Brian & Jenny McDowell
Fahanlunaghtamore, Miltown Malbay, Co. Clare V95 X3X2

An Coimisiún Pleanála
64 Marlborough Street,
Dublin 1,
D01 V902

June 24th, 2026

RE: Strategic Infrastructure Development (SID) Application

- **ACP Case Reference:** PAX03.324270
- **Development:** Slieveacurry Wind Farm (9 Turbines & Substation Extension)
- **Location:** Glendine North, Knockalassa, Tooreen, Fahanlunaghta More, Co. Clare
- **Observers:** Brian and Jenny McDowell
- **Address:** Fahanlunaghtamore, Miltown Malbay, Co. Clare, V95 X3X2

Dear Inspector(s),

Please accept this formal submission regarding application PAX03.324270. The statutory fee of €50 is enclosed. As adjacent residents whose residential amenity and local environment are directly impacted, we request that the Board refuse planning permission based on the following binding legal, environmental, and cumulative planning grounds.

1. Principle of Res Judicata and Unchanged Planning History

The Board previously refused this exact infrastructure footprint under **ABP-312728-22**.

- **Identical Siting:** The physical constraints of this upland site and its close proximity to local rural dwellings remain completely unchanged.
- **Procedural Avoidance:** Re-introducing this development as a Strategic Infrastructure Development (SID) does not cure its historical flaws. Shifting jurisdiction via the SID framework cannot erase the material planning defects correctly identified by Clare County Council and the Board in the prior refusal.

2. Legal Project Splitting & Interdependence (EIA Directive 2011/92/EU as amended by 2014/52/EU)

This application represents a coordinated, piecemeal industrialisation of the local ridge line, relying on tactical project splitting ("salami-slicing") to mask its true environmental toll, which is in direct conflict with the EIA Directive.

- **The Shared Infrastructure Matrix:** While submitted under different corporate entities, this proposal is physically and functionally interdependent with the adjacent 5-turbine Illaunbaun project **(Ref: 25/60520)** and the 1-turbine Slievenalicka application **(Ref: 25/60578)**. These projects rely on the same access corridors, grid connection strategies, and overlapping environmental baseline data.
- **EIA Compliance:** Under European law, the use of distinct corporate shells or Special Purpose Vehicles (SPVs) does not split an interdependent project. The Board is legally required to assess the absolute cumulative impact of this 15+ turbine cluster, rather than evaluating PAX03.324270 in a vacuum.

3. Direct Conflict with the EU Nature Restoration Law & Unresolved Peat Hydrology Defects

The proposed development directly undermines Ireland's statutory obligations under the EU Nature Restoration Law (Regulation 2024/1991).

- **Supremacy of European Environmental Law:** European environmental regulations place binding, non-derogable obligations on member states. These absolute environmental protections take legal precedence over conflicting domestic planning mechanisms, regional zoning, or national renewable energy targets when critical, protected ecosystems are threatened.
- **The Previous Refusal Core Finding:** In the underlying assessment for ABP-312728-22, the planning framework explicitly identified a catastrophic risk to the blanket bog fabric, citing an *"adverse impact on ground stability or hydrology from management of peat."*
- **Failure to Remedy Localized Flaws and Corporate Track Record:** Excavating thousands of tonnes of ancient peat to construct 9 massive turbine bases, access tracks, and a permanent substation extension will cause irreversible drainage to the active peat layer. The Board must note that the parent developer behind this application, Enerco Energy Limited, has a documented history of catastrophic peat instability failures on identical upland bog terrain—specifically the massive **2020 Meenbog bog slide** in County Donegal caused by its planning subsidiary, Planree Limited. Approving major industrial excavations on an upland site already flagged for severe hydrological fragility under an operator with this specific risk profile directly contradicts the binding mandates of the EU Nature Restoration Law to restore and rewet degraded blanket bogs.

4. Severe Ecological Impacts & Species Mortality (EU Birds & Habitats Directives)

The developer has completely failed to overcome the core ecological refusal reasons of ABP-312728-22, which explicitly highlighted severe threats to protected biodiversity.

