: How does the medical practitioner know whether it is a normal pregnancy or whether the patient has developed pseudocyesis?
>
> Answer: We give them complementary medical diagnostic tests!

In the case of pseudocyesis, a simple, non-invasive ultrasound imaging of the uterus is generally sufficient to establish a differential diagnosis.

36.
It should, by now, be clear to the Reporters of the Appeal Hearing that the way in which 'noise pollution' is being measured, as mandated by government-approved guidelines (Fig. 4), *technically precludes* higher resolution information from being gathered.

37.
Without this higher-resolution information, it is impossible to quantify the potential agent of disease—a *sine qua non* condition for establishing scientifically-valid *dose*-response relationships.

38.
Another *sine qua non* condition for establishing proper dose-response relationships is a *bona fide* clinical measure of the *response*, for which the "noise annoyance" parameter (usually quantified through self-reported questionnaires or surveys) does not qualify.

J. Unanswered questions – Part 2

39.
Why hasn't the medical community been prescribing complementary diagnostic tests to the people who are complaining of symptoms that they attribute to 'wind turbine noise'?

40.
Why have not the General Practitioners of Scotland been made aware of the World Health Organization's (WHO) codes for these types of symptoms?

"**W42 - Exposure to Noise**
Sound waves
Supersonic waves

W43 – Exposure to Vibration

Infrasound waves"

In: WHO *International Classification of Diseases (2010)*

"NF08.2Y – Other specified effects of vibration

Vertigo from infrasound

QD70.Z – Problems associated with the natural environment or humanmade changes to the environment

Problems associated with exposure to vibration"

In: WHO *International Classification of Diseases (2020)*

K. 2017 HPS Document "Wind turbine noise and human health impacts in Fairlie, North Ayrshire" – Part 2

41.

Let us now take another look at the 2017 HPS document.
Which research publications (items) were actually scrutinized?

1. Material hosted on Wind Concerns Ontario website.
2. *Low frequency noise-induced pathology: contributions provided by the Portuguese wind turbine case (2015).*
3. *How does wind turbine noise affect people? (2014)*
4. *Environmental noise pollution: has public health become too utilitarian? (2017)*
5. *Health effects related to wind turbine noise exposure: a systematic review (2104).*
6. *Wind turbine amplitude modulation review, Phase 2 Report (2016).*
7. *Infrasound levels near windfarms and in other environments (2013).*
8. *Low frequency noise from large wind turbines (2011).*
9. *Wind turbines and health. A critical review of the literature (2014).*

42.

Curiosity: Items 7 and 8 were "additional papers [that HPS] identified as relevant" (p. 2). These two items were the only ones for which the HPS Assessment self-reported their lack of technical expertise.

43.

Question: Of all the items evaluated by HPS, which reflect basic science?
Meaning, which item is actually detailing medical evaluations of the complainants?

Systematic reviews and critical reviews of the literature, while useful in some fields of study and in some points in time, are mostly useless for the subject matter at hand because most of the studies on which these reviews are based:

a) *assess noise* in dBA, 10-min time averages and 1/3rd octave band resolution;

b) *evaluate health endpoints* through self-reported questionnaires or surveys; and
c) *consider the impact of wind turbine noise* to be solely based on audible phenomena.

44.
The research publication items based on literature reviews were evaluated as to their methodology in *selecting* the papers on which to base their review, *and not* on the scientific methodology employed by each individual study that was included in the review. Example:

> HPS Assessment of Item 5):
>
> "This paper was assessed using the AMSTAR [Assessing the Methodological Quality of Systematic Reviews[93]] objective appraisal tool for systematic reviews. The paper meets many of the criteria required of a good quality, objective and systematic review. The review gives a clear description of the key questions addressed and the methods used to search for, identify and critically appraise relevant literature. A comprehensive literature search method was used to access peer-reviewed and non-peer-reviewed sources. Duplicate reviews were carried out to evaluate and screen candidate papers; critical analysis of the full text papers reviewed was carried out to assess quality; the role of selection and information bias in the evidence identified was considered (though not explicitly publication bias), as were the implications of bias on the conclusions drawn" (p. 8).

45.
I would like to invite the Reporters of this Appeal Hearing to click on the website offered in footnote 7, and view the checklist that establishes whether or not a systematic review should be considered valid.

L. Occupational Medicine is the 'canary in the mine' for Environmental Medicine—Every medical practitioner knows this...

46.
There are numerous examples in the History of Medicine where an agent of disease (of whatever category) was first identified within occupational settings and, subsequently, restricted or eliminated from all environmental settings (asbestos, for example).

47.
I am co-author of research publication item number 2

Therefore, initially, I had decided *not* to comment on this item, due to the possibility of issues being raised related to the potential existence of conflict of interests.

[93] https://amstar.ca/Amstar_Checklist.php

Particularly since the HPS Assessment of item 2 was:

> "The evidence in this paper is essentially a case report of a particular situation in Portugal. The anecdotal findings cannot be generalised to situations elsewhere. It is not possible to assess the evidence presented independently to determine if the health effects reported by the family involved were caused by exposure to noise generated by the wind turbines. The paper therefore adds little new to the body of existing epidemiological evidence on wind turbines and their potential impacts on human health" (p.4).

48.
Item 2 is, indeed, a case report; in fact, a follow up from a 2007 report. It shows the 2015 medical evaluation of one man living in close proximity to industrial wind turbines, and compares it to his medical situation in 2007.

49.
It is a shame that Dr. Ramsay did not perform the due diligence (presumably required by a person of his professional standing) to actually find out what "respiratory drive" is, nor why its evaluation is important among ILFN-exposed individuals:

> "Clinical findings reported included: slowing of nerve conduction times and other abnormalities in the child; pericardial thickening in the two adults; and reduced "respiratory drive" (not defined) below a normal range that the authors suggested might indicate a possible impact on the neurological control of breathing. There was no further evidence provided to support this hypothesis" (p.3).

50.
Respiratory drive is the 'strength' with which we inhale and that is neurologically controlled by the autonomic nervous system, i.e., the human has no conscious control over this part of breathing.

Organically, the neurological control of breathing is located in the brainstem (as any Anaesthesiologist could confirm).

For the uninformed medical practitioners: when the respiratory drive is compromised, individuals are unable to hyperventilate in the presence of excessive CO_2, i.e., the neurological control of breathing (located in the brainstem) could be impaired.

51.
In workers exposed to ILFN, brain MRI's show lesions in the brainstem.

52.
In workers exposed to ILFN, their respiratory drive values are below normal.

53.
Research publication item 2:

a) shows that the values of the respiratory drive of the man living near industrial wind turbines were below normal in 2007, and dropped even further by 2015;

b) explains the reason why the respiratory drive test was given to this man;

c) shows how the other complementary diagnostic tests prescribed to this family (deemed relevant because of the body of evidence collected among the IFLNexposed workers) revealed 'pericardial thickening', which equates with cardiovascular changes and 'abnormal nerve conduction times' which equates with impaired cognition.

54.
Why is this respiratory drive test so important?

Because it is:

a) *non-invasive*, and

b) *objective*, i.e., not subject to operator or patient manipulation (such as questionnaires) or post-processing subjective analysis (such as ultrasound or MRI imaging techniques).

55.
The respiratory drive test is, then, a potential candidate for the <u>response</u> part of the doseresponse relationships.

... as opposed to "noise annoyance."

56.
Again, it has been my experience that professional acousticians do not generally possess the knowledge-base of Medical Sciences, and hence all the above issues have to be explained to them. However, it is not expected that these issues require explanation to medical practitioners.

57.
For the edification of the Reporters of this Appeal Hearing, additional information is given on this Portuguese case:

- Four industrial wind turbines are installed in late 2006
  (The closest tower was located 200 m from the home)
- Family develops symptoms in 2007
- Legal proceedings begin in 2007

- Family moves out in 2008, except for the man
- Legal proceedings reach the Supreme Court in 2013
- Supreme Court's decision: removal of the 4 industrial wind turbines
- Epilogue: from 2007-2013, more wind turbines were installed around this residence and these were, obviously, not included in the original legal proceedings—today, the home sits 600 m away from the closest tower.

M. 2017 HPS Document "Wind turbine noise and human health impacts in Fairlie, North Ayrshire" – Part 3

58.

Excluding research publication item 1, these are excerpts the of HPS Assessment for each corresponding item:

2. *Low frequency noise-induced pathology: contributions provided by the Portuguese wind turbine case (2015).*

   "...adds little new to the body of existing epidemiological evidence...." (p. 4).

3. *How does wind turbine noise affect people? (2014).*

   "...provides little in terms of new epidemiological evidence" (p. 5)

4. *Environmental noise pollution: has public health become too utilitarian? (2017).*

   "...adds relatively little new material to the body of existing epidemiological evidence..." (p. 6)

5. *Health effects related to wind turbine noise exposure: a systematic review (2104).*

   "...add to the existing body of epidemiological evidence..." (p. 8)

6. *Wind turbine amplitude modulation review, Phase 2 Report (2016).*

   "...findings add further to the existing body of epidemiological evidence..." (p. 9)

7. *Infrasound levels near windfarms and in other environments (2013).*

   "This was not an epidemiological study..." (p. 10)

8. *Low frequency noise from large wind turbines (2011).*

"This was not an epidemiological study and so it adds nothing..." (p. 10)

9. *Wind turbines and health. A critical review of the literature (2014).*

"The review adds to the body of epidemiologic evidence..." (p.12)

59.
Dr. Colin Ramsay is mostly correct in his assessment here: most (if not all) of these studies *are not* epidemiological studies.

60.
Properly conducted epidemiological studies are, usually, *very* expensive undertakings.

61.
Proper epidemiological studies to investigate the health effects of ILFN, a physical agent of disease, are even more expensive, essentially because:

a) physical agents require sophisticated technology to be quantified, and they must be quantified in *both* exposed and control locations.[94]

b) a personal history is required of each individual in the study (exposed *and* controls), collected by a trained medical practitioner, i.e., a proper and comprehensive anamnesis[95] *must* be obtained for each subject—otherwise prior exposures (especially foetal exposures) can function as a confounding factor.

c) control groups (usually assumed to have zero exposure) do not exist; instead, a rating system is generally defined to categorize individuals as having mild, moderate or intense prior exposures to ILFN.

d) complementary medical diagnostic tests are expensive, and for a proper epidemiological study one would need many, over certain period of time.

e) dissemination of information to the public is also a non-trivial cost.

---

[94] Uninformed researchers would probably think it a great idea to study people living next to industrial wind turbines and compare them to people *not* living next to industrial wind turbines. This is an unscientific proposition. The agent of disease is not the industrial wind turbine *per se*, but what is spews. The correct study design would be to consider people who live near industrial complexes that emit artificial infrasound (whatever the source) and compare them to people who live in residential environments where artificial infrasound is minimum.

[95] *Anamnesis* is the technical term for taking a patient's history. As any medical student would tell you, a good a Anamnesis is the crux of a diagnosis. The information gathered by a medical practitioner during Anamnesis is often confused with 'anecdotal evidence.' As any proper medical practitioner would tell you, Anamnesis *is not* 'anecdotal evidence.'

N. Unanswered Questions—Part 3

62.
Who would have the money to pay for something like this?

63.
The industry responsible for generating the agent of disease or the governmental agencies responsible for protecting public health?

64.
Besides the local residents who 'feel' affected, who would be sufficiently motivated to conduct *proper* epidemiological studies of the health effects of industrial wind turbine noise? Workers' Unions?

O. Is infrasound an agent of disease?

65.
The WHO recognizes infrasound as a potential etiological factor for disease (see Paragraph 40).

66.
The Russian Federation has established permissible exposure levels for infrasound exposure since the 1970's. Figure 6 shows the numbers in 2000, limiting infrasound exposure in the workplace, populated areas and in residences.

Premise	Sound pressure levels, dB, in octaval bands of averaged geometric frequencies, Hz				General sound pressure level dB "Lin"
	2	4	8	16	
Different jobs inside industrial premises and production areas:					
- Different physical intensity jobs	100	95	90	85	100
- Different intellectual emotional tension jobs	95	90	85	80	95
Populated area	90	85	80	75	90
Living and public premises	75	70	65	60	75

Figure 6. Permissible exposure levels for infrasound as per legislation of the Russian Federation. Note the different specified locations (occupational vs. general public), the segmentation of the acoustical spectrum into 2 Hz, 4 Hz, 8 Hz and 16 Hz, and the expression of these numerical values in dB Linear (as opposed to dBA).[96]

67.

[96] Stepanov V. Biological Effects of Low Frequency Acoustic Oscillations and their Hygienic Regulation. 2000. State Research Center of Russia: Moscow. https://apps.dtic.mil/dtic/tr/fulltext/u2/a423963.pdf

Here are some titles of peer-reviewed research papers, detailing basic science investigating the effect of infrasound on brain structures (these *are not* systematic or critical literature reviews):

- Involvement of microglial cells in infrasonic noise-induced stress via upregulated expression of corticotrophin releasing hormone type 1 receptor (2010).[97]

- Glial cell-expressed mechanosensitive channel TRPV4 mediates infrasound-induced neuronal impairment (2013).[98]

- Damage to hippocampus of rats after being exposed to infrasound (2016).[99]

- Inhibitive effects of FGF2/ FGFR1 pathway on astrocyte-mediated inflammation in vivo and in vitro after infrasound exposure (2018).[14]

I could list more such studies that focus on the impact of infrasound exposure on heart structures or on organs of the reproductive system, in order to show the Reporters of this Appeal Hearing that infrasound can, *de facto*, be a physical agent of disease.

P. Unanswered Questions – Part 4

68.
Clearly, there is sufficient international consensus to (at least) suspect that infrasound and low frequency noise may be agents of disease.

How, then, can one justify that an institution such as the HPS/PHS self-reports its lack of expertise and ineptitude to 'survey and monitor environmental health hazards.'

69.
While Dr. Ramsay seems to be a very reputable professional, there appear to be some significant lacunae in his knowledge of the subject matter at hand.

Why, then, did HPS select Dr. Colin Ramsay to evaluate the Research Publications?

[97] Du F, Yin L, Shi M, Cheng H, Xu X, Liu Z, *et al.* Involvement of microglial cells in infrasonic noise-inducedstress via upregulated expression of corticotrophin releasing hormone type 1 receptor. Neuroscience. 2010;167:909-919. DOI: 10.1016/j. neuroscience.2010.02.060
[98] Shi M, Du F, Liu Y, Li L, Cai J, Zhang GF, *et al.* Glial cell-expressed mechanosensitive channel TRPV4 mediates infrasound-induced neuronal impairment. Acta Neuropathologica. 2013;126:725-739. DOI: 10.1007/ s00401013-1166-x
[99] Zhang MY, Chen C, Xie XJ, Xu SL, Guo GZ, Wang J. Damage to hippocampus of rats after being exposed to infrasound. Biomedical and Environmental Sciences. 2016;29: 435-442. DOI: 10.3967/bes2016.056 [14] Shi YJ, Shi M, Xiao LJ, Li L, Zou LH, Li CY, *et al.* Inhibitive effects of FGF2/ FGFR1 pathway on astrocytemediated inflammation in vivo and in vitro after infrasound exposure. Frontiers in Neuroscience. 2018;12:582. DOI: 10.3389/fnins.2018.00582

70.

Why did Dr. Colin Ramsay include 2 additional research items just to then assess that HPS lacked sufficient technical expertise to evaluate them?

Q. Emails exchanged between Mr. Brennan and Ms. Tomlinson

71.

Very little is added by the information contained in these emails where 2 additional Review Studies (2019) are listed, as well as the 2018 WHO document titled *Environmental Noise Guidelines for the European Region* (email dated 05 June 2020).

72.

If the Reporters of the Appeal Hearing have actually managed to get through my Commentary herein, then they are now able to discern for themselves the implicit and explicit incongruences inherent to these Reviews.

73.

Regarding the 2018 WHO Report, the word "infrasound" has one single entry, on page 85, under the section heading "Wind turbine noise":

> "Wind turbines can generate infrasound or lower frequencies of sound than traffic sources. However, few studies relating exposure to such noise from wind turbines to health effects are available. It is also unknown whether lower frequencies of sound generated outdoors are audible indoors, particularly when windows are closed."[100]

74.

Traffic noise does not produce the horizontal lines seen in Fig. 5A, which characterize the wind turbine acoustic signature.

75.

The suggestion that the audibility of infrasound levels (in itself, an oxymoron) can be mitigated by closed windows clearly indicates a profound lack of knowledge of the physical attributes of propagating airborne pressure waves within the infrasound range.

76.

However, in defence of this position taken by the WHO, it must be acknowledged that its Noise Teams have restricted themselves to using the low-resolution methodologies for quantifying acoustic energy, as described in Figure 4.

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[100] https://www.euro.who.int/en/publications/abstracts/environmental-noise-guidelines-for-the-europeanregion-2018

R. Conclusions of the 2017 HPS Document

77.
The 2017 HPS document's final conclusions were:

> "HPS therefore remains of the view that the balance of the objectively reviewed scientific evidence does not support there being a direct causal link between the symptoms described by residents of Fairlie and the operation of nearby wind turbines.
>
> Given the consensus on the limited quality of the current evidence base, HPS also reiterates the view that it remains difficult to categorically exclude the possibility that there might be some sort of relationship between WTN exposure and symptoms in individual cases. On balance however, the strength and consistency of the existing scientific consensus suggests that this is unlikely" (p. 14).

78.
So, paraphrasing... 'there is no causal link between health effects and industrial wind turbine noise, but the possibility cannot be categorically excluded, however it is unlikely.'

Extraordinary!

79.
And meanwhile, citizens are falling ill with an insidious, whole-body pathology.

S. Reiteration of symptoms developed by individuals living in the vicinity of industrial wind turbines—Closing Submission to the Planning Application Appeal, Public Inquiry regarding the Arecleoch Wind Power Plant Extension

80.

SYMPTOMS DEVELOPED BY MS. PAT SPENCE AND OTHERS

Among *some* of the symptoms described by Ms. Pat Spence, from July 2019 to March 2020 are:

Nausea
(CD 21.22, Entries on 6 Jul, 3 Aug, 18 Aug, 12 Oct, 20 Oct, 4 Nov, 6-7 Nov, 10 Nov)
Dizziness
(CD 21.22, Entries on 7 Jul, 3 Aug, 13-14 Sep, 20-21 Sep, 26 Sep, 28 Sep, 24 Nov, 14-16 Jan, 27-28 Jan)
Pain in ears
(CD 21.22, Entries on 16 Jun, 18 Jun, 5-9 Jul, 15 Jul, 18 Jul, 22 Jul, 26 Jul, 31 ul, 1 Aug, 3 Aug, 9-12 Aug, 21 Aug, 23 Aug, 13-14 Sep, 2 Oct, 4-5 Oct, 10 Oct, 17 Nov, 22 Dec, 27 Dec, 30 Dec, 1-2 Jan, 8-11 Jan, 17 Jan, 23 Jan, 26 Jan, 28 Jan, 29 Jan)
Sleep disturbances
(CD 21.22, Entries on 10 Jun, 2 Jul, 4 Jul, 14 Jul, 18 Jul, 22 Jul, 24 Jul, 13 Aug, 25 Aug, 13 Sep, 20 Sep, 12 Oct, 15 Oct, 3-5 Nov, 17 Nov, 23 Nov, 18 Jan)
These symptoms are not mutually exclusive and can occur simultaneously.

Dizziness and **sleep disturbances** are also described by Ms. Karen Brodie from Fairlie (CD 23.68).

Similarly, **nausea** and **balance disorders** are also reported by Ms. Rita Holmes, from Fairlie (CD 23.67).

Other Fairlie residents report **nausea** (CD 23.64 and CD 23.65) and **pain in ears** (CD 23.64).

Reporters of this Inquiry are reminded that Fairlie residents were exposed to (only) two IWTs (albeit designed for off-shore operations).

Ms. Cindy Aubad (CD 23.84) described **balance disorders** in her husband, but only when he is at home and, for herself, she reports **nausea**. Both report **sleep disturbances**.

In 2007, Mr. and Mrs. R (CD 23.89) reported **sleep disturbances**, while their 12-year-old's school-teacher noted that the child seemed "permanently tired" and questioned: "Does he sleep sufficient hours during the night?" By 2015 (CD 23.87), Mr. R's **balance disorders** had caused several falls requiring medical treatment.[101]

While not a part of the evidence already provided, all these symptoms are occurring in people living in the vicinity of IWTs all over the English and non-English-speaking world (!!)

T. Conclusions and Recommendations

81.

The institutions that, in Scotland, are mandated to protect human health against environmental hazards self-report a lack of expertise in this scientific field when the environmental hazard is infrasound and/ or low frequency noise.

82.

As a result, they are unable to carry out and implement their obligations which include surveillance and monitoring of environmental hazards.

83.

Consequently, Scottish citizens with environmental health complaints that are suspected of being related to excessive exposure infrasound and low frequency noise (whatever the source) go ignored, and often even ridiculed.

84.

Since it is the health of Scottish citizens that is at play here, and since HPS/PHS has admitted to its lack of expertise of this subject, this would be my first suggestion to the appropriately competent decision-makers—a fairly inexpensive first step that could provide invaluable epidemiological data (if properly done):

[101] This paragraph refers to the same case described in item 2 of the 2017 HPS document (See Paragraphs 48, 49, 53 and 57).

Implement a mandatory notification rule for all Medical Practitioners (General Practitioners in particular) so that all patients exhibiting specific signs and symptoms suspected of being related to 'noise' exposure could be formally counted and associated with a specific geographic location and/or occupation.