- **Annex II Marsh Fritillary:** The construction footprint directly fragments wet heath habitats containing Devil's-bit Scabious, threatening the survival of this globally vulnerable butterfly species and failing to resolve the prior ecological assessment.
- **Annex I Avifauna:** This sensitive upland bog serves as a documented foraging and nesting corridor for the highly protected Hen Harrier and Golden Plover.

- **Cumulative Displacement:** The developer has provided no long-term, empirical monitoring data from the adjacent operational Slieve Callan wind farm to prove that adding a 9-turbine development will not cause unsustainable cumulative collision mortality or permanent habitat displacement.

5. Destructive Impact on Residential Amenity: Unenforceable Acoustic Burden, Obsolete Setbacks, and Proven Property Devaluation

The positioning of this industrial array poses immediate, unmitigated threats to adjacent properties, specifically regarding cumulative acoustic saturation and inadequate spatial separation.

- **Inadequacy of Spatial Setbacks:** Turbines are proposed as close as approximately 700m from our family home. While the developer may attempt to defend this distance using the operative 2006 Planning Guidelines or subsequent drafts, both frameworks are fundamentally obsolete. The 2006 guidelines were written for turbines a fraction of the physical scale of the industrial structures proposed today. Applying outdated spatial limits to modern, massive turbines completely fails to account for the unique low-frequency noise, aerodynamic amplitude modulation, and overwhelming visual dominance they introduce just 700m from a rural dwelling.
- **Acoustic Nuisance & Objective Baseline Breaches:** This community has a well-documented history of unresolved noise complaints formally lodged with the Environmental Protection Agency (EPA) regarding the existing operational Slieve Callan turbines. Siting an additional 9 larger turbines in the exact same wind corridor creates an intolerable, cumulative acoustic burden.
- **Demonstrated Operational Track Record and Acoustic Liability:** The Board cannot safely rely on the applicant's predictive noise modeling when the parent developer, Enerco Energy Limited and its subsidiaries, possesses an established legal track record of noise nuisance claims in Ireland resulting in significant out-of-court settlements and court-mandated damages to impacted families. The developer's standard legal strategy of paying out substantial damages while maintaining a position of "no admitted liability" serves as clear evidence that their pre-construction acoustic assurances do not prevent severe, long-term harm to residential amenity.
- **Material Property Devaluation and Misleading Assurances:** A turbine footprint sited just 700m from a family home will result in immediate and catastrophic material devaluation of the property due to overwhelming visual dominance, low-frequency amplitude modulation, and acute threat to residential amenity. The Board must reject any boilerplate assurances from the applicant claiming that proximity to industrial turbines has no adverse economic impact on local housing stock. In 2021, the Advertising Standards Authority for Ireland (ASAI) formally upheld a complaint against this exact parent developer, Enerco Energy Limited, ruling that leaflets they circulated making flat assertions that wind farms do not affect home values were misleading and inaccurate. The developer's own industry framework—which relies on mandatory annual RESS structural payments to properties within 1km to 2km of their boundaries—serves as an explicit admission that a severe material deficit is imposed upon adjacent property owners. The Board cannot legally or ethically ignore the

targeted destruction of private asset values under an operator with a proven regulatory history of misrepresenting this exact risk profile.
- **Attached Empirical Evidence:** We refer the inspector to the attached **Independent Acoustic Report (Appendix A)**. This independent data explicitly indicates a clear breach of acceptable acoustic regulations under current baseline conditions. While this evidence forms the basis of ongoing enforcement engagement with the EPA, it serves as immediate, empirical proof to the Board that the local air corridor is already acoustically saturated.
- **Hydrological Risk to Private Water:** Heavy piling, excavation, and drainage alterations on this blanket bog pose a severe risk of sediment contamination and water-table disruption to the private, independent drinking water wells serving adjacent properties, and future public or private water infrastructure requirements.

6. Acute Cumulative Shadow Flicker and Ambient Over-Saturation

The developer’s baseline calculations are fundamentally flawed regarding human health and residential amenity.