85.
My second suggestion would be to the Reporters of the Appeal Hearing, to uphold the decision by North Ayrshire Council which denied permission for the installation of the Rigghill wind power station.

Chapter

Infrasound Exposure: High-Resolution Measurements Near Wind Power Plants

Huub Bakker, Mariana Alves-Pereira, Richard Mann, Rachel Summers and Philip Dickinson

Abstract

This chapter focuses on infrasonic (≤20 Hz) noise exposure as captured in and around homes located in the vicinity of wind power plants. Despite persistent noise complaints by local residents, no satisfactory acoustical event has yet been identified to justify this troublesome (worldwide) situation. Continuous (days), high-resolution recordings—spectral segmentation of 1/36 of an octave and 1-second temporal increments—have been acquired in many homes across the world revealing the presence of wind turbine acoustic signatures. These consist of trains of airborne pressure pulses, identified in the frequency domain as harmonic series with the fundamental frequency equal to that of the blade-pass frequency of the wind turbine. This report documents three such cases (Portugal and Scotland). The highest peaks of the wind turbine acoustic signature (up to 25 dB over background noise) occurred within the 0.5–5 Hz window which is classically defined as below the human hearing threshold; and yet these 'inaudible' phenomena appear to trigger severe biological reactions. Based on the prominence of the peaks in the harmonic series, a new measure is proposed for use in determining dose–response relationships for infrasonic exposures. This new methodology may be applicable to infrasonic exposures in both environmental and occupational settings.

Keywords: harmonic series, harmonic prominence, wind rose, 1/36-octave bandwidth, time profile, low frequency noise, environmental noise, wind turbines

1. Introduction

Hearing loss, speech intelligibility and noise annoyance are some of the most studied impacts of noise exposures on human health and well-being. A common denominator of these three outcomes is the audibility of the sound. Exposure to loud noise over extended periods of time can cause hearing impairment; noisy environments can interfere with the correct understanding of speech; and certain types of continuous or intermittent sounds can cause people to feel annoyed by noise, which can, in turn, exacerbate underlying disorders or diseases.

There are, however, additional features of sonic environments that are unrelated to the human audibility of sound, but that can also deleteriously affect human health and well-being, specifically, infrasound (≤20 Hz).

1.1 Infrasound and human health: brief overview

With the growing industrialization and mechanization that occurred worldwide in the 1960s, infrasound in the environment began to take its toll on workers and urban citizens. Thus, in 1973, the National Research Council of France organized an International Colloquium entirely dedicated to infrasound [1]. One of the outcomes was the establishment of permissible levels for infrasound exposures in the Russian Federation [2]. **Figure 1** shows the legislated values for the year 2000.

With the introduction of industrial wind turbines (IWT) in mostly rural areas, noise complaints by local residents began to emerge in the media [3, 4, for example] and in scientific journals [5, 6, for example]. And yet, the vast majority of noise measurements performed in and around homes near wind power plants (WPP) showed values well within the established guidelines [7, 8, for example]. This apparently paradoxical situation has even prompted some authors to assume a psychosomatic origin for resident noise complaints [9], or to associate these health complaints with a lack of monetary gain from the WPP [10]. In direct contradiction to the notion of a psychosomatic origin for these noise complaints, are the animal studies showing increased physiological stress when living in the wild, close to WPP [11, for example], or under laboratory conditions, simulating occupational environments [12, 13, for example].

1.2 Frequency-weighting systems, spectral segmentation and temporal resolution as applied to acoustical data acquisition

The ability of the human auditory system to capture sound depends on the combination of the amplitude of the pressure wave (usually evaluated in deciBels, dB, referenced to 20 microPascal), and the frequency (Hz). Different frequencies require different levels of sound pressure in order to be heard. Some decades ago, the International Organization for Standardization (ISO) established a frequency-weighting network that simulated the human hearing threshold and that was specifically focused

No.	Premise	Sound pressure levels, dB, in octaval bands of averaged geometric frequencies, Hz				General sound pressure level dB "Lin"
		2	4	8	16	
1.	Different jobs inside industrial premises and production areas:					
	- Different physical intensity jobs	100	95	90	85	100
	- Different intellectual emotional tension jobs	95	90	85	80	95
2.	Populated area	90	85	80	75	90
3.	Living and public premises	75	70	65	60	75

Figure 1.

Permissible levels for infrasonic exposures (at 2, 4, 8 and 16 Hz) for two occupational and two environmental settings. Values are provided in dB Linear (no weighting) and, as expected, are lower for public areas than for occupational environments [reproduced from 2].

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on preventing hearing loss—the "A" frequency-weighting system [14]. The use of the A-weighting system yields sound pressure levels in the dBA metric.

ISO has also ratified procedures for evaluating infrasound and lower-frequency components: ISO 7196:1995(E) defines the "G" frequency-weighting system as appropriate for quantifying acoustic energy within the range of 0.25–250 Hz [15]. The use of the G-weighting system yields sound pressure levels in the dBG metric. **Figure 2** compares data to which A- and G-weighting have been applied. It also shows the values when no weighting is imposed.

The environment shown in **Figure 2** is within a rural home in the proximity of a WPP, and where residents have noise complaints (see Section 2 below, Home 2). In this 10-minute data segment, the average noise level was less than 30 dBA, well within compliance levels for most rural areas around the world. The G-weighting system, while over-evaluating the sound pressure levels within the range of 10–25 Hz, yielded an average noise level of around 55 dBG. In Japan, for example, the limit for infrasound generated by IWT is 92 dBG [16]. The unweighted capture, which measures the actual levels present in the environment, yielded an average noise level above 60 dB. The highest peaks in this environment, measured without weighting, occurred at frequencies below 8 Hz, i.e., below the defined threshold of human audibility. Taken alone, it would seem that these numerical values are insufficient to adequately characterize the instigator of these residents' noise complaints.

In addition to showing the problematic usage of different frequency-weighting systems, **Figure 2** emphasizes two other aspects of noise measurements: the segmentation of the acoustical spectrum into bands of 1/3 of an octave, and the temporal resolution of 10-minute averages, as per ISO guidelines [14]. As for the spectral segmentation, a higher resolution is technologically possible, but the results are considered mostly academic, since practically all tabulated values related to permissible noise exposure levels use 1/3-octave segmentation.

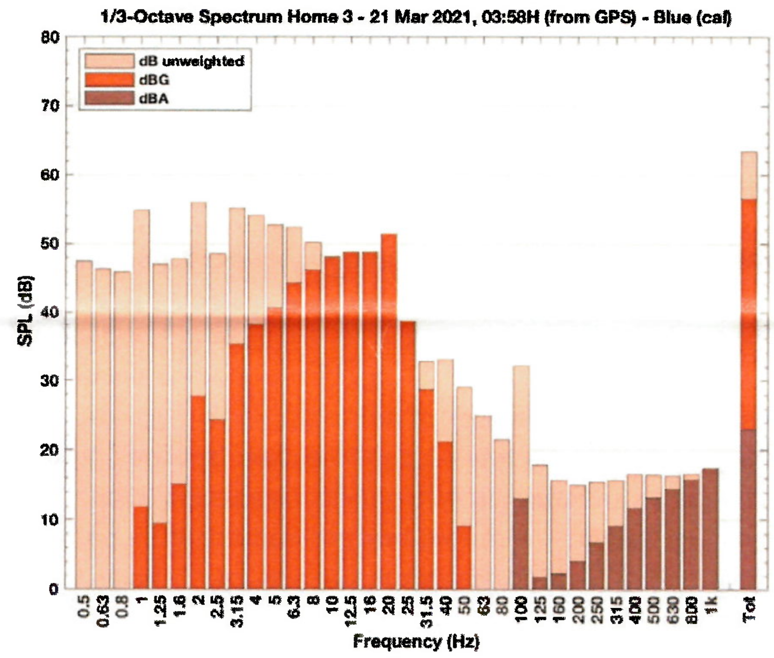

Figure 2.

Comparison of acoustical data acquired with unweighted, G-weighted, and A-weighted systems (10-minute average). Note that between 10 and 25 Hz the G-weighting sound pressure levels are defined to be higher than the unweighted values. (See Section 2 below for detailed methodological capture of this data in Home 2).

1.3 Goal of this report: Going beyond ISO recommendations

Could it be that the spectral segmentation into the 1/3 of an octave and the 10minute average temporal resolution are too coarse and rudimentary to identify biologically-relevant acoustical phenomena, such as those emanating from WPP?

This report documents the acoustical environments captured in homes located near WPP, using a spectral resolution of 1/36 of an octave, and a temporal resolution of 1-second. Sound pressure levels were analyzed in dB (unweighted).

2. Background and methodology of data collection

Data reported herein were collected in Portugal in Jul-Aug 2020 (Home 1) and in Scotland in Feb-Mar 2021 (Homes 2 and 3), at the invitation of the separate homeowners—usually due to the onset of a pattern of debilitating symptoms which, they claim, only began after WPP became operational in their residential areas [17]. A two-channel sound recording device was placed in and around each home with continuous data acquisition over several days. During the sound recordings, residents were asked to keep a date- and time-logged diary detailing the onset or absence of symptoms, such as sleep disruption. This onset or absence of symptoms could then be compared with changes in the sound recordings that might suggest a causal connection.

2.1 High resolution sound recording

The recording equipment was a SAM Scribe Full Spectrum (FS) system (Soundscape Analytics, Palmerston North, New Zealand), Model Mk1 in Portugal and Mk2 in Scotland [18]. It is a two-channel device with sampling rates up to 44.1 kHz, that is designed to capture recordings of sonic environments with high precision, especially in the infrasonic and low-frequency bands. Data streams are delivered via USB to a Windows notebook computer and stored as uncompressed wav files to a hard disk. GPS information is stored in the files as metadata, which also include a digital signature. Each wav file corresponds to a 10-minute (600-seconds) recording of the sonic environment. The system can accurately record from 0.1–1000 Hz, as per the manufacturer frequency response of the two electret condenser microphones [19].

All measurements reported here cover the range from 0.5–1000 Hz and were captured with a sampling rate of 11.025 kHz. All recordings included a standard reference calibration tone at the start and end, produced with a Type I calibrator (part of the SAM Scribe system) at 1000 Hz/94 dB.

Calibration of the SAM Scribe system rests on 1) the manufacturer's frequencyresponse curve for the microphone and 2) calibration against a certified Larsen-Davis 831 sound level meter in the range of 6.3–1000 Hz.

2.2 Homes where recordings were captured

2.2.1 Home 1: Portugal (the E. family)

Period of continuous recording: 18 Jul 2020 (00:00)—09 Aug 2020 (10:00). *Microphone location:* At the foot of the bed in master bedroom (ground floor), tripodmounted 1.5 m above the floor.

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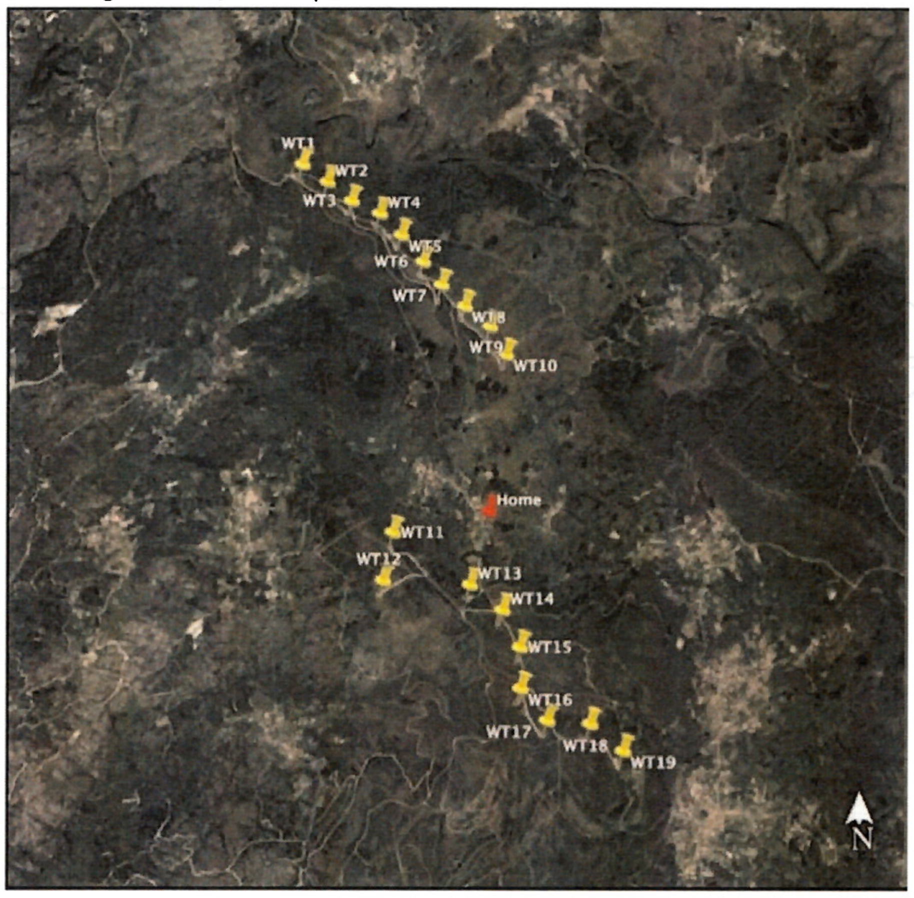

Figure 3.
Relative positions of Home 1 and the 19 industrial wind turbines (labeled WT in the figure) that constitute this wind power plant. (Image adapted from Google Earth).

Figure 3 shows the relative position of Home 1 and the WPP (19 Senvion MM92 turbines of 2 MW each, with blade length 45.2 m). The closest IWTs to the home are numbers 11, 12, 13 and 14, at 843 m, 1085 m, 648 m, and 844 m, respectively. IWT1 and IWT19 are the furthest away, at a distance of 3422 m and 2282 m, respectively.

The E. family—Mr. E. (age 63) and Mrs. E. (age 64)—have lived amid these 19 IWT since 2016. Their health deterioration has been documented by neurological medical reports.

2.2.2 Home 2: Scotland (the P. family)

Period of continuous recording: 24 Feb 2021 (17:30)—07 Mar 2021 (00:00).

Microphone location: Beside the head of the bed in an upstairs bedroom with a dormer, tripod-mounted 1.5 m above the floor.

Mrs. P documented some of her symptoms from Jul 2019 to Mar 2020. **Table 1** shows a 6-month sample (Jul–Dec 2019).

2.2.3 Home 3 – Scotland (The J. Family)

Period of continuous recording: 20 Mar 2021 (16:20)—27 Mar 2021 (18:40).

Microphone location: Middle of attic bedroom, tripod-mounted 1.5 m above the floor.

Symptom	Dates on which symptom was reported
Nausea	6 Jul, 3 Aug, 18 Aug, 12 Oct, 20 Oct, 4 Nov, 6–7 Nov, 10 Nov
Dizziness	7 Jul, 3 Aug, 13–14 Sep, 20–21 Sep, 26 Sep, 28 Sep, 24 Nov, 14–16
Pain in ears	5–9 Jul, 15 Jul, 18 Jul, 22 Jul, 26 Jul, 31 ul, 1 Aug, 3 Aug, 9–12 Aug, 21 Aug, 23 Aug, 13–14 Sep, 2 Oct, 4–5 Oct, 10 Oct, 17 Nov, 22 Dec, 27 Dec, 30 Dec
Sleep disturbance	2 Jul, 4 Jul, 14 Jul, 18 Jul, 22 Jul, 24 Jul, 13 Aug, 25 Aug, 13 Sep, 20 Sep, 12 Oct, 15 Oct, 3–5 Nov, 17 Nov, 23 Nov

Table 1.
Six-month sample of some of the symptoms documented by Mrs. P.

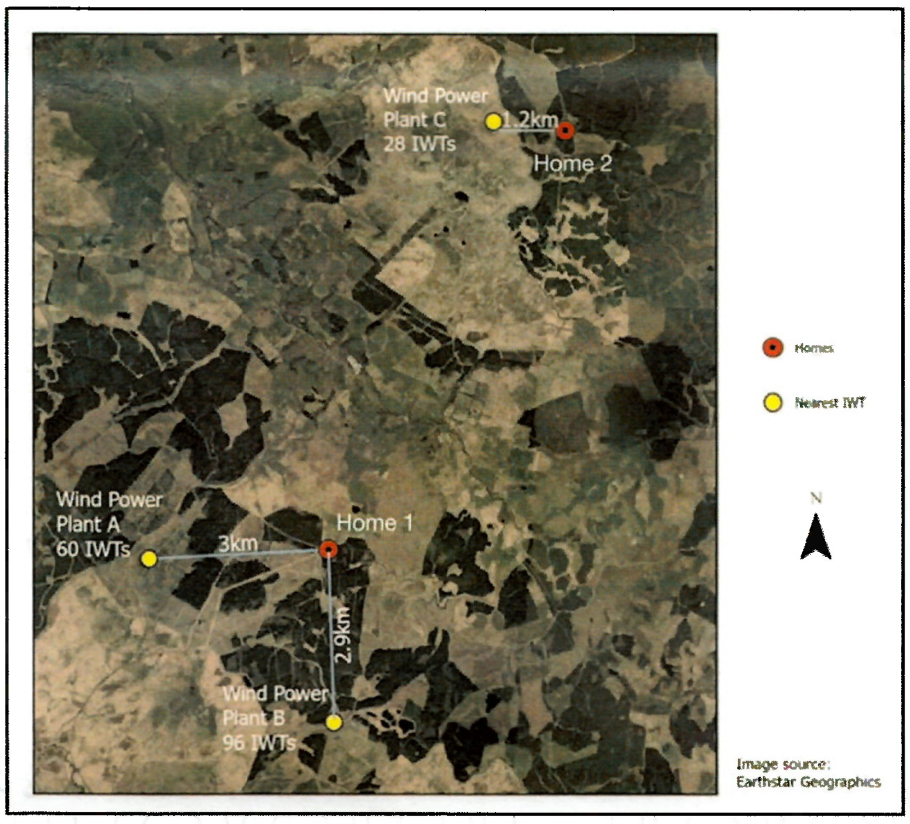

Figure 4.
Relative positions of Home 2 and Home 3 and the closest industrial wind turbines of wind power plants A, B and C.

Figure 4 shows the relative positions between Homes 2 and 3, and the three WPP located in the vicinity.

WPP A has 60 Gamesa G80/2000 turbines of 2 MW each, with blade diameters of 80 m. It is located 4.6 km to the west of Home 2 and 14.5 km to the southwest of Home 3. It has been operational since 2011.

WPP B has 96 Gamesa G114/2500 turbines of 2.5 MW each, with blade diameters of 114 m. It is located approximately 2.9 km to the south of Home 2 and 13.1 km to the south of Home 3. It has been operational since 2007.

WPP C has 28 Gamesa 87/2000 of 2 MW each, with blade diameters of 87 m. It is located approximately 9.5 km to the north of Home 2 and 2.1 km to the southwest of Home 3. It has been operational since 2011.

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2.3 Wind data

Information on wind speed and direction was retrieved for the entire period during which recordings were made.

In Portugal, data was obtained from the Portuguese Institute of Sea and Atmosphere (IPMA [20]). Data points were requested in 10-minute increments, from three distinct meteorological stations: at 58 km (altitude above sea level: 995 m), 12.5 km (altitude above sea level: 642 m) and 52.7 km (altitude above sea level: 558 m) away from the E. family home (altitude above sea level: 850 m). In Scotland, weather data was obtained from the British National Weather Institute via the Open Weather service [21] in one-hour intervals. The location for which weather data was obtained was 3.5 km away from Home 2 and 7.8 km from Home 3. Wind data was timematched to the GPS time-stamped acoustical recordings.

3. Results

3.1 Home 1: Diary

The E. family kept a diary from 13 July through 31 July, 2020.

On 29 July at 04:00, the family's sleep had been disrupted for several hours and Mr. E. felt so unwell that he was compelled to take medication (benzodiazepine) (*'Severe' episode*). By comparison, on the morning of 22 July, Mr. and Mrs. E. slept uninterruptedly until 07:00 (*'Peaceful' episode*).

Priority was therefore given to the analysis of the period between 03:00 and 06:00 (eighteen 10-minute recordings) on both these days, the choice of identical diurnal periods helping to alleviate any extraneous differences between the two mornings.

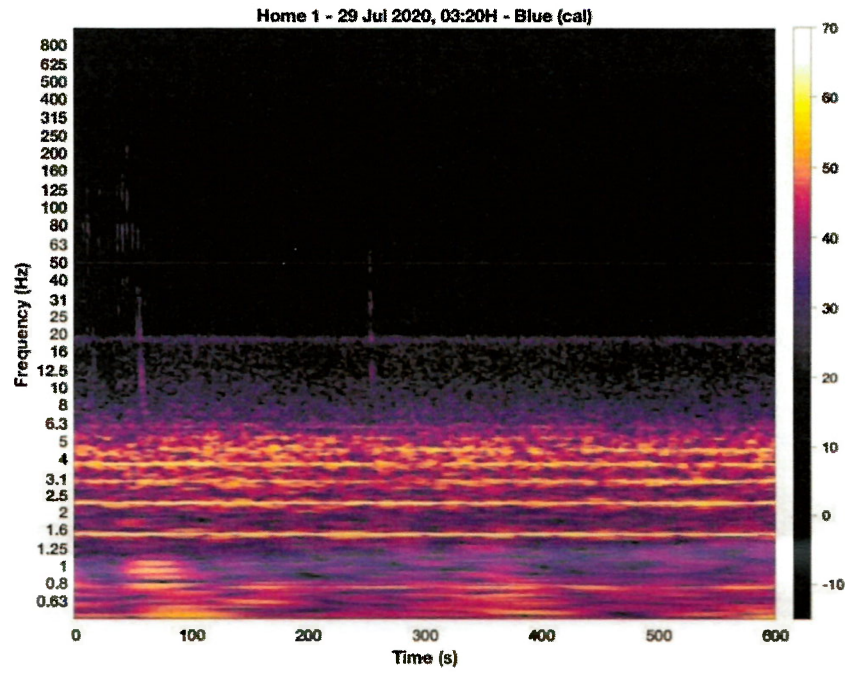
3.2 Home 1: At 03:20 on the morning of the 'severe' episode (29 Jul, 2020)

Figure 5 shows the results of the sound data acquired between 03:20 and 03:30, on the morning of 29 July, when the E. family's sleep was disrupted and Mr. E. felt the need to self-medicate.

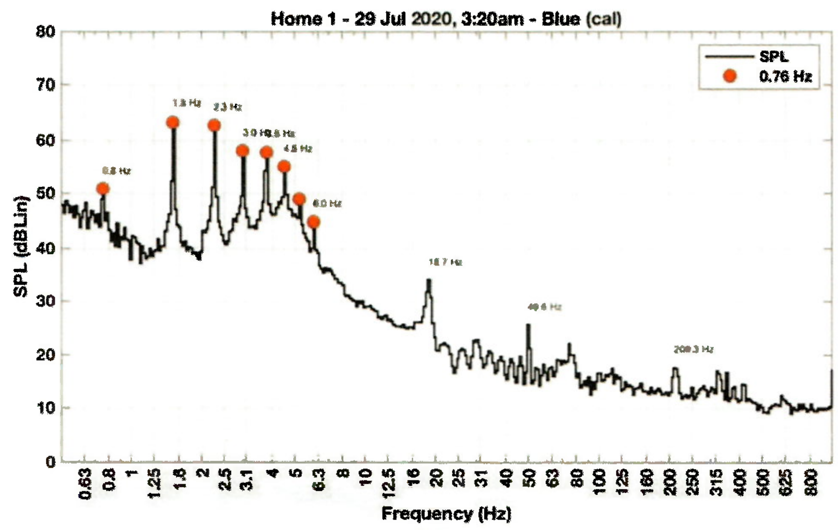
Figure 5A shows a sonogram reflecting the acoustic environment inside the bedroom over a 10-minute period (600 seconds), with 1/36th-octave-band resolution (vertical axis) and 1-second temporal resolution (horizontal axis). The sound pressure level at each frequency and at each second in time, is indicated in the color-coded scale on the right (measured in dB). The yellow color of the straight, horizontal lines visible across the image at 1.5 Hz, 2.3 Hz, 3.0 Hz, and 3.8 Hz reflect the large amount of acoustic energy (50–60 dB) present at these frequencies. Additionally, the lack of discontinuities in these lines indicate that the phenomena were continuously present during the entire 600 seconds.

Figure 5B shows the same numerical data as in **Figure 5A**, but as a frequency spectrum. A series of peaks is readily identifiable, occurring at the same frequencies as the continuous, horizontal lines seen in the sonogram (**Figure 5A**). The mathematical relationship between the frequencies of each peak (red dots) constitutes a harmonic series with a fundamental frequency of 0.76 Hz (0.8 Hz in the figure).

In all 18 recordings (from 03:00 to 06:00, 29 Jul), the sonograms presented similar, continuous horizontal lines and, in all corresponding spectrograms, the same harmonic series (fundamental at 0.76 Hz) was visible. The blade-pass frequency of the IWT



(A)



(B)

Figure 5.

(A) Sonogram *showing the sonic environment inside the master bedroom of home 1 (on 29th Jul when sleep was disrupted and medication was required) over a 10-minute period (600 seconds), with 1/36-octave band resolution ('frequency' on vertical axis) and 1-second temporal resolution ('time' on horizontal axis). The colorcoded scale on the right measures sound pressure level in (unweighted) dB. Continuous (over the entire 600-second interval), horizontal lines cross the image at 1.5 Hz, 2.3 Hz, 3.0 Hz, and 3.8 Hz with a pressure level of 50–60 dB.*

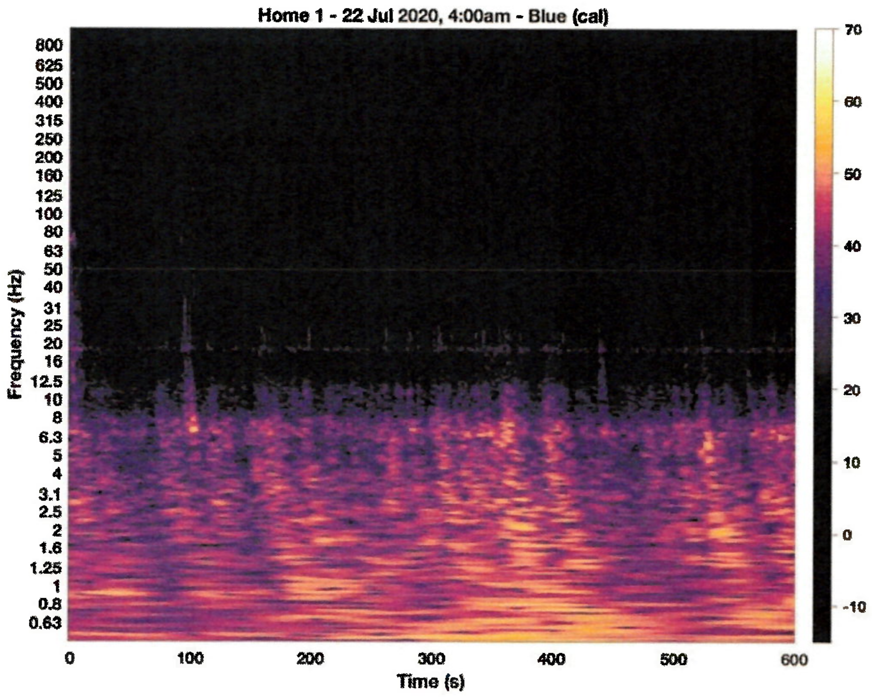
(B) Spectrogram *in the form of a frequency distribution, constructed with the same numerical data as in* ***Figure 5A****. A harmonic series is identified when the frequencies of each peak (red dots) are multiples of the fundamental frequency of 0.76 Hz (0.8 Hz in the figure).*

installed around the home of family E. is 0.75 Hz. The harmonic series identified in Home 1 is the acoustic signature that emanates from these machines, and that reflects the airborne propagation of a pulsed, pressure wave generated by rotating IWT blades.

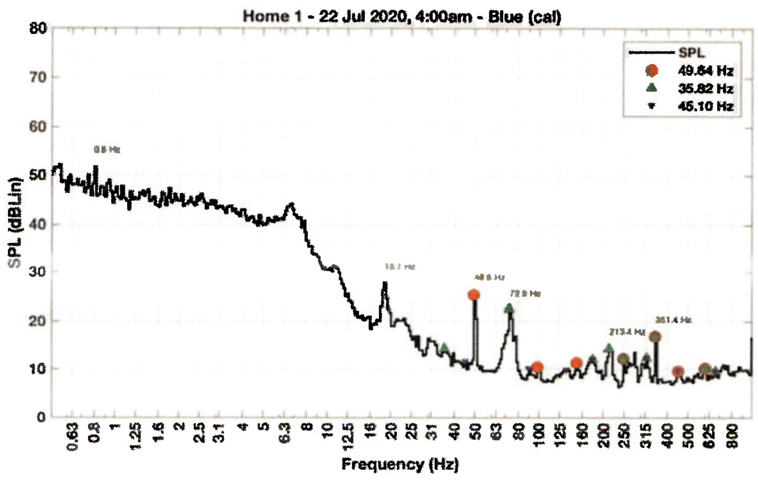
This IWT acoustic signature occurs below the threshold of human audibility.

3.3 Home 1: At 04:00 on the morning of the 'peaceful' episode (22 Jul, 2020)

In **Figure 6**, the sonic environment in the master bedroom of family E. is shown, as captured between 04:00 and 04:10, on the morning of 22 July, when the E. family slept peacefully. The lack of continuous, horizontal lines throughout the sonogram (**Figure 6A**) is notable, as is the absence of regular peaks in the corresponding



(A)



(B)

Figure 6.
(A) Sonogram *showing the sonic environment inside the master bedroom of Home 1 (on 22nd Jul when no sleep disruption occurred) over a period of 600 seconds—With 1/36-octave band resolution, 1-second temporal resolution—and pressure levels in dB as indicated by the color-coded scale. The triangular, pink shapes that span various frequencies are due to blowing wind, and do not exceed 50 dB. Continuous, horizontal lines as observed in* ***Figure 5A*** *are absent. (B)* Spectrogram *without any regular, large peaks of acoustic energy in the infrasonic range. Harmonic series, as related to IWT acoustic signatures, are absent.*

spectrogram (**Figure 6B**). The triangular, pink shapes that span various frequencies in the sonogram are due to blowing wind, and do not exceed 50 dB. In all 18 recordings (from 03:00 to 06:00, 22 Jul), no IWT acoustic signature was identified.

3.4 Homes 2 and 3

Regrettably, the residents of these Homes were not sufficiently assiduous with their diary entries so that health-related information could be compared with simultaneous recordings.

Homes 2 and 3 have three different models of IWT among the 3 WPP located in their vicinity, as opposed to Home 1 that only had one type. For asynchronous (constant with varying wind speeds) IWTs, each model will have its own blade-pass frequency and, therefore, their acoustic signatures will be different.

Figure 7 shows the sonogram and spectrogram of the sonic environment captured in the attic bedroom in Home 3. The very clean and continuous horizontal lines that extend throughout the 600-second recording (**Figure 7A**) reflect the existence of a prominent IWT acoustic signature. This is confirmed by the sequence of peaks that constitute the harmonic series, as can be clearly identified in the corresponding spectrogram (**Figure 7B**). The two harmonic series (i.e., IWT acoustic signatures) identified in Home 3 are also present in Home 2, as can be seen in the spectrogram in **Figure 8**.

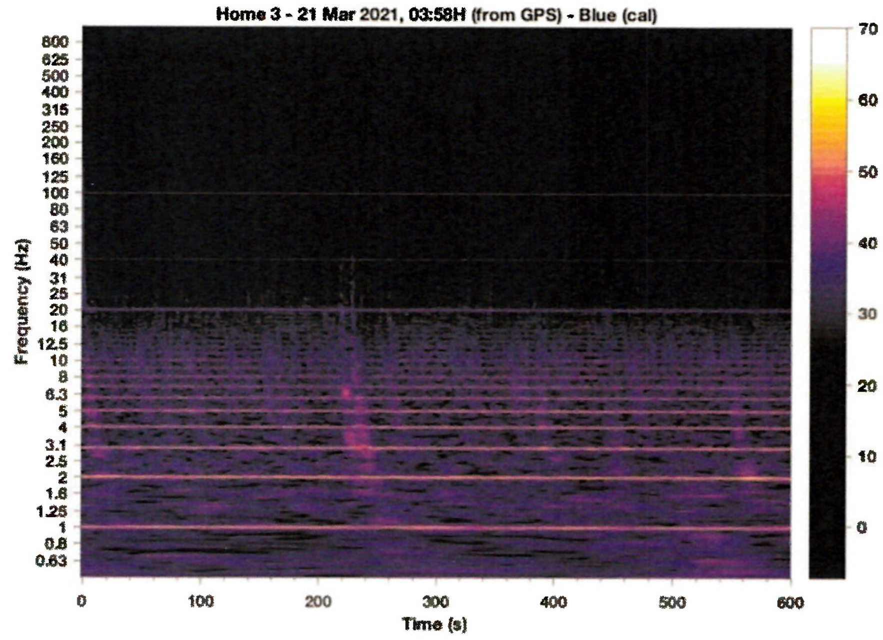
Figures 7B and **8** show very similar examples of dominant IWT acoustic signatures. The harmonic analysis highlights a harmonic series with a fundamental frequency of 1 Hz (0.99 Hz in the figures) and at least the first 19 harmonics. The Gamesa 80 and 87 IWT models have a blade-pass frequency of 1 Hz. A second harmonic series is identified with a fundamental frequency of 0.67 Hz. The blade-pass frequency for the Gamesa 114 model is 0.67 Hz. A separate harmonic series begins at 20 Hz from an unknown source, possibly the IWT gearboxes.

4. Discussion

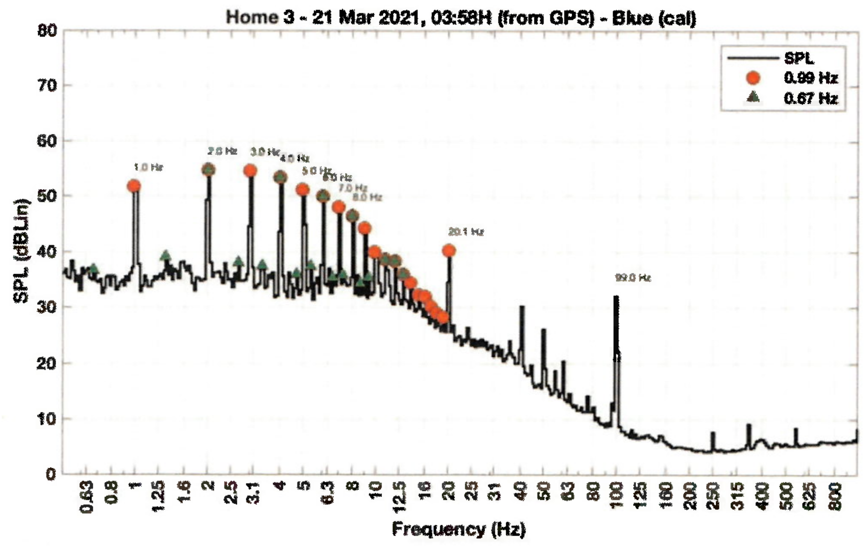
4.1 Sleep disruption and the prominence of harmonic peaks

The harmonic series observed in all 18 samples of the 'severe' episode, and that were absent in all 18 samples of the 'peaceful' episode, is recognized as the IWT acoustic signature with a blade-pass frequency of 0.75 Hz. The acoustic signature generated by an IWT is a train of pressure pulses, with a period equal to the reciprocal of the blade-pass frequency of the IWT. It presents as a harmonic series of peaks in the infrasonic region of a spectrogram, visible in **Figures 5B, 7B** and **8**, while absent from **Figure 6B**. In the sonograms, the IWT acoustic signature is present as continuous horizontal lines, as seen in **Figures 5A**, and **7A**, while absent from **Figure 6A**.

This new, high-resolution methodology for assessing infrasonic environments is analogous to transitioning from a magnifying glass to a microscope. Previously undetected acoustic events are now identifiable and, even, quantifiable (see Sections 5.2 and 5.3 below). What was undetectable—and thus assumed to be non-existent, presumably justifying a psychosomatic origin for resident complaints—using the classical noise assessment methodologies (1/3-octave band segmentation in 10-minute averages and with sound pressure levels measured in dBA or dBG), became visible with high-resolution observations.



(A)



(B)

Figure 7.
(A) Sonogram *showing the sonic environment inside the attic bedroom of Home 3 over a period of 600 seconds, with 1/36-octave band resolution, 1-second temporal resolution, and pressure levels in dB, as indicated by the color-coded scale. Continuous, horizontal lines are readily observable at frequencies below the threshold of audibility, and that reflect the existence of IWT acoustic signatures. (B)* Spectrogram *showing the two most prominent harmonic series, with fundamental frequencies at 0.67 Hz and 0.99 Hz, reflecting IWT acoustic signatures from different IWT models, with different blade-pass frequencies.*

Despite being at frequencies and sound pressure levels that are classically considered as 'below the human hearing threshold,' a very clear correlation has been shown between the existence of these peaks in the frequency spectra and disruption of the normal biological function—sleep disruption followed by the need for self-medication with benzodiazepines. Nevertheless, while the correlation is very clear, the confidence of the correlation is reduced by the relatively small timeframe. Improved confidence

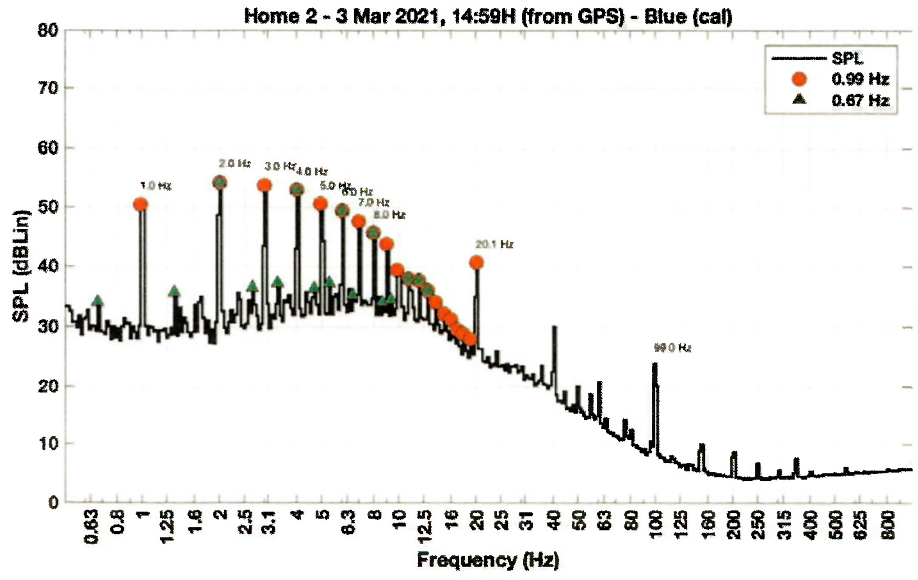


Figure 8.

Spectrogram *showing the sonic environment inside the upstairs bedroom of Home 2, over a period of 600 seconds, with 1/36-octave band resolution and 1-second temporal resolution. Two of the most prominent harmonic series are readily identifiable, with fundamental frequencies at 0.67 Hz and 0.99 Hz, reflecting IWT acoustic signatures from different IWT models, with different blade-pass frequencies.*

can only come from more work to extend the use of this measure to many other cases (an ongoing endeavor by these authors).

The question as to how these infrasonic acoustic events can cause the biological disruption is still unclear. Studies by German scientists, however, using functional magnetic resonance imaging—while exposing subjects to infrasound—may have uncovered a significant clue: in addition to activating the classically identified auditory pathways, infrasonic stimuli also activate regions of the brain that are considered responsible for emotional and autonomic responses [22].

4.2 Prominence of the harmonic peaks—A new metric?

The prominence of these harmonic peaks above the background noise appears to be highly relevant for health-related issues. **Figure 9** depicts a harmonic series as identified in an IWT acoustic signature, an airborne train of pulses occurring within the 0.5–5 Hz window. Note that the persistent or continuous existence of this type of harmonic series ties this acoustic event to human-made sources because the manifestations of such harmonic series from natural sources are exceedingly rare. There is no established methodology to quantify the prominence of these peaks.

A new metric is herein suggested; one that may more accurately provide a measure of the "dose" of this pulsed agent of disease. We have called this measure the *Harmonic Prominence*, H_p, defined as the largest prominence of any harmonic frequency of any harmonic series, within the 0.5–5-hertz frequency window. In **Figure 9**, $H_p = 17$ dB, at 1.5 Hz. In the specific case of IWT, only harmonic series with a fundamental frequency equal to the IWT blade-pass frequency are considered. In the specific case of the data acquisition methodology detailed above, the highest prominence of the harmonic series is determined in temporal segments of 600-seconds.

There are a variety of mathematical definitions, methodologies and software packages associated with quantifying peak prominence above background, for almost any and all types of wave phenomena. These authors have adhered to the formal

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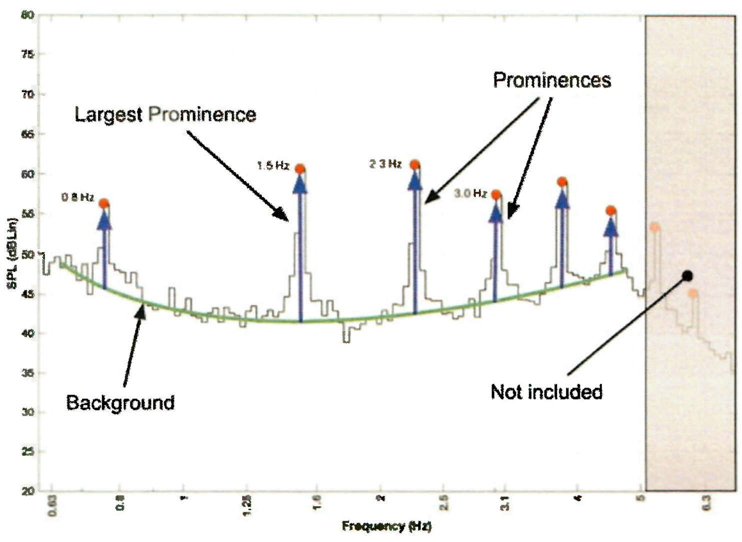

Figure 9.
Determination of prominence levels based on 1/36-octave frequency bands. The largest prominence, H_p (see text), in this series is approximately 17 dB over background. (Numerical data for this figure were obtained in Home 1, during the 'severe' episode).

definition of prominence in a frequency spectrogram as established by MATLAB which has a robust definition of prominence in terms of the peak height and the local background level [23].