- **The Slievecallan Overlap:** The proposed 9 Slieveacurry turbines are uniquely positioned directly adjacent to the massive, pre-existing **29-turbine Slievecallan Wind Farm** (Turbines 9 to 37 on the local ridgeline grid).
- **The Mathematical Deficit:** By adding 9 more industrial-scale turbines to an environment already heavily saturated by 29 operational turbines, the local terrain faces an unprecedented cumulative window for shadow flicker. The developer’s EIAR relies on localized "mitigation banking" (promising to turn off turbines dynamically), but this does not erase the structural, baseline reality that our home falls directly within a severe cumulative flicker zone. The Board must refuse permission on the grounds that this community has already absorbed its fair share of industrial wind infrastructure, and adding this layout crosses the threshold from a rural setting into an absolute industrial corridor.

7. Failure to Account for Commercial Forestry Clear-Felling Dynamics

The developer's underlying peat stability, drainage, and hydrological assessments fail to account for the physical lifecycle of the surrounding land.

- **The Siltation Risk:** The upland terrain at Glendine North and Knockalassa is heavily reliant on commercial forestry monoculture to bind upper soil layers together. Over the lifespan of this proposed wind infrastructure, massive tracts of this surrounding forestry will undergo standard commercial clear-felling operations.
- **Compounded Peat Failure:** The combined impact of heavy turbine construction excavation alongside widespread forestry clearing removes the vegetative root systems holding the blanket bog together. The developer has treated the forestry as a static, permanent shield in their drainage models. In reality, the inevitable clear-felling, when combined with 9 massive concrete turbine bases and deep access road trenching, creates an unmitigated risk of deep-seated peat failures, massive siltation runs into local streams, and landslide risks that the EIAR fails to model dynamically.

8. Structural Deficiencies in the Baseline Traffic Management Plan

The local road network is physically incapable of safely absorbing the construction phase of this development.

- **Inadequate Haulage Infrastructure:** The access routes linking Miltown Malbay and Ennistimon to the upland site consist of narrow, single-track local roads (L-roads) with highly fragile roadside margins and ancient stone bridge structures.
- **Structural Subsidence:** Bringing hundreds of multi-ton, high-axle concrete deliveries and oversized turbine components over these local arteries will cause immediate sub-base failure and severe roadside structural deformation. The developer's traffic plan provides temporary mitigation for turning circles, but completely fails to address the fact that the underlying rural road geology cannot sustain continuous heavy industrial loading without causing permanent subsidence and safety hazards for local resident transport.

Conclusion

A strategic shift in the planning pathway to an SID framework does nothing to alter the severe physical, ecological, and structural realities of this upland site. The proposed development directly violates the EIA Directive via tactical project splitting, degrades protected Annex-listed habitats, directly conflicts with binding EU Nature Restoration targets, and inflicts an unmitigated cumulative acoustic and shadow flicker burden on adjacent residential properties. Furthermore, the developer has failed to account for the dynamic geotechnical risks associated with local commercial forestry lifecycles or the structural limitations of the rural road infrastructure.

We urge An Coimisiún Pleanála to uphold the precedent of its previous decision under ABP-312728-22 and refuse planning permission for case PAX03.324270.

Yours faithfully,

Brian McDowell

(Signing on behalf of myself and my wife, Jenny McDowell)

Appendix Attached

- **Appendix A:** Independent Acoustic Compliance and Noise Impact Report.

HUSON & ASSOCIATES

Peer Review of Proposed Slieveacurry Wind Farm Planning Application (PAX03.324270)

W Les Huson BSc(Hons) MSc CPhys MInstP MIoA MAAS

Slieveacurry Wind Farm Review.docx
JUNE 2026

INTRODUCTION

Huson & Associates has been commissioned by the Miltown Locals Say No To Windfarm group to review an Environmental Impact Assessment Report (EIAR) prepared by MKO Planning and Environment Consultants for Slieveacurry Ltd containing Chapter 12 'Noise and Vibration' (NVA) prepared by AWN Consulting Ltd to support a Planning Application lodged with An Coimisiun Pleanála (Case Ref. PAX03.324270) on 5 May 2026 for the Slieveacurry Renewable Energy Development. The application is for a wind farm containing up to nine wind turbines.

The proposed wind farm development (see Figure 1) has been deemed suitable for assessment by An Coimisiun Pleanála (ACP). A similar application was assessed and refused by Clare County Council with a subsequent Appeal to An Bord Pleanála that was also dismissed (8 Feb 2023).