The H_p parameter does not measure the total energy of the pulses in the pulse train that emanates from IWT. This energy is spread out over all the harmonic components of the pulses—the peaks in the spectrogram—whereas the measure only looks at the peak with the largest prominence. Therefore, H_p cannot be considered as an energy measure.

Another approach would be to look in the time domain, rather than in the frequency domain. Here a measure such as the crest factor could be used to gain a measure of the 'peakiness' of the pulses, using their total energy. These additional avenues of research are undergoing further scrutiny by these authors and their colleagues [17].

4.3 Day-time plots—Evaluation of long-term infrasound exposures

The H_p parameter can provide health scientists with a rudimentary indicator of the largest prominence above background that exists within a 10-minute measurement. When continuous measurements are maintained over several days (or weeks), a clearer picture regarding the long-term variation of exposure to these trains of pulses is revealed.

Figure 10 shows a Day-Time plot for the data collected in Home 1, 18 Jul-09 Aug, 2020. Here H_p is plotted as a surface with the date as the abscissa and the time of day as the ordinate. For each 24-hour period, there are 144 ten-minute samples. The values of H_p were determined for each 10-minute sample, and then binned (scale: <5 dB, 5–10 dB, 10–15 dB, 15–20 dB, 20–25 dB and > 25 dB), as reflected by the colorcoded scale in **Figure 10**.

Similar day-time plots were constructed for Homes 2 and 3, as shown in **Figures 11** and **12**, respectively. While these types of plots are informative as to the time and

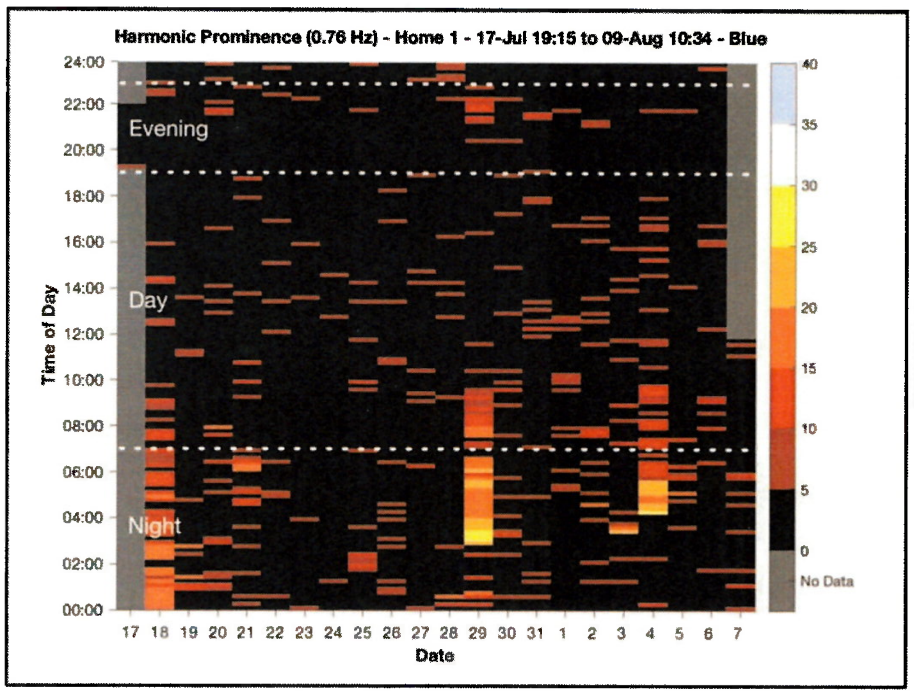

Figure 10.

Day-time plot for Home 1. *The 'severe' episode took place on 29th Jul, while the 'peaceful' episode took place on 22 Jul. The nights of 18 Jul and 4 Aug also show the presence of prominences. The 'peaceful' morning (22 Jul) has only one 10-minute sample with a significant H_p level. The following two mornings also appear to have no significant H_p samples but were not noted in the residents' diary as either peaceful or disturbed. The 'severe' morning (29 Jul), from 3 am until about 9 am shows up in stark contrast to the other mornings, indicating not only that the H_p levels were high but also that they were the highest in the entire length of the recording. The night of 4 Aug also shows an interval of 10-minute samples with severe H_p levels. Since the residents' diary stops on 31 Jul their experience on this day was not recorded. Finally, the night of 18 Jul shows elevated H_p levels from midnight onwards, although these did not reach the same levels as for 29 Jul or 4 Aug. The Es⁰ diary entry for 18 Jul at 04:00 indicated that the "noise was unbearable" and "sounded like a derailing train."*

duration that people are exposed to higher or lower levels of H_p, it is still important to view the sonograms to get a true understanding of the nature of the sonic environment at that point in time. For example, it is not possible from this graph alone to determine if the lower H_p levels seen in Home 2 on the morning of the 27th (**Figure 11**) are caused by the presence of a higher background noise level or whether the levels of H_p were actually diminished.

Note that not all the 10-minute intervals where the H_p is shown as 0 (black) are, in fact, 0. Impulsive sound—caused by such events as people walking over a floor or a door closing—can contaminate an entire 10-minute recording since the impulse is spread over longer and longer time intervals as the frequency of the 1/36-octave bands decrease.

To use the H_p measure as part of a dose–response metric, the simplest method would be to integrate it over time, i.e., multiply each value by 10 minutes and sum for a metric in decibel-minutes. Long-term exposure might be measured in decibel-years. Future research might even develop infrasound dosimeters for workers, similar to those used for radiation exposures.

Comparing the infrasonic environment in Home 1 with those encountered in Homes 2 and 3, a major difference becomes obvious: in the latter two homes, periods of respite (black areas in the day-time plots) are almost non-existent. Periods of respite are understood as biological recovery times, during which the agent of disease is not present and physiological cellular repair can be undertaken unimpeded by the acoustic aggressor. In Home 1 there is the possibility of comparison between the

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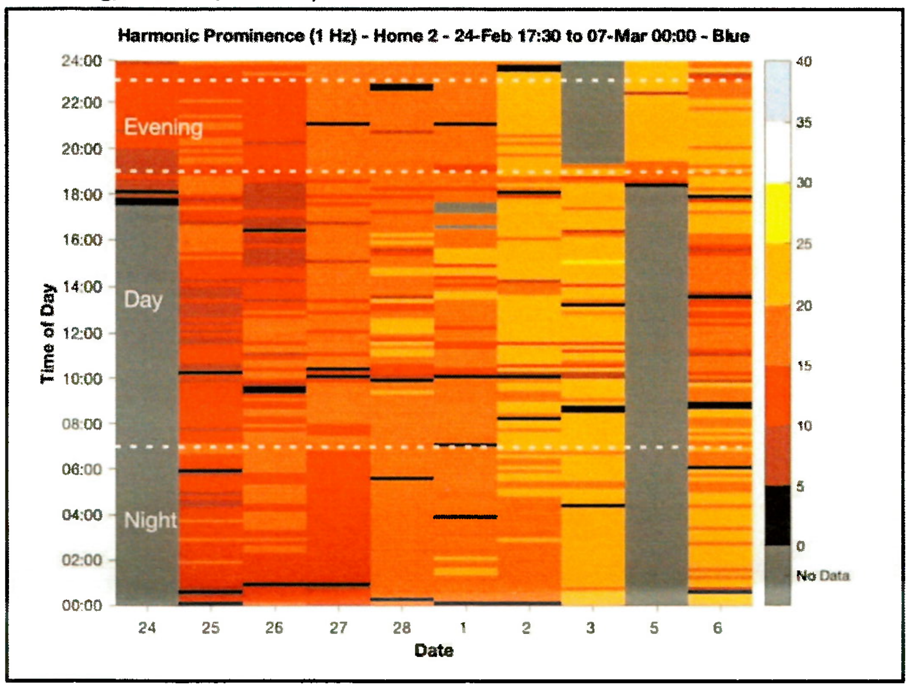

Figure 11.
Day-time plot for Home 2. *A visual inspection shows that the H_p was most dominant from the 2nd through the morning of the 6th reaching its highest value at around 3 pm on the 3rd, with H_p between 25 and 30 dB above background.*

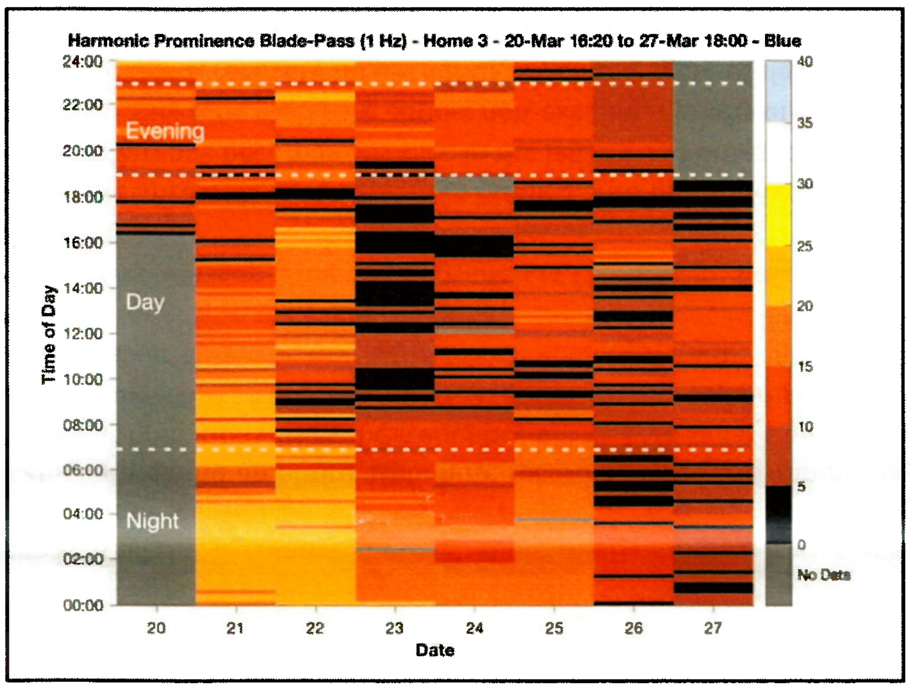

Figure 12.
Day-time plot for Home 3. *The most dominant episodes, i.e., highest level of H_p, were at night. The mornings of the 21st and 22nd registered the strongest H_p (20–25 dB), while the morning of the 27th presented with the weakest.*

periods of time when the IWT acoustic signature is present and when it is absent. Clearly, this is a much more difficult proposition in Homes 2 and 3, where the H_p level indicates that IWT acoustic signatures are almost always present, to a greater or lesser extent (color-coded scale).

4.4 Harmonic prominences wind roses

Airborne sound propagation is affected by wind and weather conditions. In addition to the obvious fact that wind 'carries sound,' thus reducing attenuation downwind, other atmospheric properties can greatly alter both the propagation and attenuation of sound. For instance, increasing humidity will improve propagation, while atmospheric inversion layers can create 'dead zones' where sounds will not be heard despite proximity to the source. Beyond these effects, the propagation and attenuation of infrasound differs in some important respects from sound at higher frequencies. While higher-frequency sound diminishes by 6 dB per doubling of distance—the inverse-square law—infrasound only diminishes by 3 dB. Infrasound is also more prone to refraction around large objects such as hills and to being funneled down valleys.

A data fusion of meteorological data (wind direction) and acoustic data (H_p) can provide insight into these weather- and terrain-induced differences that can significantly influence H_p levels. A *harmonic prominence wind rose*, which takes its inspiration from the common wind rose, is the nomenclature given to this data fusion. An example can be seen in **Figure 13**, reflecting data obtained in Home 1.

The H_p wind rose is a stacked, frequency histogram plotted in polar coordinates. It shows the number of 10-minute samples with an H_p in each dB-level bin in the direction of the then-prevailing wind. Each bin is identified by a color and the number of samples is indicated by the length of each segment in the radial direction. This provides important information if, for instance, the strongest levels of H_p align with a given wind direction.

The closest national meteorological stations must be used to provide wind data if a certified weather station is not available at the site of the sound recordings. This may be problematic since many weather services do not provide data at the closest weather

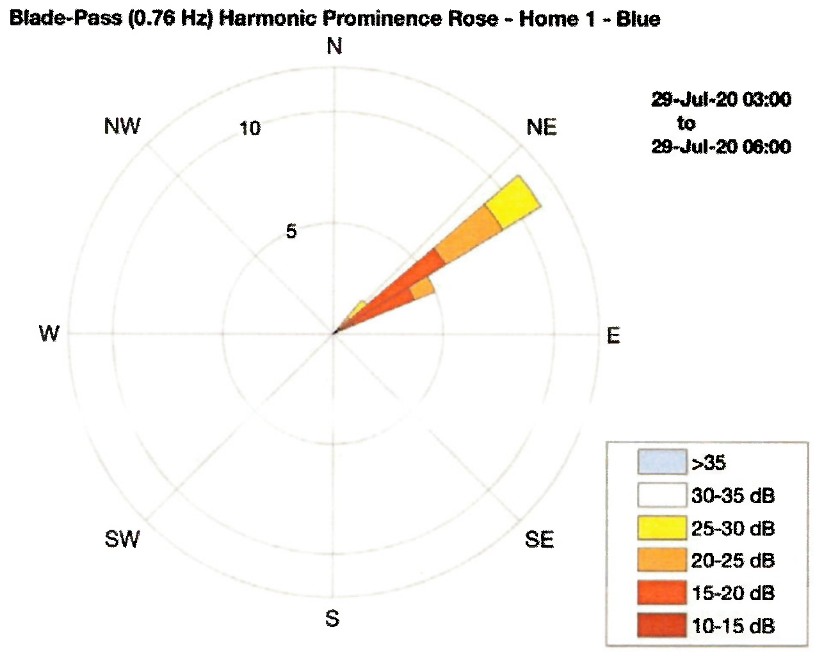

Figure 13.
Harmonic prominence wind rose for Home 1. *Data refers to the 18 samples examined during the 'severe' episode. The highest Hp levels (yellow) were registered when wind was from the north-eastern quadrant. (Wind data from weather station located 12.5 km from Home 1).*

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station but rather synthesized weather information, using their proprietary weather models. The wind direction provided is, therefore, not necessarily the same as at the recording site. Moreover, the wind direction at the hub-height of the IWTs may not be the same as at the height of the weather station or the home. The wind direction cannot, therefore, be said to indicate the direction of the source of the IWT acoustic signature in relation to the home.

While the wind direction can provide some understanding, the windspeed may also have a tale to tell. This leads to H_p wind roses plotted for data within wind-speed ranges. Examples are shown in **Figures 14** and **15** for three ranges. The left graph is a H_p wind rose for all 10-minute periods in the recording interval when the wind was between 0 and 10 km/h, the middle graph is for wind speeds of 10–30 km/h and the right graph is for wind speeds of 30–60 km/h.

The fact that the multi-day recording in Home 3 does not include any wind from the eastern half of the compass emphasizes the fact that a reasonable sampling of wind conditions will involve recordings from throughout the year to cover all seasons.

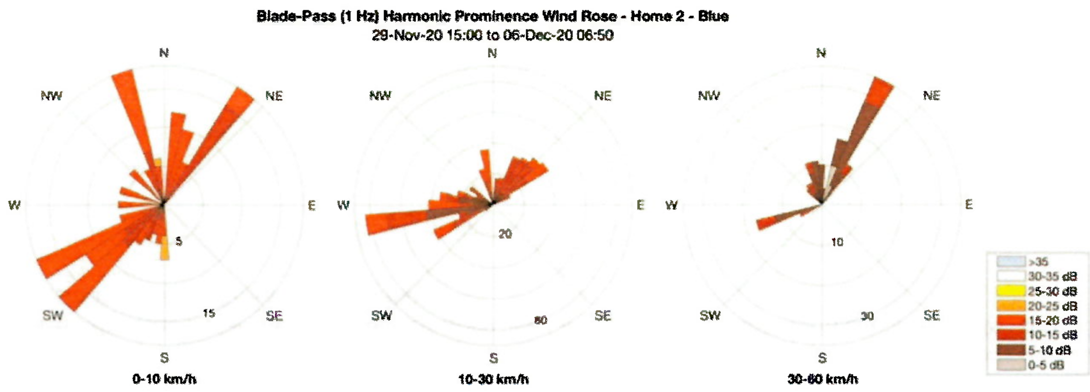

Figure 14.
Harmonic prominence wind roses for three wind-speed ranges for Home 2. *The strongest H_p is at the lowest windspeed, and this is most consistently dominant when the wind is between southwest and north-northeast; i.e., the sectors of the wind rose in these directions are almost entirely made up of 10-minute intervals where the H_p was between 15 and 20 dB (red). By comparison, where the wind was from the northeast, only about 15% of the sound files have this level. At the highest windspeeds, no instances of 15 –20 dB H_p can be seen.*

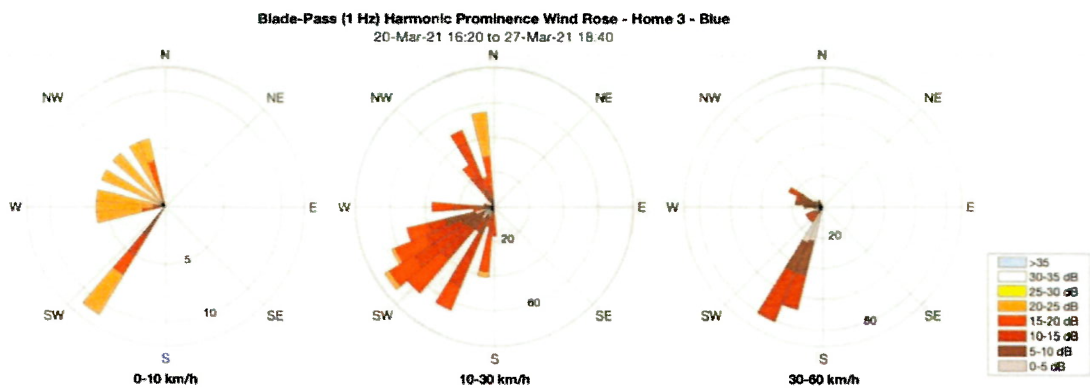

Figure 15.
Harmonic prominence wind roses for three wind-speed ranges for Home 3. *The strongest H_p is at the lowest windspeed and this is most consistently dominant when the wind is from the west through to northwest. That is, the sectors of the wind rose in these directions are almost entirely made up of 10-minute intervals where the H_p was between 20 and 25 dB (orange). By comparison, where the wind was from the southwest, only about 1/3 of the sound files have this level. At the highest windspeeds, no instances of even 15–20 dB H_p can be seen.*

The inverse dependence of H_p on wind speed is because the wind noise increases with wind speed, thus increasing the levels of background noise—including in the infrasound region. The sound pressure levels of the IWT pulses, however, remain constant. Thus, H_p will have lower values (see **Figure 9**). The unanswered question is whether the human brain processes the information of the IWT acoustic signatures when these appear obscured by, or embedded in, the increased background noise, as measured by a machine.

4.5 The position of other authors

In this type of scientific endeavor, it is normally expected that the work of other authors also be presented to form a context and allow a comparative analysis of results obtained and/or of the methodologies used. Regrettably, most, if not all, papers on infrasound are conducted with a ⅓–octave resolution, which immediately precludes any data comparison with that presented here. Due to a variety of conditioning factors that have been in place for decades, sound level meters readily available on the market do not possess the technical capabilities for this type of data acquisition and subsequent analyses. Simultaneously, many of the health-related aspects that are studied within the context of IWT are restricted to measures of "annoyance" (a non-clinical and highly subjective parameter) or to the audibility of the sound, neither of which are very relevant to the results presented here.

In 2018, the World Health Organization (WHO) published a document titled: *Environmental Noise Guidelines for the European Region* [24]. The word "infrasound" has one single entry, on page 85, under the section heading *Wind turbine noise*:

> *"Wind turbines can generate infrasound or lower frequencies of sound than traffic sources. However, few studies relating exposure to such noise from wind turbines to health effects are available. It is also unknown whether lower frequencies of sound generated outdoors are audible indoors, particularly when windows are closed."*

These and other statements reflect a profound misunderstanding of the importance of the time-profile of an exposure to sound as it relates to biological responses (e.g., traffic does not produce harmonic peaks with a one-second pulse rate). However, in defense of this position taken by the WHO, it must be acknowledged that the methodologies it uses for assessing sound necessarily preclude the observation and identification of harmonic series associated with IWT. The suggestion that the audibility of infrasound levels (in itself, an oxymoron by classical definitions) can be mitigated by closed windows clearly indicates a profound lack of knowledge on the physical attributes of propagating airborne pressure waves within the infrasonic range [25–27].

5. Conclusions

This chapter provides a different approach to the measurement and analysis of infrasound in and around homes located in the proximity of wind power plants. Examples show how using higher temporal- and spectral-resolutions (1 second and 1/36 of an octave), and without any frequency weighting, can reveal acoustical features in the infrasonic range that may indicate a causal relationship with self-reported medical symptoms. This possibility is usually considered non-existent since the infrasonic range is generally viewed as inaudible, and thus innocuous, to humans. The

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suggestion therefore arises that current noise protection procedures are insufficient to protect public and occupational health. The approach used by these authors offers a more solid framework with which to pursue the establishment of dose–response relationships for infrasonic exposures. Future studies are being extended into noisy occupational environments and different environmental settings where wind power is not the acoustic source.

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This project has received ethical approved from the NZ Ethics Committee (see www.nzethics.com), application number NZEC19_12.