This review also considers the grounds for refusal by Clare County Council and An Bord Pleanála (ABP-312728-22) of the prior application that was refused. The prior application had wind turbines fundamentally in the same location as the current application but without turbine T9.

An application for the Illaunbaun Wind Farm lies to the north-west, currently under review by ACP, and the application documents for this wind farm have also been reviewed insofar that they relate to the Slieveacurry Wind Farm application.

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.

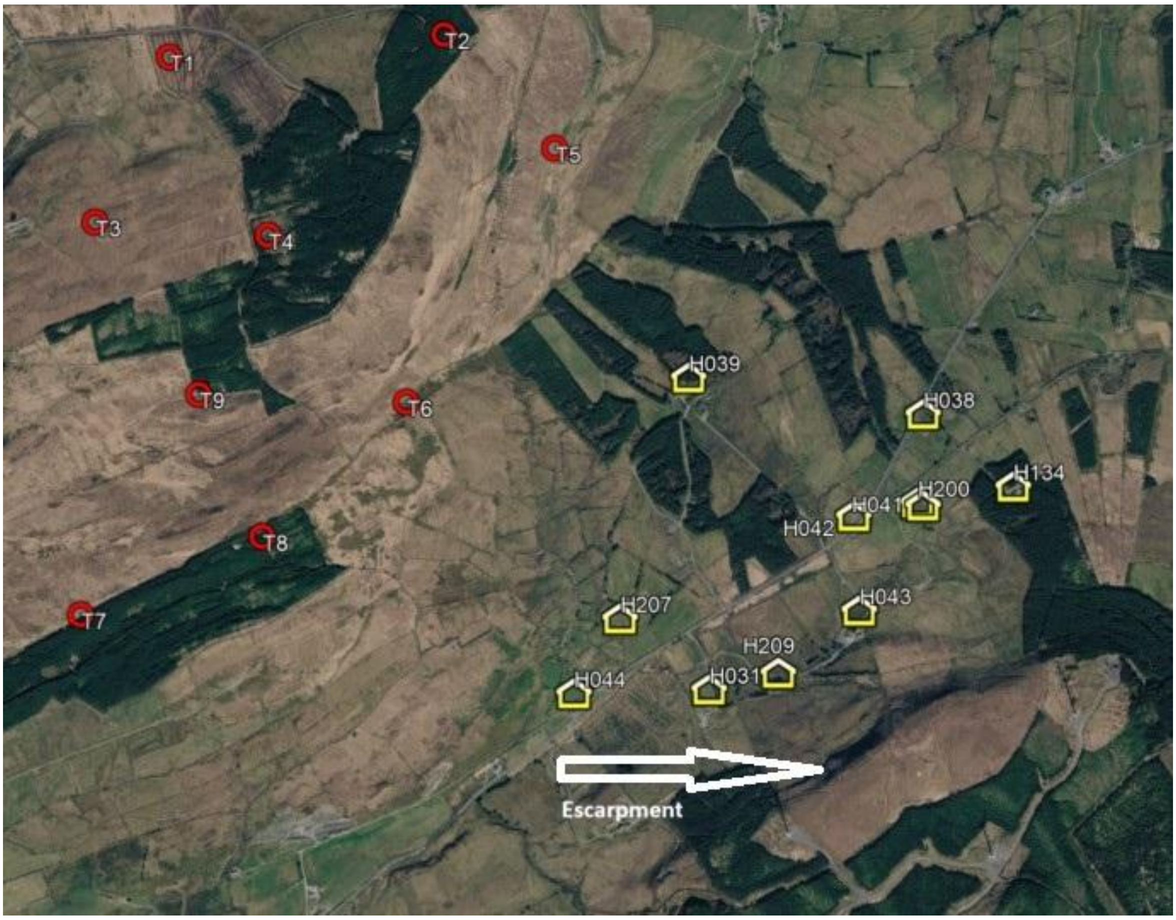


Figure 1 Location of wind turbines (T) and some NSLs

SUMMARY

An Coimisiún Pleanála would be justified in dismissing the Slieveacurry Wind Farm Application for the following reasons:

- The minimum recommended setback of 10 times the rotor diameter, a best practice setback distance of 1.5 km for the proposed wind turbine rotor diameter of 150m, has not been applied with one dwelling (H033) being only 529m from the nearest wind turbine.
- The wind turbines are located too close to each other that will result in increased wake turbulence that in turn will increase noise emission and the characteristic of amplitude modulation. The NVA has not considered these effects.
- Noise compliance with WEDG 2006 should have been completed at 10 m/s, not 8 m/s. All wind speeds in this report refer to standardised hight of 10 m above ground level.
- WEDG 2006 target noise limits have been misinterpreted in the NVA to produce higher proposed noise limits.
- WEDG 2006 requires: "Any existing turbines should not be considered as part of the prevailing background noise". Background noise measurements have all been corrupted by noise from the Slieveacallan Wind Farm and the method chosen to correct this interference is not mathematically sound and introduces increased uncertainty. A more representative and recent background survey that can be used as proxy for dwellings surrounding the Slieveacurry Wind Farm, that is less influenced by extraneous noise from the Slieveacallan Wind Farm, is that provided in the Illaunbaun Wind Farm planning application currently under review by ACP.
- Target day time noise limits should be lower at 35 dB(A) in 10 m/s wind speed.
- Predicted sound levels in the NVA are too low.
- When less optimistic noise model inputs are used the predicted noise levels shown in the NVA will be at least 2 dB higher.
- The current WEDG 2006 does not reflect best practice and is outdated, but if applied properly, shows that this proposed wind farm is non-compliant.
- 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 NVA.
- Ambient sound levels are shown at times to be below the 17 dB(A) instrument noise floor in wind speeds up to 10 m/s at H161 compared with cumulative sound levels optimistically predicted to be more than 38dB(A) at this location.

- The soundscape in the area will change by more than 20 dB for the surrounding Community if the wind farm is approved and this is contrary to the requirement of the WEDG 2006.
- According to the Environmental Protection Agency, Ireland's 'Guidelines on the Information to be contained in Environmental Impact Assessment Reports' (EPA, 2022), the impact of the proposed development when operational will cause a 'Very Significant' to 'Profound' effect. Accordingly, the development application presents an unacceptable impact and should be refused.
- The layout of the nine wind turbines is such that excessive amplitude modulation will arise but the NVA has not accounted for any penalty due to this or other special audible characteristics (tonality, impulsive sound).
- The sound power levels for the wind turbines of the Slieveacallan Wind Farm that were input to the cumulative noise predictions are too low by 0.5 dB that will translate to higher cumulative sound levels.
- The NVA has listed several dwellings as being derelict, yet, these properties could be occupied in the future. It is not appropriate for the NVA to set daytime and night time noise limits at 55 dBA for these properties.
- Current best practice in assessing wind farm noise should be reflective of target noise limits set in Germany and the Australian States of New South Wales and Tasmania.
- Low frequency noise impact has not been assessed, despite this being discussed in the NVA.
- With noise model inputs used in the NVA and no consideration of special audible characteristics there will be 181 noise sensitive locations (NSLs) that exceed the correct noise limit target of 35 dB(A) at 10 m/s.
- With more conservative noise model inputs (+2dB) and no special audible characteristics 207 NSLs will exceed the correct noise limit target at 10 m/s.
- If special audible characteristics were to warrant a 5 dB penalty with the correct noise model inputs, then all 208 NSLs considered in the NVA will exceed the correct noise limit target at 10 m/s.
- The NVA does not refer to any noise predictions for the substation and only refers to an unspecified detailed future design. The NVA is deficient in this regard.
- An escarpment to the south east of the proposed development has the potential to increase noise levels through reflection for dwellings between it and the proposed Slieveacurry Wind Farm that are shown in Figure 1.

The following expands upon these issues.

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) detail the current guidelines to set noise limits for wind energy developments.

The NVA 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' (GPG) to change recommended noise limits in WEDG 2006.

It should be recognised that the scope of the GPG was not to examine noise limits described in ETSU-R-97. The GPG states that "The approval of this guide by the IoA Council should not be seen as an endorsement of the noise limits within the ETSU-R-97 document since the setting of these limits is a policy matter for Government."