Conflicts of interest

HHCB developed software for capturing and analyzing the sound files for the SAM system, no financial interest. MAP no conflict. RM no conflict. RS contributed to the development of the SAM system, no financial interest. PD no conflict.

Author details

Huub Bakker[1], Mariana Alves-Pereira[2]*, Richard Mann[3], Rachel Summers[1] and Philip Dickinson[1]

1 International Acoustics Research Organization (IARO), Palmerston North, New Zealand

2 Lusófona University, Lisbon, Portugal

3 University of Waterloo, Ontario, Canada

*Address all correspondence to: m.alvespereira@gmail.com

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[17] IARO-International Acoustics Research Organization-represents a group of scientists who, collectively, hold over 200 years of scientific experience in the field of infrasound and low frequency noise, and its effects of human health. Since 2016, our researchers have been recording and analysing acoustical data in and near homes located in the vicinity of onshore wind power stations, in the following countries (alphabetical): Australia, Canada, Denmark, England, France, Germany, Ireland, New Zealand, Northern Ireland, Portugal, Scotland, Slovenia, and The Netherlands. Prior to 2016, all IARO scientists were already working either in acoustics alone or in acoustics and health. All research conducted by IARO is part of the Citizen Science Initiative for Acoustic Characterization of Human Environments (CSI-ACHE), the research protocols for which have been approved by the New Zealand Ethics Committee (application number NZEC19_12). www.iaro.org.nz

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Grosvenor Consultancy

Seskin Wind Power Plant Proposal.

Planning application Reference: 2460122 Carlow County Council.

Objection Operational Wind Turbine Noise & Residential Amenity Impacts.

Annex 10.

A third of Groningen villages visit the doctor because of complaints about wind turbines

https://www.ad.nl/binnenland/een-derde-van-gronings-dorpje-bezoekt-dokter-vanwege-klachtenwindturbines~a345fae9/?fbclid=IwAR1s626KDwb7_16Onwb4DB-3GW

Epidemiologist and former general practitioner Dick Bijl: "If you really want to do good research, we have to conduct door-to-door surveys. And don't forget those who have already moved as a result of the nuisance." © Erik van 't Woud

A third of Groningen villages visit the doctor because of complaints about wind turbines

"A soundproof cabinet," says GP Cornelis Pet in Meeden, Groningen. "That's what a couple had built in their home as a last-ditch effort to shut out the noise and hum. The wind turbines drive Mr. and Mrs. crazy screaming."

Edwin Timmer 03-18-24, 04:34 **Last update:** 03-18-24, 11:17

Other of his patients flee the Groningen ribbon village, less than a kilometer away from the N33 Wind Farm, whenever they can. "*I know of several people that they regularly sleep elsewhere,*" says Pet. *In a chalet in Drenthe, with family or on a boat in Friesland.* Since the commissioning of the first of a total of 35 turbines in 2020, the Tegenwind N33 foundation has collected almost eight hundred complaints. Many of the complainants appear at the consultation hours of Pet, the village doctor since 1991. "*I estimate that more than a third of the population in Meeden experiences inconvenience.*"

Powerless and furious

Many are at their wits' end. Pet: "*The insomnia leads to stress, anger, fatigue and increased levels of irritation and alertness. Parents complain about unruly children and learning delays. I see arguments,* *depression and suicidal tendencies". But despite all the cries for help from politicians, nothing is improving. As a doctor I feel powerless."* As a human being he is sometimes *'fierce'*.

Wind turbines just below Rotterdam in Geervliet and Heenvliet © Arie Kievit

His colleague Sylvia van Manen from Den Bosch has also noticed a number of complaints in her practice in recent years. *"Dizziness, migraine and a feeling of restlessness and fear,"* she explains. After four tall windmills appeared in the Engelen district in 2020, she decided to do a random sample in the immediate area. *"A third of the residents seem to experience serious inconvenience."* Doctor Van Manen also sees how local residents use their own homes differently as a result of a form of self-medication. "*Since the arrival of the turbines, a patient no longer sits in the living room with her children, but in the kitchen. To be able to ignore the noise and the cast shadow.*"

Iam very concerned about how the government is working. The only goal seems to be theinstallation of wind farms. While it has been proven that constant noise increases the risk of cardiovascular disease

- Anneke Bodde, General Practitioner in Derekamp

Van Manen, like colleagues approached by *AD* , is therefore outraged by a recent Nivel report, which claims just the opposite. According to the Netherlands Institute for Healthcare Research, between 2012 and 2021, general practitioners did not diagnose acute or chronic health problems more often in people living near wind turbines than in people further away.
"*Blob work*," says former general practitioner and epidemiologist Dick Bijl about the Wind Turbine Health Outlook study. Nivel looked at a connection between postal code areas and the codes with which general practitioners register the diagnoses of their patients. *"Methodologically there is a lot to comment on. You really cannot draw this conclusion,"* says the scientific advisor of the doctors' collective Wind Wiki.

Tunnel vision

Nevertheless, the client, the Ministry of Health, Welfare & Sport, sent the study to the House of Representatives.

Proponents of onshore wind energy responded enthusiastically. Like*: 'See, not much going on'.* It would of course also be best for the rollout of climate policy and the desire to generate renewable energy if health problems turned out to be an illusion.
But according to GP Anneke Bodde from Denekamp, politicians and administrators suffer from *'tunnel vision'. "I am very concerned about how the government is working. The only goal seems to be the installation of wind farms. While it has been proven that constant noise increases the risk of cardiovascular disease. Yet only the favorable studies are selected."*

▲ General practitioner Anneke Bodde addressed the Dinkelland municipal council in December about plans to install wind turbines at Denekamp. © Robin Hilberink

According to Bodde and her colleagues, the ICPC codes used in the Nivel study are not at all suitable for scientific conclusions. "*I can write down complaints such as anxiety or sleep problems under many different codes. At the same time, the system is not detailed enough to indicate whether a diagnosis is related to nuisance caused by wind turbines."*
Flevoland general practitioner Paul Kemps is also not happy with the Nivel study. In the past, wind turbines in the agricultural municipality of Dronten were located far away from the four residential areas. In recent years, dozens of turbines of more than 200 meters high have been built, including one row close to the village of Swifterbant.

One person says it 'drives him crazy', others continuously hear a hum in the house and still others continuously lower the shutters. There is no solution. Yes, shut down those turbines

- Paul Kemps, General Practitioner in Swifterbant

It shows in a nutshell what he believes is lacking in the report. *"The Nivel looks back ten years. But at that time, windmills were a lot smaller and located further away from residential areas. This study has no predictive value whatsoever, nor for what is happening now,"* the doctor warns.

Kemps experiences 'a general picture of unrest and dissatisfaction' among some of his patients. *"One person says it 'drives him crazy'*, others continuously hear a hum in the house and still others continuously lower the shutters. The nuisance is horrible and there is no solution. Yes, shut down those turbines. But that doesn't happen."

Sleeping pills not an option

Sleeping pills are no way out. Because *'addiction takes you even further away from home',* his colleagues also agree. But a relaxing walk in the village forest is also not possible, Kemps complains. *"Those b.......s were supposed to be placed far from the village, but were ultimately placed along the edge of the forest without any participation".*

Epidemiologist Bijl mentions another point of criticism. *"Four-digit postal code areas are too large to measure the effect on citizens within one kilometer of wind turbines. The deviations dilute in the rest of the area. If you really want to do good research, we have to conduct door-to-door surveys. And don't forget those who have already moved as a result of the nuisance."*

▲ Epidemiologist Dick Bijl calls a Nivel study 'shoddy work'. © Photo: Erik van 't Woud

When asked, Christos Baliatsas, senior researcher in disasters and environmental threats at Nivel, acknowledges the limitation of the postcode areas. At the same time, he calls the study *'one of the largest in the international literature in terms of sample size and also the most comprehensive in terms of health problems examined'*. In addition, there has been little epidemiological research into the effects of wind farms, especially in the Netherlands.

Tension headache

According to Baliatsas, the fact that the study shows no link with diseases does not mean that *'an impact on health should be completely ruled out'. "We have seen that a limited number of symptoms such as tension headaches and feelings of depression are more common near wind turbines, especially in the more recent years of the study."* But the outcome is not very clear.

In Meeden, the hum also regularly keeps GP Pet awake. Yet he does not want to emphasize that. *"I don't want to be the cause of polarization within our village.* The farmers on whose land the turbines were placed were also never able to know this in advance."

▲ Wind turbines of more than 200 meters height in Flevoland. © Photo Freddy Schinkel

Pet does believe that directors should open their eyes and act. *"The couple from the soundproof cabinet were allowed to tell their story to the mayor a year ago. Since then? Nothing. Such a report from Nivel also gives victims the feeling that they are not being heard."*

'Pure public deceit'

Doctors' collective Wind Wiki has focused on new national environmental standards for wind turbines that the government must establish. The previous ones proved to be defective, according to the European Court, and were set aside by the Council of State. Van Manen: *"Wind Wiki recommends distance standards of ten times the mast height to residential areas, because larger turbines cause more low-frequency noise."*

But to the horror of epidemiologist Bijl, the provisional draft rules, just like the old ones, assume an annual average as the maximum noise standard. *"Then every noise peak will soon be tolerable again, because it will average out anyway."* Pet puts it more sharply. *"It is pure public deception and a deliberate way to cause health damage. According to the law, you are not allowed to do anything to your loved ones, but apparently something different applies to the government."*

END.

Appendix D

HUSON & ASSOCIATES – REVIEW OF SESKIN WIND FARM APPLIACATION

Sound

HUSON & ASSOCIATES

Review of Proposed Seskin Wind Farm Planning Application

WLes Huson BSc(Hons) MSc CPhys MInstP MIoA MAAS

Seskin Wind Farm Review.docx
August-2024

INTRODUCTION

Huson & Associates has been commissioned by Rural Residents Wind Aware And Environmental Group (RRWAAEG) to review Appendix 12.2 'Wind Turbine Operational Noise Report' (Report), prepared by TNEI, of an EIAR accompanying the planning application for the Seskin Wind Farm (Application).

After refusal of the Application by Carlow County Council (case number ABP-320354-24, planning reference no. 2460122) the proponent (EDF Renewables Ireland Limited) has lodged an Appeal of the decision. This review also considers the Appeal response to Reason 3 of the refusal that was prepared by MKO on behalf of EDF Renewables Ireland Limited.

This review has been prepared by W Les Huson BSc(Hons) MSc CPhys MInstP MIOA MAAS (brief CV in Appendix A).

Referenced papers can be made available on request if required.

SUMMARY

Carlow County Council (CCC) are justified in refusing the planning application for the Seskin Wind Farm. There is a lack of detail provided in the Report and the assessment has been made based upon optimistic noise targets that are currently under review. The noise model used has deficiencies that have not been addressed, yet, despite the optimistic parameters used in the noise model and higher chosen noise limits from the range suggested in WEDG 2006 there remain predicted non-compliance for some dwellings.

The Appeal against the CCC refusal has failed to address the deficiencies of the Application, in particular the noise Report in Appendix 12.2, and has simply reiterated statements made in the noise Report.

The Report and Appeal document rely heavily on ETSU-R-97 and the IoA Good Practice Guide, 2013 when these guidelines are currently under review.

I recommend that current best practice in assessing wind farm noise is reflected in target noise limits set in the Australian States of New South Wales and Tasmania.

The requirement from WEDG 2006 that '*that there is no significant increase in ambient noise levels at any nearby noise sensitive locations*' has not been addressed in the Report or the Appeal reply to refusal Reason 3. Ambient sound levels are shown to be well below 17 dBA in wind speeds up to 6 m/s (10m AGL) at some dwellings with predicted sound levels more than 40dBA for several dwellings.

The soundscape in the area will change dramatically if the wind farm is approved.

PLANNING GUIDANCE ON NOISE FROM WIND FARMS

The Irish Government Department of Environment Heritage and Local Government document '*Wind Energy Development Guidelines, 2006*' (WEDG 2006) list the current guidelines to set noise limits for wind energy developments. However, WEDG 2006 is considered to require updating and a DRAFT WEDG 2019 has been prepared but not formally adopted as it remains under review. The Report has adopted the principles of WEDG 2006 but has added interpretations contained in UK wind farm noise guidance using ETSU-R-97 'The Assessment and Rating of Noise from Wind Farms' with further guidance from the Institute of Acoustics in 2013; 'A good practice guide to the application of ETSU-R-97 for the assessment and rating of wind turbine noise' (IoA, GPG).

The Report states that "the WEDG 2006, is very limited and it is widely agreed that the limits proposed in the WEDG 2006 were drafted to broadly align with the UK guidance". This statement is debatable although there are some similarities regarding sound level objectives since both documents reflect WHO guidance.

WEDG 2006 states "*Good acoustical design and carefully considered siting of turbines is essential to ensure that there is no significant increase in ambient noise levels at any nearby noise sensitive locations.*" WEDG 2006 has been drafted to balance the objectives of providing renewable power with acoustic amenity and for quiet areas states; "*in low noise environments where background noise is less than 30 dB(A), it is recommended that the daytime level of the LA90, 10min of the wind energy development noise be limited to an absolute level within the range of 35-40 dB(A).*"

The Report has generally chosen to set lenient target noise limits in the daytime at 40 dB(A) L90, where background noise levels were <30 dB, and 45 dB(A) L90 or background plus 5 dB, whichever is the greater, where background noise levels were >30 dB. The night time noise limit has been set in the Report at 43 dB(A) L90 or background plus 5 dB, whichever is the greater.

Alternative noise limits have been applied at some noise sensitive receivers (NSR) based upon permitted noise limits from other wind farm approvals in the area. I do not believe that permit conditions for other wind farms have any relevance to this development application.

With the suggested noise limit in the Report there is a predicted no-compliance for NAL15 during the day. The Report suggests that noise reduction measures can be applied to reduce sound levels at NAL15.

I consider that target noise limits during the day and at night are set too high in the Report. The background sound level charts in the Report clearly show that the area is a low noise environment and current WEDG 2006 guidance would set the noise level target at 35 dB or background plus 5dB. EU required Noise Maps (https://gis.epa.ie/EPAMaps/) show that the area is unaffected by any industry, aircraft, rail or roads.

Night time sound levels at NML5 and NML6, for example, show that the sound measurement equipment regularly recorded sound levels at the noise floor of the instruments. Sound monitoring equipment is classified under IEC61672. The sound level meters used have a noise floor of typically 17 dBA. However, the sound level range over which the instrument is linear and compliant with Class 1 generally is some 6 dB higher. Thus, sound levels shown in the background charts between 23 dBA and 17 dBA are compressed. This means that real background sound levels in the area are often much lower than 17 dBA. This phenomenon is explained in Huson (2015)[102]

The night time noise targets in ETSU-R-97 are based upon the WHO 1980 guidance. The WHO 1999 Community Noise Guidelines states: "*Sleep disturbance is the critical effect in bedrooms, in dwellings and preschools. Recommended guideline values inside bedrooms are 30 dB LAeq for steady-state continuous noise, and for a noise event 45 dB LAmax, preferably even lower, about 40 dB LAmax. Lower sound pressure levels may be annoying depending on the nature of the noise source. The maximum level should be measured with the instrument set at "fast".*

At nighttime outdoors, sound pressure levels should not exceed 45 dB LAeq, so that people may sleep with bedroom windows open. This value has been obtained by assuming that the reduction from outside to inside with the window open is 15 dB; note that the actual reduction may be less in some cases, maybe only 5-7 dB, which then would mean that the sound pressure level outdoors needs to be kept at or below 35-37 dB LAeq."

Outdoor noise target limits are based on the outdoor to inside attenuation values that are frequency dependent with outdoor sound pressure levels for some properties needing to be kept at or below 35 dBA Leq.

The ETSU-R-97 and WEDG 2006 night time target noise level of 43 dBA L90 should be reduced by 5 dB, at least.

With this changed target noise limit many more NSR locations will become non-compliant at night.

The WHO sleep protection noise target is not based upon wind farm noise and recent recommendations from the WHO recognise that wind farm noise has special audible characteristics that can be more disturbing than similar sound levels set for other noise sources.

The Northern Ireland Assembly's Committee for the Environment produced a 'Report on the Committee's Inquiry into Wind Energy' in 2015.
https://www.niassembly.gov.uk/globalassets/documents/official-reports/environment/20132014/140605_inquiryintowindenergycharteredinstituteofenvironmentalhealth.pdf

This inquiry recommended that the Department should review the use of the ETSU-97 guidelines on an urgent basis, with a view to adopting more modern and robust guidance for measurement of wind turbine noise, with reference to current guidelines from the World Health Organisation.

Reasons for recommendation that ETSU-R-97 is updated

[102] Huson, W. Les. "Constraints imposed by and limitations of IEC61672 for the measurement of wind farm sound emissions" 6th International Conference on Wind Turbine Noise, Glasgow 20-23 April 2015

Modern wind turbines are considerably larger now than those that were in place in 1997, this can result in more lower frequency noise and an increased risk of AM due to high level wind fluctuations.

ETSU - R - 97 The Assessment and Rating of Noise from Wind Farms' is influenced by BS4142 Method for rating industrial noise affecting mixed residential and industrial areas.

BS4142 is currently being updated. The draft revised BS4142 includes further emphasis on the annoyance from tones and fluctuations. The draft proposes that when both characteristics are present the two should individually be taken into account.

The WHO guidance for indoor noise levels at night was 35dB when ETSU-R-97 was published in 1997, it has now been revised to 30dB

ETSU-R-97 advises using the LA90,10min noise index for both turbine and background noise.

Most other relevant standards use LAeq for source noise. LA90 was adopted by ETSUR-97 as it was assumed at the time of drafting that wind turbine noise was relatively steady and characterless. Evidence and knowledge since 1997 has highlighted that certain wind farms/single wind turbines produce AM and hence the original assumption within ETSU-R-97 that wind turbine noise was relatively steady and characterless no longer holds true. ETSU-R-97 needs to be updated to take account of much greater understanding of the acoustics of large wind turbines and the annoyance/health effects of wind turbine noise.

In particular, consideration of the following content of ETSU-R-97 is recommended:

- The statement that it is not necessary to use a margin above background approach in low noise environments
- The use of LA90 for both the background noise and the wind farm noise
- Night time limit of 43dBA bearing in mind the revised WHO guidelines
- The assumption that background noise rises with increasing wind speed
- The consideration of fluctuations and tones.

BS4142 has now been revised with the latest edition dated 2019 that also has an accompanying Methods Implementation Document.

The UK Department for Energy Security and Net Zero (DESNZ) issued a tender in May 2024 on the following subject: **Update to ETSU-R-97 Onshore Wind Noise Guidance** Sourcing Reference Number: PS24055

Overview of Scope of Services (PS24055)

Onshore wind is a mature, efficient and cheap technology, with over 15GW of installed capacity in the UK today. To achieve a low-cost net zero system in the future, we will require a sustained increase in locally supported onshore wind to 2030 and beyond, alongside other renewables such as offshore wind and solar.

The Department of Energy Security and Net Zero (DESNZ) owns policy and guidance in relation to noise from onshore wind turbines. The current guidance for the assessment of turbine noise emissions is 'The Assessment and Rating of Noise From Wind Farms', otherwise known as ETSU-R-97, or ETSU, which dates back to 1996. ETSU uses contemporary evidence of turbine noise emissions to provide noise thresholds, split between daytime and night-time limits, above which noise from proposed wind turbines would be considered too loud. These thresholds are not absolute: ETSU generally sets these thresholds at a decibel level relative to background noise so turbine noise impacts are not considered in isolation.

ETSU is regularly used by Local Authorities across the UK for appraising planning applications for onshore wind developments. ETSU is technical guidance, and has no statutory or legal foundation, though it is referenced in several planning policy documents. Planning applications for an onshore wind farm must take the impact of noise into account.

Due to advances in both sound measurement and turbine technology since 1996, in 2021 Government commissioned WSP, an external consultancy, to produce a scoping review into whether the current ETSU guidance could, or should, be updated. The report, published in 2023, recommended that the guidance would benefit from specific, targeted updates. The report also concluded that there are significant gaps in the knowledge base and more research would be required should more substantial revisions to the guidance be desired.

Government considered the recommendations in detail and in November 2023 convened a steering group comprising of policy officials and technical experts from across Government and the Devolved Administrations. The steering group agreed to proceed with undertaking specific, targeted updates to ETSU guidance in the shortterm. DESNZ are therefore **seeking an organisation to undertake an update to the ETSU guidance according with the recommendations made in the WSP report**.

The successful bidder of this contract will produce two documents. An informal paper of secondary research to be shared internally with Government, and updated ETSU guidance to be published on gov.uk. The expectations of the contractor are:

- The Supplier will work closely with the Government throughout the duration of the contract to iterate the final product. The updated guidance will be published by, and the intellectual property of, the Government.
- The Supplier should have technical expertise and knowledge of acoustics and noise, specifically in air-borne noise, that can be applied to this contract to ensure quality of outputs when updating technical noise guidance.
- The Supplier should have expertise in evaluating research in a highly technical area, and drafting guidance documents to a high standard.

- The Supplier will peer review the guidance thoroughly and have access to a group of relevant experts to review and iterate the guidance.

This work will be conducted between June 2024 – March 2025. The final product should be ready for publication by the early March 2025.

Noise target limits are under review in the UK and the current guidance used in the Report is outdated and subject to change within the next 12 months, but those changes are currently unknown.

Current best practice in wind farm noise guidance is provided in the Australian States of New South Wales and Tasmania where night time target noise limits are set at 35 dBA Leq or background plus 5 dB with additional penalties for special audible characteristics such as tonality, impulsiveness and amplitude modulation. Wind farms have been approved under these target noise limits and a good balance has been struck to provide renewable energy yet protect the nearby population.