Furthermore, the GPG is only applicable for those involved in the assessment and rating of wind turbine noise when applying ETSU-R-97 assessment procedures. The GPG may not be appropriate guidance if other assessment procedures are used.

WEDG 2006 requires updating and a DRAFT WEDG 2019 was prepared but not formally adopted as it remains under review.

The limits proposed in the WEDG 2006 broadly align with the UK guidance found in ETSU-R-97 that reflects but does not reference WHO guidance in 1997. However, noise limits to protect sleep were reduced by 5 dB in subsequent WHO guidance in 1999 that remain current.

WEDG 2006 does not require that ETSU-R-97 or guidance on its implementation be used to assess wind turbine noise.

WEDG 2006 states that "*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." This requirement is a test that has not been addressed in the NVA.

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).*"

Justice Richards observed the following in a recent Supreme Court nuisance noise case (Uren v Bald Hills Wind Farm S ECI 2020 00471) 25 March 2022 in Australia:

"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.*"

A recent court case in Ireland (Ms Justice Emily Egan) echoes this observation:

"*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*."

The WEDG 2006 does not set fixed noise limits. The guideline provides advice for local authorities (Councils) to develop their own planning guidelines for noise that can differ from those suggested in WEDG 2006. In this regard, for example, the Limerick County Council has set low frequency noise guidelines that are not contained within the WEDG 2006 and they also allow a night time noise limit of 38 dB(A), L90, or Background plus 5 dB. Many other local councils have set noise criteria for wind farms that differ from those in the WEDG 2006.

BACKGROUND NOISE MEASUREMENTS

NVA, Appendix 12-5 and NVA Table 15, has chosen to set lenient target noise limits in the daytime at 45 dB(A) L90 or background plus 5 dB, whichever is the greater, where background noise levels were >30 dB(A) from five residences (A, B, C, D and E) around the proposed development, <u>all of which were acknowledged to be affected by noise from the Slieveacallan Wind Farm.</u>

Several proxy locations are suggested to be representative of the five background measurement locations. For example, Background measurements at location E (H006) is suggested to be representative for H002, H003, H004, H006, H008, H011, H012, H013, H014, H026, H069, H115, H116, H117, H118, H119, H140, H141, H142, H143, H144, H145, H146, H160, H161, H162, H163, H177, H178, H180, H181, H182, H183, H186, H187, H188, H189, H190, H191, H192, H198, and H213.

Conversely, if one of those proxies had background measurements unaffected by noise from the Slieveacallan Wind Farm then that could be used as a proxy to represent those listed above.

The NVA has suggested correcting their background noise measurements by removing data outside particular wind directions and to further correct the corruption from the Slieveacallan Wind Farm by 'removing' its contribution.

However, the 'removal' method of correction is to simply take LAeq predicted noise levels, corrected by 2 dB to LA90 and then to take predicted LA90 levels away from background measurement data. This correction methods is not mathematically sound and it is preferable to use background data from a representative location in the area that is unaffected by noise from other wind farms.

It would have been possible to use background noise measurements taken for the Slieveacallan Wind Farm before it was constructed but this data would be more than 16 years old.

I suggest that the background survey data (November 2023) from NML2 in the Illaunbaun Wind Farm application to ACP is the most recent and reliable background noise survey upon which to set target noise limits for all NSLs surrounding the proposed Slieveacurry Wind Farm.

It should be noted that measured background sound levels regularly fall below 20 dB(A) in wind speeds up to 8 m/s. When consideration is given to the compression of sound level measurements close to the noise floor of the sound level measurement instruments[1] the real average background sound levels at many noise measurement locations (NMLs) will be well below 30 dB(A), justifying the lower target base noise limit of 35 dB(A) from the range suggested in WEDG 2006 during the daytime.

[1] 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

This effect is also highlighted in BS 4142:2014+A1:2019, section 8.1 which notes: "*Care is necessary in circumstances where background sound levels are low to ensure that self-generated and electrical noise within the measurement system does not unduly influence reported values, which may be the case if the measured background sound levels are less than 10 dB above the noise floor of the measuring system*."

'Guidance Note for Noise Assessment of Wind Turbine Operations at EPA Licensed Sites (NG3)' has been referenced about infrasound and low frequency (12.3.5.9) but the NVA has not mentioned that it also provides compliance limits in the daytime between 35 dBA and 40 dBA for quiet daytime environments of less than 30 dBA that echoes the lower limits in WEDG 2006.