It is worth noting that in a recent Supreme Court nuisance noise case (Uren v Bald Hills Wind Farm S ECI 2020 00471) 25 March 2022 in Australia Justice Richard observed:

"The generation of renewable energy by the wind farm is a socially valuable activity, and it is in the public interest for it to continue. However, there is not a binary choice to be made between the generation of clean energy by the wind farm, and a good night's sleep for its neighbours. It should be possible to achieve both."

Justice Richards also observed that because noise from a wind farm is intermittent a test against a night time noise limit for 10% of any individual night is an appropriate way to protect sleep, rather than average many nights of exposure.

CUMULATIVE NOISE

The Report has produced noise model outputs for the cumulative effects of other nearby wind farms using directivity guidance described in the IoA GPG. This wind farm is located on the side of a valley and it is to be expected that local wind directions may not be uniform across the areas containing the nearest wind farms considered. A CFD wind analysis, that is commonly available to wind farm developers, would assist in showing if the assumptions made in the Report are valid for the directivity effects applied to the noise models.

A CFD wind analysis would also show any site effects that the decision to place the wind turbines on the side of a valley may have. Site effects can significantly alter the sound power of a wind turbine that is generally specified for flat terrain with minimal inflow turbulence.

Despite the wind turbine foundations being located below the ridges of the valley the hubs of the wind turbines will be seen from all the surrounding nearby dwellings.

Manufacturer data was used in the cumulative noise model rather than actual data that could be obtained from compliance testing. It is not known how well the manufacturer's sound power data compares to the installed situation that can be influenced by site effects.

NOISE MODELS

The Report has misinterpreted a European Commission (EC) research project into wind farm noise propagation over large distances, published as 'Development of a Wind Farm Noise Prediction Model,' JOULE project JOR3-CT95-0051 in 1998. This project identified a simplified version of ISO 9613-2 as the most suitable at that time. The preferred model was called the IEA model and is effectively ISO 9613-2 without corrections for barrier attenuation, meteorological effects (Cmet) and ground absorption.

The Report has used the 'full' ISO 9613-2 noise model including ground absorption, rather than the recommended IEA model, with additional modification due to ground concave profile effects, the latter being a general correction recommended in the JOULE project.

ISO 9613-2 prediction results are sensitive to the value of ground absorption/attenuation effect, G, that can range between 0 and 1. G=0 indicates no ground absorption and G=1 represents full ground absorption of sound. A paper by Brittain and Charalampous[103] shows the inadequacy

of the ground effect calculations in ISO 9613-2 for a source height of 100m, which conveniently approximates the hub height of the proposed candidate wind turbines in the Report.

The Report has used a value of G=0.5 in the ISO 9613-2 noise model for all the ground between the wind turbines and all noise sensitive receivers with an artificial receiver height of 4m (in practice all sound level surveys are completed at a height of approximately 1.5m). The peculiarities of the ground effect calculation in ISO 9613-2 show that predicted sound levels for a receiver height of 1.5m (the standard measurement height) there is a 4 dB difference in predicted sound levels dependant on whether G=0 or G=0.5 is used. G=0 produces typically 4 dB higher predicted sound levels than when G=0.5 is used.

It is best practice to err on the side of conservatism and use G=0 when using ISO 9613-2. This point was made by Eric Sloth, one of the authors of the JOULE study in his presentation (Appendix B) where he advises that if ISO 9613-2 is to be used for wind farm noise predictions, then G=0 should be used with additional corrections to account for site effects such as inflow turbulence. The Report has not accounted for any site effects that can increase wind turbine sound power levels. Furthermore, the Report *assumes* that there will be no special audible characteristics from whatever wind turbine is chosen to be used in the wind farm.

The ISO 9613-2 noise model has a stated limitation for its calculations in conditions where the source to receiver average height does not exceed 30m and when average propagation enhancement from vector wind does not exceed 1m/s to 5m/s measured at a height above ground between 3m and 11m. ISO 9613-2 for this wind farm application is being applied well outside of its intended use.

[103] Brittain, F., Charalampous, P: 'Assessing Accuracy of ISO 9613-2 for Calculating Ground Effects of Stack Height and Distance Using Olive Tree Labs OTL Suite'. NOISE-CON 2016, Providence, Rhode Island, 13-15 June, 2016

Section 4.4.5 of the Report has not correctly reported the uncertainty associated with the use of ISO 9613-2. The preferred IEA method recommended in the JOULE report suggests a standard deviation uncertainty of 0.004dB/m. For a propagation distance of 1000m this translates to +/-4 dB (+/- one standard deviation). ISO 9613-2 predictions are estimated in Table 5 of the standard to have an uncertainty of +/-3dB at 1000m if all inputs are accurate but notes that:

"The estimates of accuracy in table 5 are for downwind conditions averaged over independent situations (as specified in clause 5). They should not necessarily be expected to agree with the variation in measurements made at a given site on a given day. The latter can be expected to be considerably larger than the values in table 5." The JOULE study also noted the following:

"As a result of the measurements just described it has been concluded that:

- Noise levels at all distances from the source do vary, even if the source of sound has a constant power level.
- The measured variation in noise levels increases with increasing distance from the source.
- Based on typical wind speed ranges of between 0ms-1 and 10ms-1 encountered during the experimental measurements, the one standard deviation spread of noise levels either

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side the mean level was found to increase at a rate of approximately 0.004dB(A) per meter increase in the source to receiver separation distance."

The JOULE summary report is in Appendix C.

The fact that wind farm sound levels vary with increasing distance (assuming all wind turbines emit a constant sound level) suggests that the use of the L90 statistic underestimates the true impact of noise from a wind farm. Whilst it is advantageous to use an L90 statistic to reduce extraneous noise effects on a measurement it unfortunately underestimates the true higher levels of noise caused by the wind farm. This underestimation can be compensated by the standard deviation of 0.004dB measured in the JOULE study.

A more realistic estimation of the higher sound levels from a wind farm is the predicted sound level using the simple IEA model (cut down ISO 9613-2 with corrections) plus the addition of one standard deviation uncertainty. For a dwelling 1000m away the prediction should be the IEA model output plus 4dB (0.004dB/m at 1000m).

WIND TURBINE LAYOUT

It is customary in the design of a wind farm to take account of the distances between wind turbines to minimise noise emissions and to maximise efficiency. An outline of such design considerations can be found in 'NSW Wind Energy Handbook 2002': Sustainable Energy Development Authority of NSW (SEDA).

From page 53 of the SEDA document:

"A wind-farm layout must take into account that turbines have substantial 'wakes', which interfere with each other depending on wind direction and spacing. The general rule of thumb for spacing (the '5r-8r rule') is five times rotor diameter abreast and eight times rotor diameter downwind. '

Appendix B of the IEC61400-11 standard indicates that at high wind speeds, wind turbulence becomes the primary source of sound. It suggests that these effects should be minimized during testing and optionally reported.

In the current layout of the Seskin wind farm, the average distance between the wind turbine towers is approximately 550 m.

The candidate wind turbines have rotor diameters, denoted as 'r', of 150 m. The spacing between the turbines is only 3.7 times the rotor diameter (3.7r), which is significantly less than the recommended spacing 8r to reduce wake turbulence effects.

An increase in wake turbulence from the wind turbines can lead to higher noise emissions and lower efficiency of the wind farm. This spacing is also less than the minimum 5r recommended by SEDA.

The Report has not considered the potential increase in sound power caused by wake effects.

WIND TURBINE SOUND POWER LEVEL

The maximum sound power level for the Vestas V150 6MW wind turbine is stated on the Vestas website to be 104.9 dBA. The Report has not provided any sound power data for the V150 that was used in the noise models, citing confidentiality concerns. The Report suggests that the V150 was used as it represents the sound power levels typical of the candidate wind turbines under consideration. However, the sound power data for the Nordex 149 5.6MW wind turbine is 105.6 dBA. These values represent manufacturer data without any addition for uncertainty.

If the Nordex 149 wind turbine was to be used instead of the V150 for the Report then the predicted sound levels should all be 0.7 dB higher.

The Carlow County Council should only consider candidate wind turbines that have complete sound power specifications provided in any planning application. The Report is deficient in this regard.

AMPLITUDE MODULATION (AM)

The Report discusses AM at length but reaches no conclusion on a penalty scheme to account for this special audible characteristic. The penalty scheme proposed by WSP has been criticised by the acoustics community. Furthermore, WSP used the IoA Preferred Method to produce an AM metric. However, the IoA AM metric bears little to no resemblance to the actual peak to trough sound levels observed in the community from a wind farm. The IoA AM Method may be suitable for a single wind turbine but fails to accurately represent the AM observed from multiple wind turbines.

ETSU-R-97 incorrectly addressed amplitude modulation and made a sweeping assumption that such a characteristic was rare in modern wind farms. This is not the case and it is now recognised that amplitude modulation is the most significantly intrusive sound characteristic of wind turbines.

The GPG refers in section 7.2 to ongoing research. Since the publication of the GPG in 2013 there has been much ongoing research and amplitude modulation is known to be a significant concern for residents near modern wind farms.

The following figures illustrate A-weighted sound levels over a 10-minute period that have been recorded at a rate of ten samples per second 800 m from two MM82 2MW wind turbines outside a dwelling.

The measurement was taken when the wind turbines were operating in the early hours of the morning when there was no extraneous insect, bird or animal sound but there was sound from wind in trees and foliage. This was confirmed by listening to the audio recordings taken at the same time.

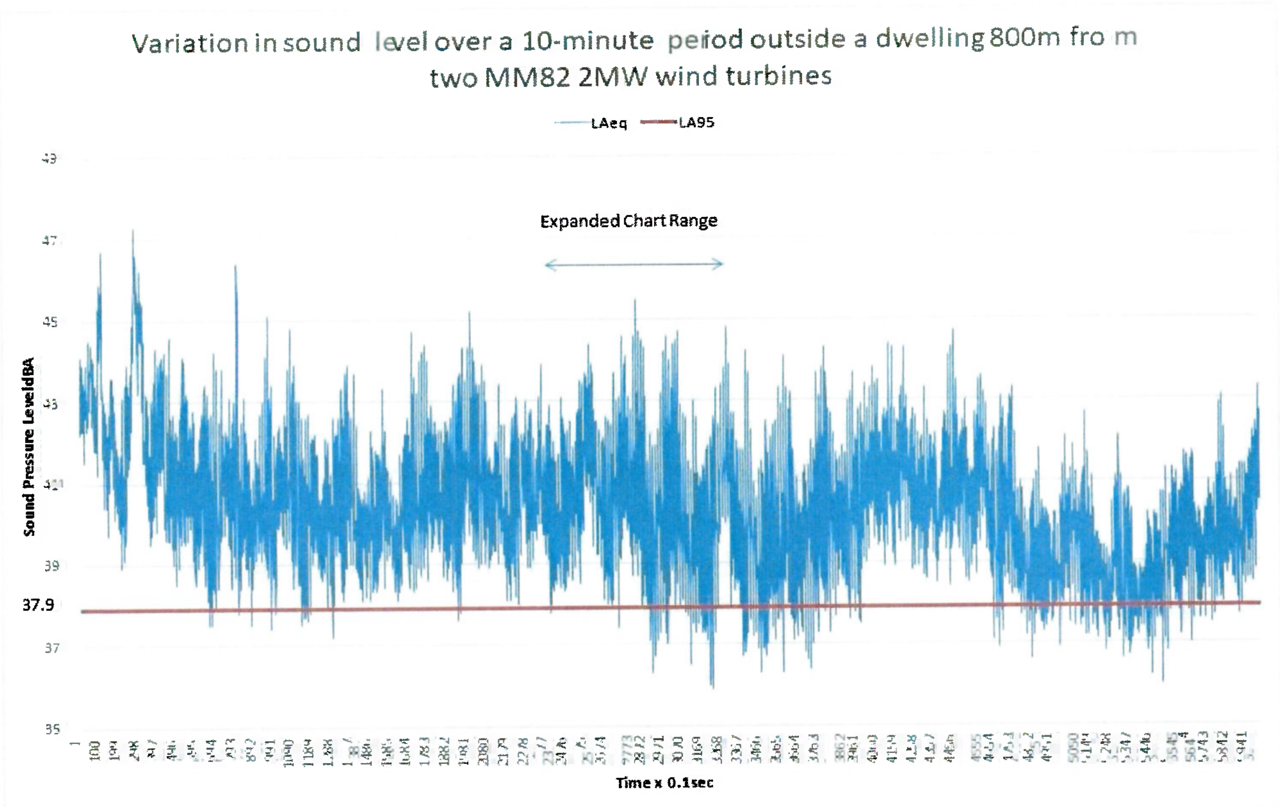


Figure 1

An expanded range from Figure 1 is shown in Figure 2 to provide more detail.

The repetitive variation in sound level is caused by sound from the two wind turbines as the blades rotate.

Sound caused by wind in trees and foliage is random, not repetitive as shown in these two charts.

Each peak and trough repetition can be linked to each time a blade passes through a part of the swept area.

As each wind turbine operates independently of others the small difference in rotation speed between these two wind turbines is causing the peak and trough repetitions to combine yielding a trace that can appear to synchronise at blade passing repetition to the time when the blades are out of synchronisation yielding an apparent doubling of the blade passing repetition.

For a wind farm containing many wind turbines the peak and trough level and repetitions vary randomly.

However, when synchronised the sound levels add together to produce an overall higher sound level compared to when the individual turbine blades lose synchronisation.

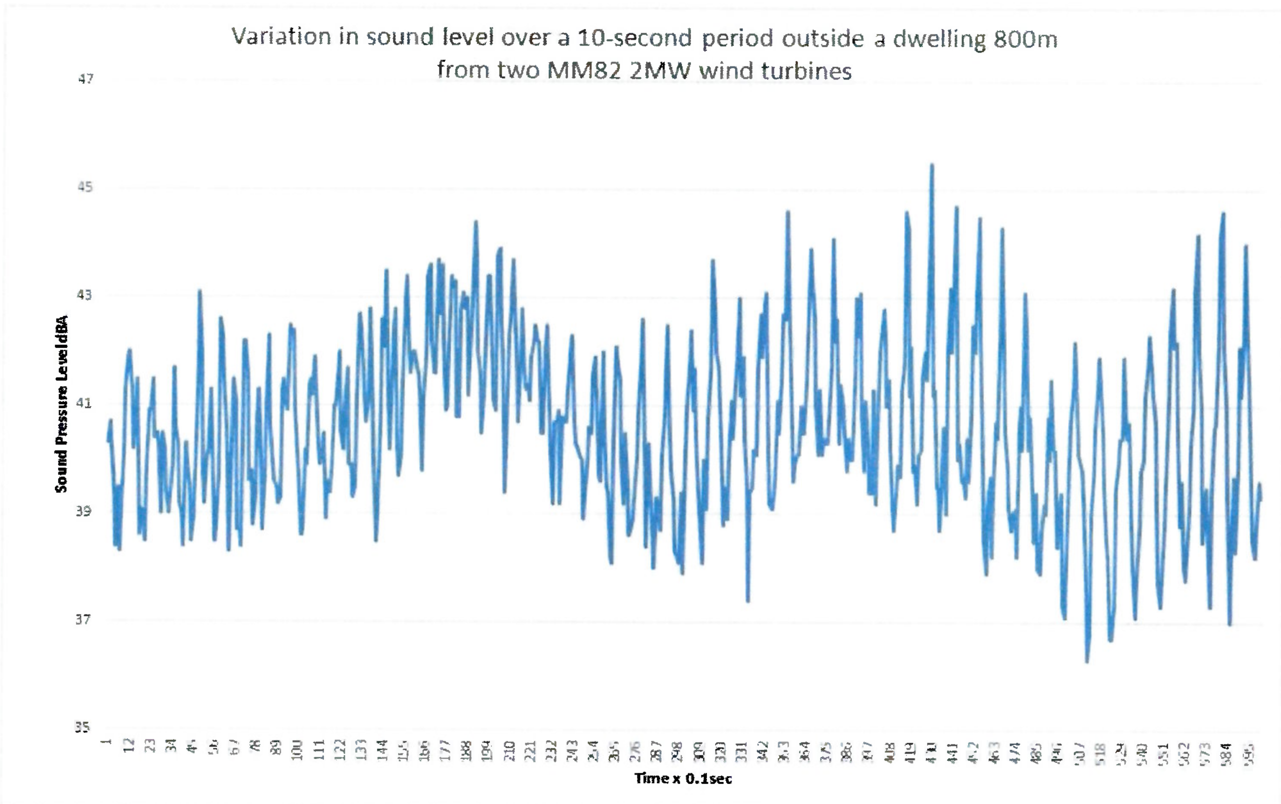


Figure 2

Figure 2 clearly shows this effect for two wind turbines where the first part of the 10-second chart shows the turbines to be out of synchronisation with a generally lower sound level variation peak to trough compared to later in the chart where the turbine blade rotations synchronise causing higher overall peak to trough sound level changes.

An unfortunate disadvantage in using the L90 statistic is that the character of sound level changes during any 10-minute measurement are lost and sound level variations are greatly underestimated.

A common observation of unusual sound level change occurs when 'whump' or 'thump' is described by observers.

Whump and thump are thought to originate from the aerodynamic sound of wind turbine blades when they encounter wind turbulence or are incorrectly adjusted for the incoming wind that causes a blade to stall temporarily.

The occasional whump and thump sounds are much louder than normal wind turbine sounds and the fact that they would not occur for more than 9 minutes in any 10-minute recording means that the LA90 centile would not identify such events.

Sound levels vary throughout the measurement period in the 10-minute duration of the chart above (Figure 1) ranging from a maximum level of just over 47 dBA to a minimum level of about 36 dBA. From the 6000 sound level samples the single statistical L90 parameter obtained from this chart is 37.9 dBA, shown as a red line across the chart.

The L90 centile is only sensitive to the lowest 10 % of sound levels within any 10-minute sample. For example, in the chart above there could be sound levels that reached 100 dBA for many minutes that will have no bearing on the calculated L90 value of 37.9 dBA.

The IoA AM Preferred Method fails to correctly evaluate AM from just two wind turbines and fares even worse when more than two wind turbines combine to produce AM.

A report[104] was prepared for DEFRA that outlines a wind farm noise statutory nuisance complaint methodology. Section 5.4.5 of this report (NAN-R-277) explains the difference between a centile statistical noise metric such as an L90 and the energy averaging Leq as follows:

> "5.4.5 Noise Indices
>
> By convention wind farm noise in the UK is measured using the LA90,10 minute noise index, as it is argued that this index minimises the influence of extraneous noise. However, excepting ETSU –R-97, there are few if any standards that set noise limits using this index. Additionally, it is argued that because the LA90,10min index focuses on the quietest periods in the measurement period it is relatively insensitive to rapid fluctuations in noise level where the noise varies rapidly over a short period e.g. as with aerodynamic/amplitude modulation, and the impact of such characteristics can be underestimated using the LA90,t noise index.
>
> However, elsewhere in the world the LAeq,t index is preferred for wind turbine noise. Use of the LAeq,t or derivatives for environmental noise measurement is recommended by international standards and bodies e.g. ISO 1996 and the WHO, and British Standards such as

[104] NANR277 "Wind farm noise statutory nuisance complaint methodology DEFRA (2011)

BS 4142, BS 7445 and BS 8223. Additionally, there are a range of standards and guidance that offer guideline and recommended values of LAeq.T noise levels against which to weigh any measurement. The energy averaging nature of this index means it tends to be biased towards the highest noise levels that occur during a measurement. The figure below shows an indicative sound pressure level trace of a time varying noise signal (SPL) and the approximate LAeq,t and LA90,t values.

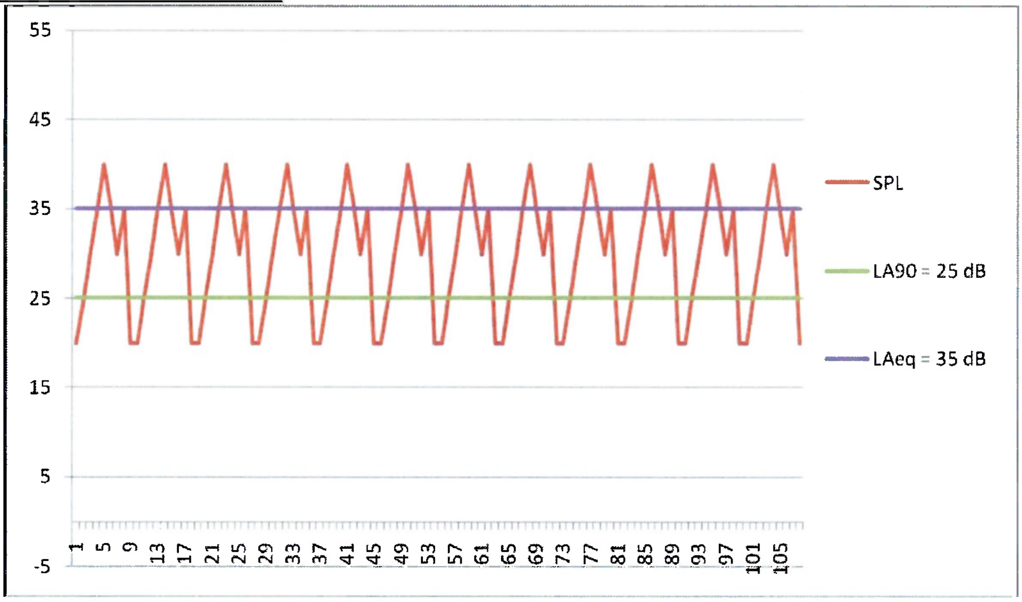


Figure 13 $L_{Aeq,t}$ and $L_{A90,t}$ values of an indicative time varying noise signal"

The GPG also explains in section 7.1 that the guide cannot provide a definitive set of conditions for a wind farm, despite suggesting some options.

There is a current noise condition in force for the Denbrook wind farm that addresses AM limits, which has been accepted by the High Court in the UK, as follows:

"Condition 20

At the request of the local planning authority following receipt of a complaint the wind farm operator shall, at its expense, employ a consultant approved by the local planning authority, to assess whether noise immissions at the complainant's dwelling are characterised by greater than expected amplitude modulation. Amplitude modulation is the modulation of the level of broadband noise emitted by a turbine at blade passing frequency. These will be deemed greater than expected if the following characteristics apply:

(a) A change in the measured $L_{Aeq,\ 125\ milliseconds}$ turbine noise level of more than 3 dB (represented as a rise and fall in sound energy levels each of more than 3 dB) occurring within a 2 second period.

(b) The change identified in (a) above shall not occur less than 5 times in any one minute period providing the $L_{Aeq,\ 1\ minute}$ turbine sound energy level for that minute is not below 28 dB.

(c) The changes identified in (a) and (b) above shall not occur for fewer than 6 minutes in any hour.

Noise immissions at the complainant's dwelling shall be measured not further than 35 m from the relevant building, and not closer than within 3.5 m of any reflecting building or surface, or within 1.2 m of the ground."

Carlow County Council may want to consider Condition 20 of the Denbrook Wind Farm as a condition for any future wind farm that may be approved.

Conditions referencing the IoA AM Preferred Method should be avoided for wind farms.

INFRASOUND AND LOW FREQUENCY NOISE (ILFN)

It is recognised that infrasound and low frequency sound is emitted from wind turbines

The references in the Report to opinions on ILFN do not hold weight. The WSP report did no research and simply repeated other selective references. The Report references the WSP report as the 'WSP BEIS' report. However, the WSP report was only commissioned by the BEIS and is not representative of or approved by the BEIS. The WSP report suggests that A-weighted sound levels are adequate to control low frequency noise which contrasts with the observation by the WHO that dBA *will not* adequately assess low frequency noise.

"The Health Effects of 72 Hours of Simulated Wind Turbine Infrasound: A Double-Blind Randomized Crossover Study in Noise-Sensitive, Healthy Adults" (https://doi.org/10.1289/EHP10757) is referenced in the Report but this study used constant amplitude *synthesised* wind farm infrasound and could not reproduce the fundamental blade pass frequency component in the laboratory. The conclusion further notes that "This study suggests that the infrasound component of WTN is unlikely to be a cause of ill-health or sleep disruption, although this observation should be independently replicated." There is a marked lack of confidence in this study.

The Australian NHMRC study was awarded to two universities and the reference given in the Report of the 72 hour survey (https://doi.org/10.1289/EHP10757) does not hold up to the standards of the WHO which observes that there remains a paucity of quality research into the effects of infrasound from wind turbines. The 72-hour study was statistically analysed in a recognised and acceptable way but the experimental exposure data used for input to that analysis was flawed. For example, the test room could not synthesise the fundamental blade pass frequency and the synthesised test signal was of constant amplitude based upon the reconstruction into a WAV file from a sample frequency spectrum obtained near a wind farm. This type of reconstruction cannot accurately represent the temporal nature of sound from a wind farm containing many wind turbines that interact between each other having different rotational phases.

A paper by Bell (2014)[105] explains these effects and casts doubt on some of the research completed in this area of work

This research is ongoing and one of the published papers in 2019 by researchers at Flinders University (Nguyen, D. P., Hansen, K. et al. Wind farm infrasound detectability and its effects on the perception of wind farm noise amplitude modulation, Acoustics 2019) stated in its conclusions that: "Overall these preliminary results suggest that WF noise complaints could potentially be governed to some degree by the presence of infrasound" and that " We found that self-reported noise sensitive individuals can detect the presence of low-level infrasound (48 ± 2 dB(G)) above chance."

The finding that infrasound at levels of 48 +/- 2 dB(G) can be observed by individuals is in stark contrast to the generally used limit of perception, which suggest that a conservative human perception threshold of 85 dB(G) might be appropriate to account for variations in sensitivity of human hearing.

A paper by Cooper, S. ("The use of synthesised or actual wind turbine noise for subjective evaluation purposes" PROCEEDINGS of the 23rd International Congress on Acoustics 2019) is critical of the use of synthesised wind farm infrasound signals and has noted that it was the change in amplitude of the infrasound signal that was observed to be a significant factor in subject disquiet.

Unfortunately, the issue of adverse health effects from wind farm generated infrasound remains contentious and authorities may wish to consider an appropriate condition when approving future wind farm developments if ongoing Australian, or other relevant international research, finds adverse health effects from infrasound.

The Report has dismissed ILFN completely. At the very least there should have been some baseline measurements covering ILFN at the NSRs.

My own measurements at the Cape Bridgewater Wind Farm, also confirmed by S Cooper in his 2014 study[106], showed that low frequency sound from the output shaft of the gearboxes to the generators exceeded DEFRA-NAN-R45 indoor recommended guideline values at 32 Hz. Furthermore, the 32 Hz tones were modulated in frequency and random in level.

The Report is deficient in its assessment of ILFN.

---

[105] Bell, A. "Constructive interference of tonal infrasound from synchronised wind farm turbines: evidence and implications" Acoustics Australia Vol. 42 No. 3 December 2014

[106] Cooper, S. "The results of an acoustic testing program - Cape Bridgewater Wind Farm" The Acoustic Group Report 44.5100.R7MSC, Nov 2014

CONCLUSION

The Carlow County Council were correct in refusing the Seskin Wind Farm application.

The Appeal document has not addressed the deficiencies of the noise Report (Appendix 12.2 of the EIAR.

Appendix A

CV of William Leslie Huson

QUALIFICATIONS

BSc (Hons) Applied Physics, UK 1975

MSc Sound and Vibration Studies, Institute of Sound and Vibration Research, Southampton, UK 1977

PROFESSIONAL AFFILIATIONS

Chartered Physicist, UK

Member of the Institute of Physics, UK

Member of the Institute of Acoustics, UK

Member of the Australian Acoustical Society

Member of the AV0001acoustics working group for Standards Australia

Australian representative for the International Institute of Noise Control Engineers (I-INCE) Technical Study Group 5 *A GLOBALAPPROACH TO NOISE CONTROL POLICY* (Now disbanded after completion of the scope of work defining this group – see http://www.iince.org/data/iince061.pdf)

EXPERIENCE

Since graduating I have been involved in several scientific areas of research and development. My early experience was in constructing a microwave device to measure the temperature of plasma inside a nuclear fusion experimentation device at the UKAEA, Culham Laboratory in the UK. I then worked in research and development of thermal imaging devices prior to completing my Masters in Sound and Vibration Studies. My work since then (1977) has been primarily associated with acoustics and vibration both terrestrial and underwater. Prior to 1991 I worked as a Sound and Vibration consultant in the UK for 12 years with involvement in a wide range of industries.

For the past 34 years I have worked in Australia as a noise and vibration consultant and have operated through my own consultancy firm for the past 28 years. I am experienced in modelling acoustic propagation from a variety of sources such as railways, roads, aircraft, underwater ordnance, wind farms, pile driving, blasting and numerous types of industry. Of relevance to the evidence provided here is the work I completed for the Toora Wind Farm in 2002 which involved detailed analysis of pre and post construction noise data using NZS6808 1998 to check compliance with license conditions. NZS6808 is based upon ETSU-R-97. My experiences in the analysis of wind farm noise data led to a paper that was presented at the joint Australia and New Zealand Acoustics conference in 2006 titled "Review of the Application of NZS6808 to wind farms in Australia." This paper highlighted the sources of error that were implicit and allowed in the NZS6808, 1998 standard and ETSU-R-97. The latest version of the NZS6808 standard (2010) addresses a number, but not all, of the data analysis error concerns described in my paper. ETSU-R-97 and the Institute of Acoustics Good Practice Guide to the Assessment and Rating of Wind Turbine Noise is regularly referenced when interpreting parts of NZS6808 in Australia and I am familiar with this document and the supporting Supplementary Guidance Notes (GPG).

Over the past ten years I have been independently gathering sound data in the audible and infrasound parts of the acoustic spectrum at numerous wind farms in Australia, the UK and Ireland. A summary of some of this research work on infrasound was presented in a peer reviewed paper: Huson, W. Les. "Stationary wind turbine infrasound emissions and propagation loss measurements." 6th International Conference on Wind Turbine Noise, Glasgow 20-23 April 2015.

I have investigated the Preferred IoA Method for the assessment of amplitude modulation (AM) in detail and applied it to several wind farm measurements taken outside dwellings near to numerous wind farms in Australia. The findings of this work are the realisation that the Preferred IoA Method is only suitable for assessing a single wind turbine, that the resulting AM values greatly underestimate short term peak to trough amplitude modulation levels observed and that the Method is wholly unsuitable to assess AM (peak to trough amplitude modulation) from multiple wind turbines.

Detailed analysis of AM from wind farms has revealed that many AM events also exhibit impulsiveness when evaluated according to BS 4142:2014+A1:2019.

Appendix B

Presentation by E Sloth

Problems related to the use of the existing noise measurement standards when predicting noise from wind turbines and wind farms.

Erik Sloth Vestas

Niels Christian Møller Nielsen VESTAS
Ejler Kristensen BONUS Energy
Bo Søndergaard DELTA

Overview

- Noise Measurements (IEC 61400-11:2002)

  - Short description of the measurement method
  - Use of measurement results, including influence on inaccuracy.

- Noise prediction
  - Terrain and meteorology influence on the actual emitted sound
  - Methods used in noise calculations

- Noise assessment
  - Descriptors
  - Noise limits
  - Further investigations needed

Noise Measurements (IEC 61400-11:2002)

We correct for:

Air pressure
Air temperature

Standard terrain
roughness z = 0.05 m

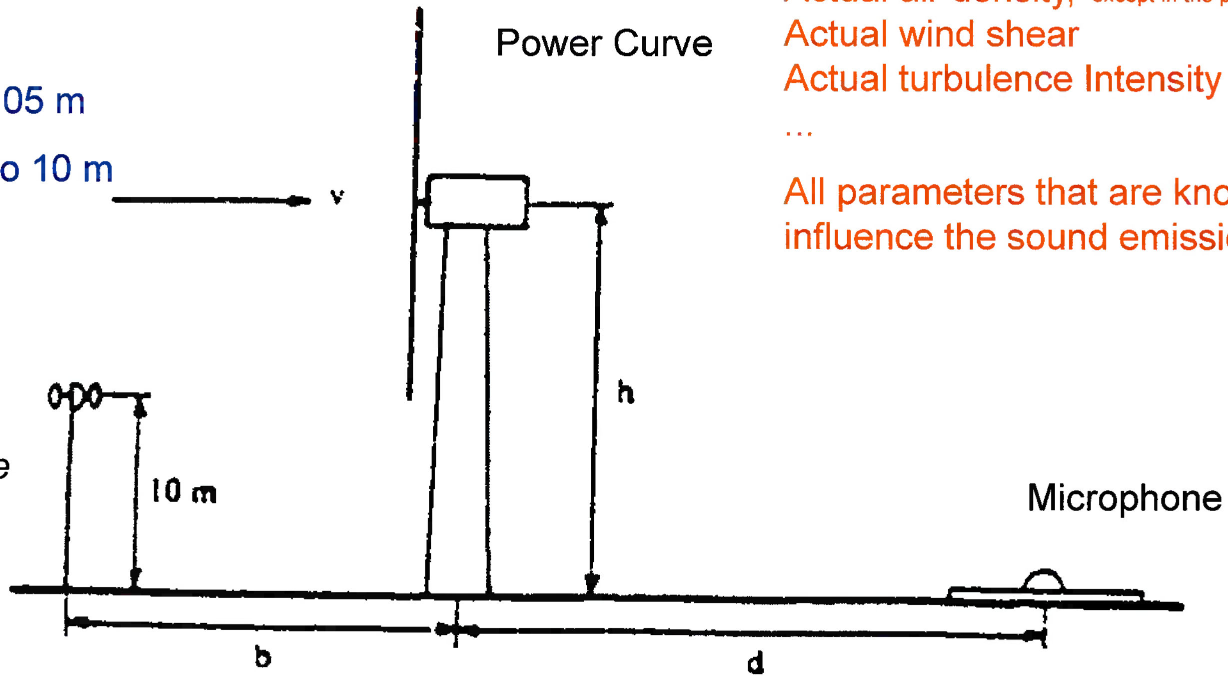
All recalculated to 10 m

We do not correct for

Actual inflow angels
Actual air density, except in the power curve
Actual wind shear
Actual turbulence Intensity
...

All parameters that are known to influence the sound emission

Anemometer
For background noise



wind speed

only

Noise Measurement

- The results are standardized noise levels, which are fairly comparable from measurement to measurement on a given turbine type.
- The wind turbine is used as a wind speed meter through a power curve measured on an ideal site (IEC 61400-12) OBS impossible if actual terrain does not fulfill conditions
- Other parameters influence the noise level: relative humidity, turbulence, inflow angle, wind shear, turbine pitching are not accounted for.

- The result is a fairly good tool for verification of warranties, but not a good tool for predicting noise at imission points where people actually can get annoyed.

- The Sound Power Level related to the produced power or at least the sound power level as a function of hub height wind speed could be a more basic relationship

Typical problems in using the measurement results

- Where do we see the major deviations from standardized conditions during actual use of measurement results

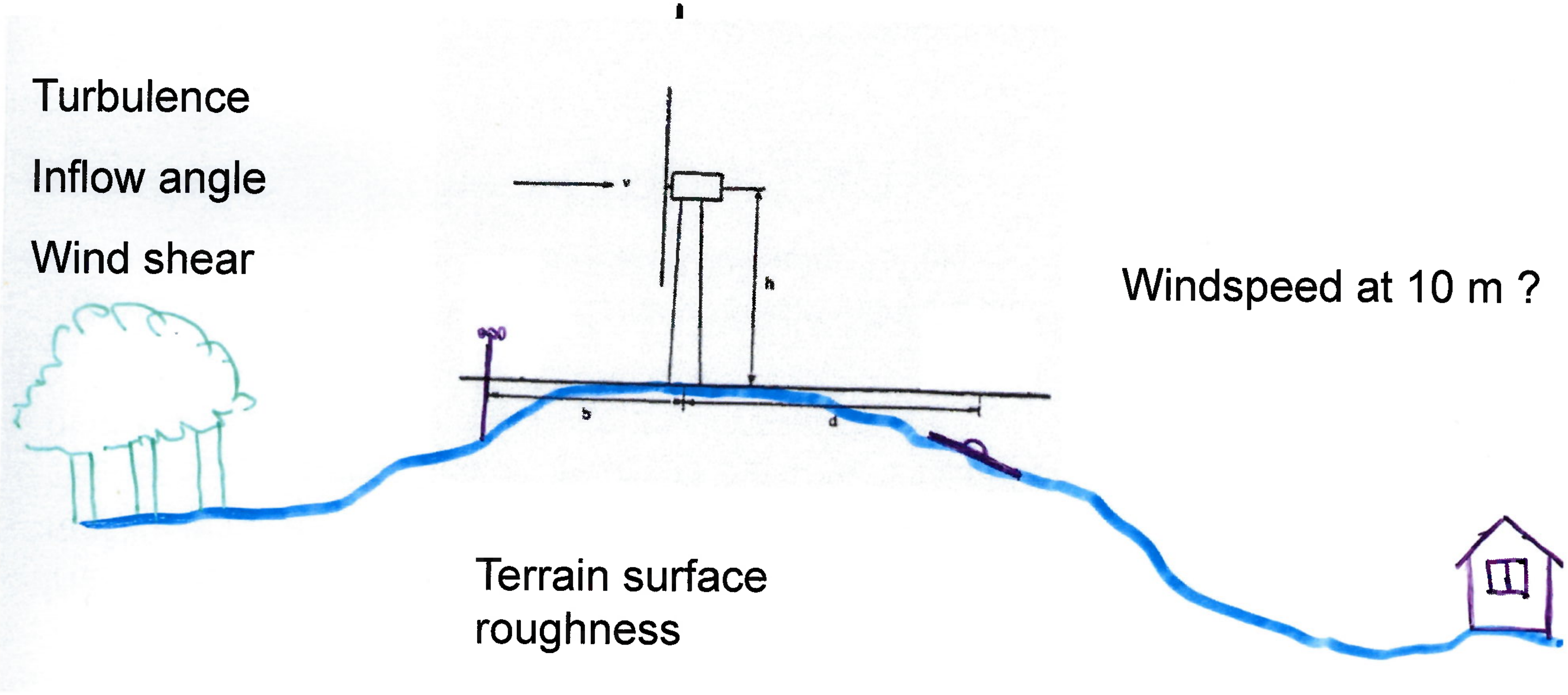
- The wind turbines are almost always raised at sites where roughness differ from the standardized completely flat measurement site.

- Further we see different air density
- different wind shear
- different turbulence in inflow air
- different inflow angles

- Finally we often see other hub heights than used during documentation

Use of measurement results

For noise control measurements



For noise level calculations

Conclusion on measurement results

- The differences in site conditions creates differences in emitted sound power level.
- The differences could be both increased and decreased emitted sound power levels in real life applications
- The differences will transfer directly to the imitted sound power levels, and may thereby create increased annoyances in real life

- Therefore – site specific sound power levels should be used unless a good safety margin is present using standardized emission levels.

Uncertainty

- According to IEC 61400-11:2002 the standard deviation of a measurement results is app. 0.9 – 1.5 for an ideal site

- If the measurements are made at a site with considerable turbulence intensity or wind shear the standard deviation can be app. 2.0 dB
- The result is that when used for calculating the noise from a wind farm at an imission point, some WTG will be higher than the expected level and some will be lower.
- To correct for this, the measured inaccuracy <u>cannot</u> be placed upon the total calculated level, but must be included in the calculations.
- The result is that the higher the number of WTG's in the project is, the smaller the resulting inaccuracy.
- If the results are used for calculating the noise from a wind farm the standard deviation should be calculated as the weighted standard deviation

$$\square_{res}\ \square\square_{method}\ \square\square_{source}\ \square\square_{method}\ \square\ \square\sqrt{(\square_i \square 10^{L_i/10})^2}$$

$$\square 10_{10}$$

Solution to the outlined problems

- Accept that different sound power levels should be used in predictions and warranties.

- Avoid using sound power levels that include inaccuracy in predictions unless there is a good safety margin.

- The inaccuracy should be included in the calculation – the higher the number of WTG's the less the probability that all are in the high end of the uncertainty interval

- Use sound power levels that at least are corrected for: hub height, wind shear, air density, turbulence, inflow angle

- Be careful to make sure that the background noise measurements and wind conditions at the turbine positions uses the same reference position.

Noise level calculation models

- There are lots of different noise level calculation models:
  - ISO 9613-2 which is the model that we see the most
  - VDI 2714 – Concawe
  - BS 5228
  - General Prediction Method (Danish)
  - Danish EPA Guidelines
  - Netherlands Guidelines 1999 – Swedish method (land/sea) – .....

- Most of the methods are developed for noise from Industry, wind speeds below 5 m/s and standard meteorological conditions and must be suspected to give poor results at larger distances.
- ISO 9613-2 is known sometimes to overestimate the terrain effects if soft ground is used
- Manufacturers, developers, consultants and authorities have an interest in a noise level calculation model developed specifically for wind turbine noise

Noise calculation models

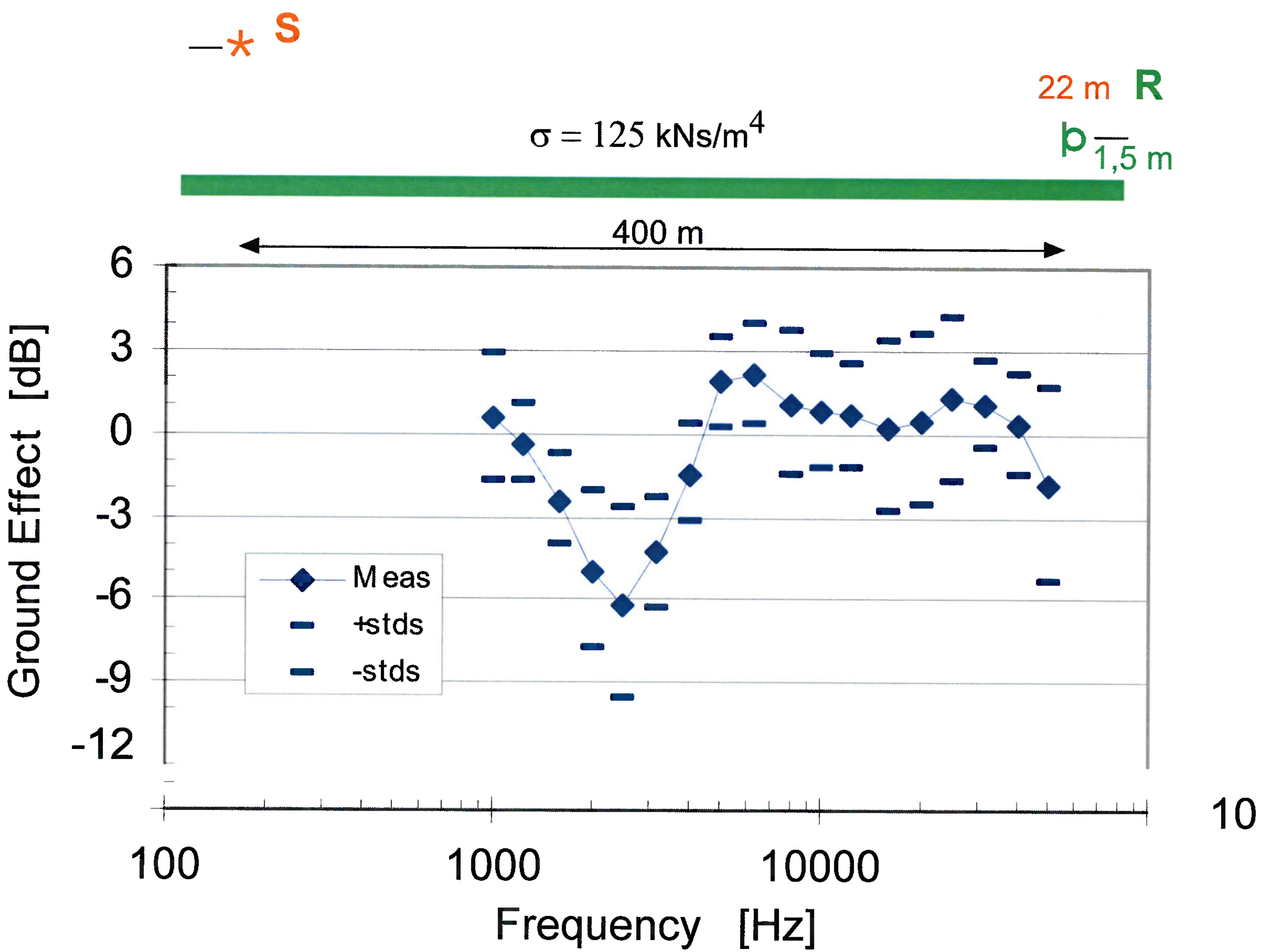
- In an EU project JOR3-CT95-0065 a model for wind turbine noise propagation (WiTuProp) was developed giving good results

- The WiTuProp model takes into account – meteorological conditions:
- Wind speed / terrrain surface roughness and direction
- Air temperature and air temperature gradient
- Relative air humidity

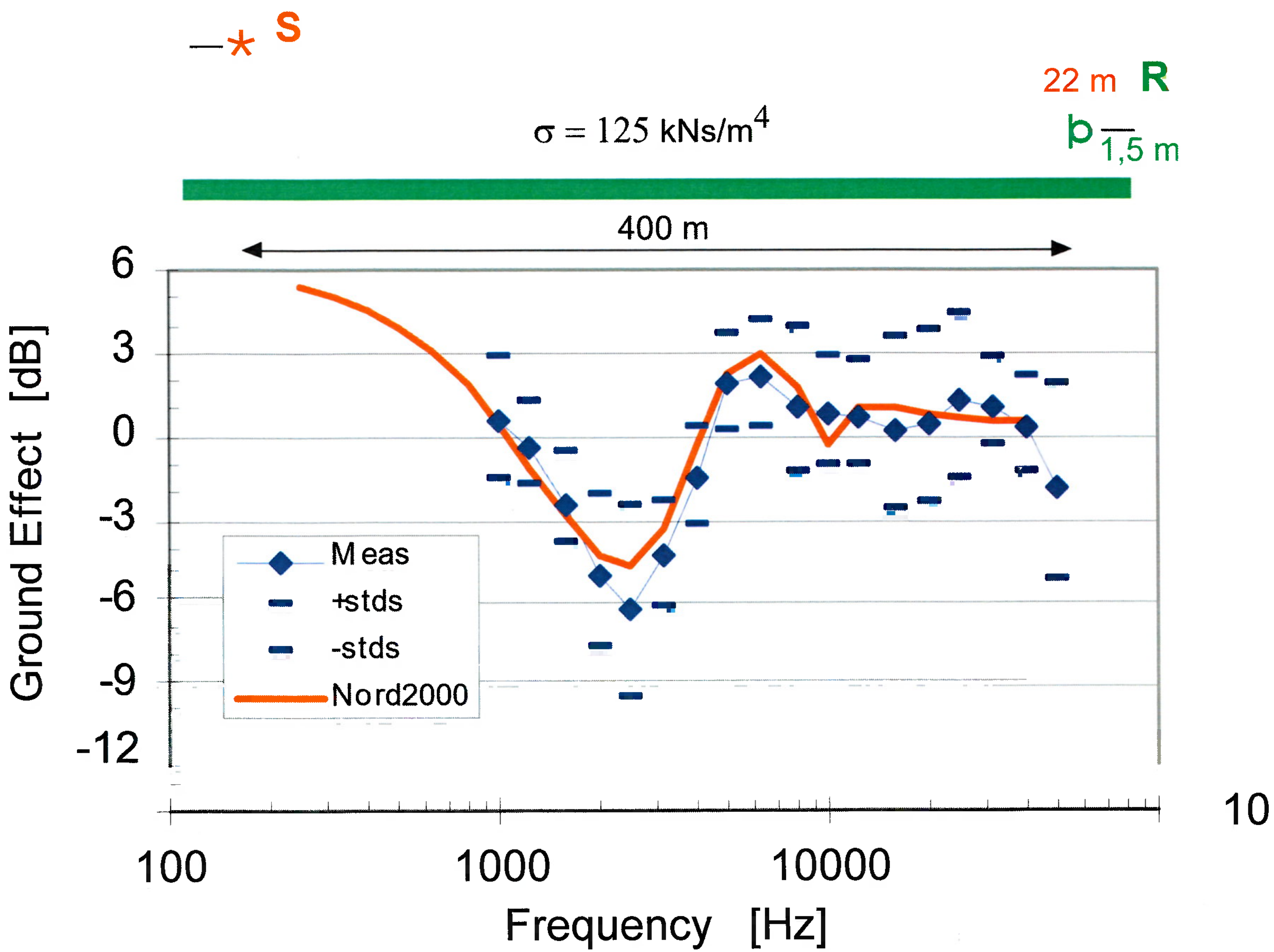
  - The ground type
- Flow resistivity for grassland and harder surfaces
  - Screening (by terain or screens / barriers)

- WiTuProp is a special case of a more comprehensive model developed later: *NORD2000*

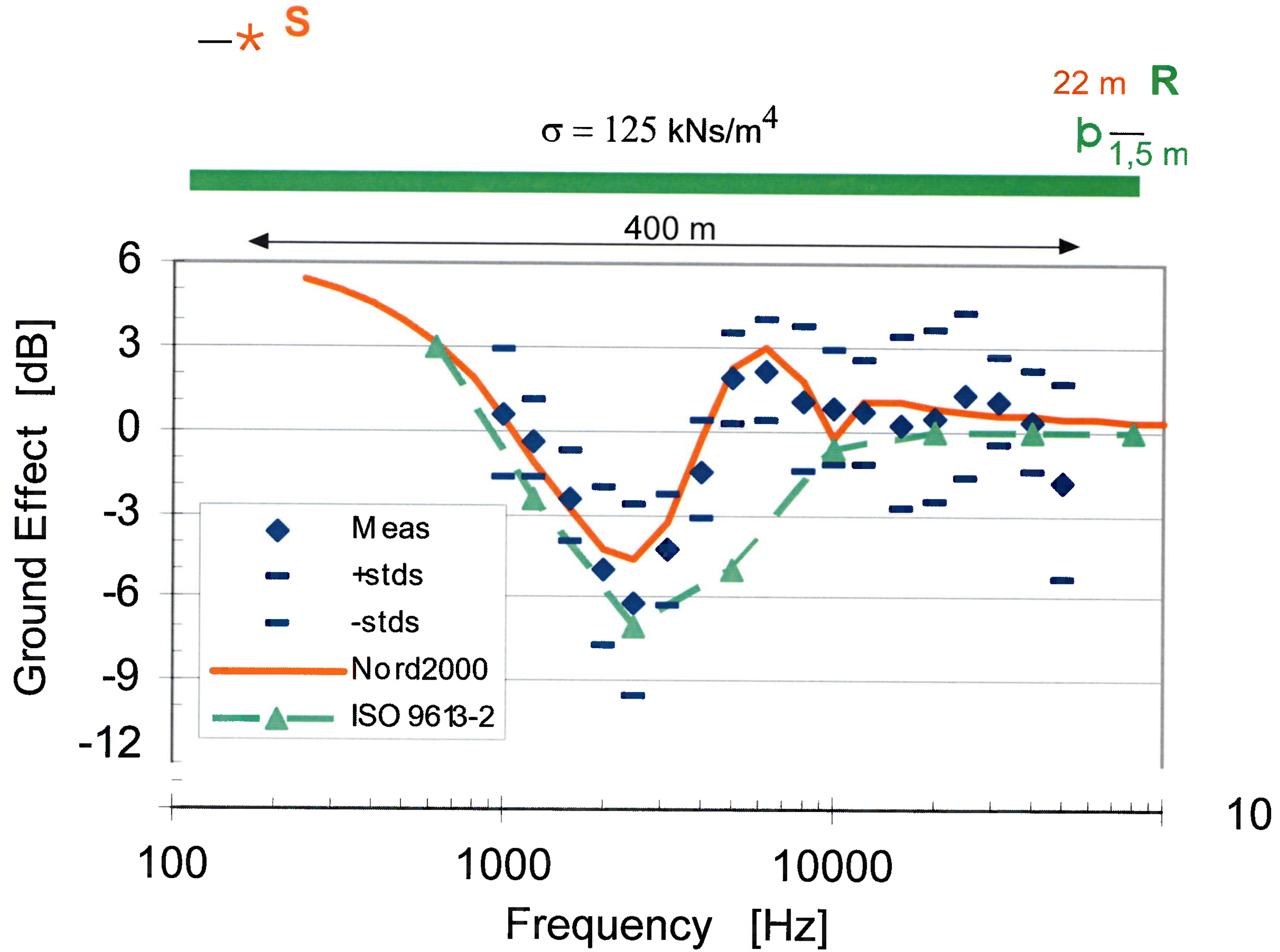
Nord2000 / WiTuProp vs. ISO 9613-2



Nord2000 / WiTuProp vs. ISO 9613-2



Nord2000 / WiTuProp vs. ISO 9613-2



Nord2000 model

- Meteorological conditions are better covered
- Complex terrain profiles (hill/valley)
- Mixed ground
- Terrain roughness
- Improved screen modelling
- 1/3 octave-band results
- Physical model – NOT empirical

Recommendation if the advanced model is not used:

- Use ISO 9613-2
- Make sure that hard terrain is used
- Be careful when defining screening effects from terrain - specially edge effects can be difficult to model

Noise Assessment

- The noise level at the imission points are normally given as an A-weighted noise level at different wind speeds.
- A tonality evaluation is normally included for the receiving points.

What do we know of the annoyance of the noise:

- We know that noise from wind turbines sometimes annoys people even if the noise is below the noise limits.
- Often people complaints on low frequency noise which many investigations often show in not present
- The noise limits are usually adapted from industrial noise limits and are based upon the principle that a given percentage of the population will feel annoyed when the limit is exactly fulfilled.

- Evaluation of tonality in the turbine noise is more based on the reproducibility of the results than on pure knowledge on what is actually annoying

Noise assessment

- Other descriptors need to be investigated to understand the annoyance caused by wind turbines

  - Low frequency noise and Infrasound – we cannot see it in our measurements
  - Modulation – may be the parameter that is heard as low frequency noise
  - Masking – which noise can mask noise from wind turbines
  - Other characteristics
  - ..

- This mean that tape recordings should me made on all sites in order to enable later analysis of up till now unrecognized parameters.
- In order to enable listener tests, artificial head investigations should be made

- We as a producer cannot cover this alone, since the local rules always need to be followed

Our recommended research program

- Artificial head measurements on real turbines of different sizes
- Background noise measurements on real sites
- Listener tests on obtained results
- These measurements are being made on a test basis during our Danish measurements

- General Research that is needed in this area includes
  - Psychoacoustic experiments
  - Listener test
  - Measurements at low frequencies
  - Analysis for other characteristics
  - ..

Vestas

BONUS Energy A/S

Questions ?

DELTA

Appendix C

JOULE summary report

DEVELOPMENT OF A WIND FARM NOISE PROPAGATION PREDICTION MODEL

J H Bass [1] A J Bullmore [2] E Sloth [3]

RENEWABLE ENERGY SYSTEMS LIMITED [1]
HOARE LEA & PARTNERS ACOUSTICS [2] ACOUSTICA A/S [3]

Contract JOR3-CT95-0051

FINAL REPORT

January 1996 to May 1998

Research funded in part by
THE EUROPEAN COMMISION in the
framework of the
Non-Nuclear Energy Programme
JOULE

15. CONCLUSIONS

The two dominant factors controlling the far field sound pressure levels due to the opration of wind turbines are the sound power output characteristics of the turbines and propagation effects. The aim of the present study is to identify and quantify the dominant factors controlling the attenuation of sound as it propagates over large distances from wind turbines.

When undertaking a programme of work designed to identify the influence of specific parameters on noise propagation it is important to isolate as fully as possible the effects of the various controlling parameters. The use of operational wind farms as the test noise source would not enable the effects of specific parameters to be investigated in isolation. This is primarily because the sound power output of a wind turbine is by no means constant, and is indeed a function of wind speed which is believed also to be one of the factors controlling noise propagation.

The major part of the project therefore involved the use of a high powered, omnidirectional loudspeaker noise source. This loudspeaker was mounted at heights of between 15m and 30m above ground level to replicate the elevated nature of the sources of noise on wind turbines. Noise levels then synchronously monitored at up to 15 receiver locations around the loudspeaker using source to receiver separation distances of between 30m and 900m. the measurements were repeated at three different green field sites with topographies on the sites being classified as flat , rolling and complex . Measurements of important meteorological parameters were also undertaken simultaneous with the noise measurements at all the sites. Measurements lasted for continuous periods of approximately four weeks on each site.

The results of the measurement campaign are believed to be unique in that very extensive and successful steps were taken to filter out all potentially corrupt data from the results. As a consequence a large database of high quality noise and meteorological measurements was available which allowed the major parameters controlling long distance noise propagation to be quantified.

The conclusions that now follow have been validated for the case of broad band noise radiation from an elevated source over arable or pasture land of all topographical complexities, from flat to complex. The results have further been validated at distances up to 900m from the source.

As a result of the measurements just described it has been concluded that:

Noise levels at all distances from the source do vary, even if the source of sound has a constant power level.

The measured variation in noise levels increases with increasing distance from the source.

Based on typical wind speed ranges of between 0ms^{-1} and 10ms^{-1} encountered during the experimental measurements, the one standard deviation spread of noise levels either side the mean level was found to increase at a rate of approximately 0.004dB(A) per meter increase in the source to receiver separation distance.

The variations in noise levels about the mean just described were found to be strongly correlated with vector wind speed, but not with the other meteorological parameters.

A positive component of vector wind speed from the source to the receiver tends to increase the received sound pressure level, whilst a negative component of vector wind speed tends to reduce the sound pressure level. The further the source to receiver separation distance, the greater the effect.

At distances of 700m to 900m from the source, positive components of vector wind speed were found to increase the received noise level by up to 5dB(A) compared with the level measured under neutral propagation conditions.

In situations where the receiver location is acoustically screened from the source, an excess attenuation of 10dB(A) or more can result under neutral or negative vector wind speed conditions. However, the effect of a positive vector wind speed is always to substantially reduce the excess attenuation.

Once the systematic effect of vector wind conditions have been isolated, the residual scatter in measured noise levels is greatly reduced especially under conditions of strong downwind propagation.

The ground between the source an receiver, and particularly closae to the receiver, has a significant effect on received noise levels. Where the ground falls away between the source and receiver, noise levels 3dB(A) higher than would otherwise be expected can result.

The results of the noise measurement exercise enabled the effects listed above to be quantified. They also allowed an accurate comparison to be made between the output of existing noise propagation prediction models and the measured levels. This comparison resulted in the following conclusions:

Models that rely on analytical descriptions of sound propagation through the atmosphere are overly sensitive to changes in meteorological parameters. Variations in noise levels of up to 30dB(A) were predicted by these models, whereas measured variations under the same range of meteorological conditions were limited to less than 10dB(A).

The more advanced empirical model tested was that set out in ISO 9613-2. This method generally provide high levels of accuracy to within 2dB(A) in predicting received noise levels under conditions favourable to noise propagation , or downwind propagation.

There are, however, two observed situations in which the ISO 9613-2 model fails to model the effects of the interaction of the ground effect and meteorological factors correctly.

The first situation occurs for acoustically screened locations under downwind propagation conditions. In these cases the excess attenuation provided by the screening can be reduced to just 2dB(A). This reduction in effectiveness is not always modelled correctly by the ISO method.

The second situation occurs where the ground falls away significantly between the source and receiver, and particularly in the immediate vicinity of the receiver. In these cases the measured noise levels are approximately 3dB(A) higher than those predicted by the ISO method.

The simplest calculation procedure tested was the IEA method. This model accounts for losses due to geometric spreading plus a single excess attenuation factor due to atmospheric absorption. This it models as linear octave band attenuation factors which are determined from published tables and are dependant on temperature and relative humidity.

For unscreened locations the IEA method generally provides levels of accuracy to within 2dB(A) in predicting received noise levels under
conditions favourable to noise propagation, or downwind propagation. This accuracy is as good as that of the ISO method, despite the greatly increased simplicity of the IEA procedure.

Because the IEA procedure does not include any facility for modelling ground profiles, it fails to predict the effects of screening or of situations where the ground falls away significantly between the source and receiver. However, these situations are in any case incorrectly modelled by the ISO method.

On the basis of the above findings it is concluded that the adoption of the IEA model as the basis for a simple noise propagation prediction method is the preferred choice. However, in order to account for the specific cases where the model has been shown to be deficient, an additional excess attenuation factor must be included.

The proposed model uses as its starting point the A-weighted sound power level, L_w, of the noise source under consideration. This sound power level is then modified by three attenuation factors to arrive at the received sound
pressure level, L_p, at a given line of sight distance d meters from the source due to the operation of that source in isolation:

$$= \cdot + \quad \cdot -_{,,}\left(\frac{Q}{4\cdot\ \pi\cdot\ d^{2}}\right) - A_{atm}\left(- \quad \right)_{\langle\rangle fi}\Big) \qquad (12.1)$$

The total received sound pressure level at any given location is then calculated by energetically summing the calculated sound pressure levels at that location due to all the individual noise sources.

The first attenuation factor in equation (12.1) accounts for the directivity, Q, of the source in its installed location and the effect of geometrical spreading over the propagation distance, d.

The second attenuation term, A_{atm}, accounts for excess attenuation due to atmospheric absorption. Values for A_{atm} can be found in ISO 9613-1.

The first two attenuation terms of equation (12.1) should be applied separately for each octave frequency band from 63Hz to 4000Hz inclusive, and the octave band results then summed to arrive at the overall A-weighted sound pressure level at the receiver.

The third attenuating term, A_{ter}, is applied to the resulting overall A-weighted level. It accounts for additional effects arising from the presence of certain ground effects between the source and the receiver. This term is zero except for the following two special cases.

Case 1:

‹»fi =_ ... ł if ,‡ $\geq 1.5 \cdot \left[\frac{abs(h_s - h_m)}{2}\right]$ (12.2)

where h_m is the mean height above the ground of the direct line of sight from the receiver to the source, and h_s and h_m are the heights above local ground level of the source and receiver respectively. Note that where this condition exists it serves to <u>increase</u> the received sound pressure level, hence A_{ter} in this instance is negative.

Case 2:

‹»fi =+ ... ł (12.3)

where the direct line of sight between the receiver and the source is just interrupted, or the interruption occurs due to a natural terrain feature that does not provide a distinct and pronounced interuption to the direct path and does not lie within 5m of the receiver.

Case 3:

‹»fi =+ ... ł (12.4)

where the direct line of sight between the receiver and the source is interrupted by a barrier that lies within around 5m of the receiver and provides a significant interuption to the direct line of sight path (a minimum interruption of 0.5m is suggested). Where any doubt exists it is suggested that the excess attenuation due to barrier effects should be limited to the 2dB(A) given in equation (12.3).

Based on the results of extensive measurements, the use of equations (12.1) to (14.4) have been shown to result in calculated sound pressure levels that lie within 2dB(A) of the level not expected to be exceeded for at least 85% of the time. The calculated levels correspond to conditions favourable to noise propagation over flat, rolling or complex terrain comprising typical arable or pasture land. Conditions �favourable to noise propagation� relate to a $6ms^{-1}$ component of wind speed in the direction from the source to the receiver measured at 10m height on the wind farm site. The increase in noise levels for stronger components of positive vector wind speed have been measured to be negligible.

The proposed calculation procedure has also been validated against measurements undertaken at a 42 turbine wind farm, with predicted levels agreeing with measured levels under favourable propagation conditions to within 2dB(A). However, the results of the wind farm measurements have indicated a greater degree of scatter of the results than for the controlled loudspeaker test measurements. This increased scatter arises from variations in the source sound power level as the wind conditions vary. Sound power output levels of turbines within a wind farm are usually calculated assuming a single wind speed applies across the whole site, whereas in practice each turbine sees a different wind speed depending on the sheltering afforded by the other turbines.

It is therefore recommended that when the recommended calculation procedure is used to predict far field noise environmental levels from wind farms, an uncertainty factor should be included for the expected variation of wind speeds seen by the different turbines.