For situations where the *average corrected* background noise level is <30 dB(A) the NVA has elected to apply the least stringent noise limit of 40 dB(A) and no noise sensitive locations (NSLs) have been assigned the 35 dB(A) base noise limit.

Background sound levels that set target noise limits generally increase with wind speed and the background measurements at H162 from the Illaunbaun Wind Farm application to ACP shows this effect in the following table.

Location		**4m/s**	**5m/s**	**6m/s**	**7m/s**	**8m/s**	**9m/s**	**10m/s**	**11m/s**	**12m/s**
H162 (NML2)	**Day**	20.0	20.7	21.7	23	24.6	26.3	28.1	30.1	32.1
	Night	20.3	21.3	22.5	23.9	25.4	26.9	28.6	30.3	32.1

VIBRATION

Section 12.3.7 refers to vibration generated by the wind turbines. Whilst ground borne vibration is expected to be low there is the possibility of induced building vibration due to acoustic emissions from wind turbines. The mechanism producing this effect is described by Kelley[2].

NOISE LIMITS

The 2018 World Health Organization (WHO) Environmental Noise Guidelines for the European Region suggests a provisional outdoor target noise limit for wind farm noise of <45 L_{den}. This roughly equates to 37.3 dB, LAeq[3] and supports the lower noise level target of 35.3 dB(A), L90 (37.3 dB LAeq – 2 dB), not that proposed in the NVA.

Based on background measurements that were unaffected by noise from the Slieveacallan Wind Farm, reported in the Illaunbaun Wind Farm EIAR (NML2, November 2023) for dwelling H162 in winds less than 11 m/s, the target noise limit should be 35 dB(A) in the day time.

Again, the NVA is not applying best practice.

[2] N.D.Kelley. A Proposed Metric for Assessing the Potential of Community Annoyance from Wind Turbine Low-Frequency Noise Emissions. Windpower '87 Conference and Exposition October 5-8, 1987 San Francisco, California.
[3] Davy, J.L., Burgemeister, K., Hillman, D. *et al.* A Review of the Potential Impacts of Wind Turbine Noise in the Australian Context. *Acoust Aust* **48**, 181–197 (2020). https://doi.org/10.1007/s40857-020-00192-4

Section 12.3.5 of the NVA states: "The Guidelines (DoEHLG 2006) are based on detailed recommendations set out in ETSU-R-97. The ETSU-R-97 document has been used to supplement the guidance contained within the Guidelines (DoEHLG 2006), where appropriate and necessary."

Guidelines DoEHLG 2006 (WEDG 2006) is not based upon detailed recommendations set out in ETSU-R-97, rather, it was considered and bears similarity to parts of ETSU-R-97 such as the target night time noise limit and the use of LA90 to measure and assess wind turbine noise.

WEDG 2006 is a workable stand-alone document and the NVA should not rely on guidelines from the UK Institute of Acoustics (currently under review) that are specifically used to implement ETSU-R-97.

WEDG 2006 outlines the current assessment requirements which do not refer to or require interpretations from the UK IoA Good Practice Guide that in some cases alter WEDG 2006 recommended noise levels.

Section 12.5.2 of the NVA outlines a rationale for the choice of noise limits that are used in the NVA.

The rationale to adopt a 43 dB(A), L90 or *Background plus 5 dB, whichever is the higher* noise limit at night is a less stringent target than WEDG 2006 recommends.

The proposed night time noise limit in the NVA is too lenient by allowing night time noise limits greater than 43 dB(A), L90.

WEDG 2006 references Environmental Protection Agency (2003) Environmental Noise Survey - Guidance Document, EPA Wexford, that has been superseded by Guidance Note for Noise: Licence Applications, Surveys and Assessments in Relation to Scheduled Activities (NG4).

The NVA (12.3.6.1 and 12.5.2) references NG4 for guidance on establishing if NSLs can be considered to be in 'low background noise' areas. 'Low background noise areas' are required to be assessed when applying WEDG 2006.

NG4 suggests that a daytime noise criterion of 45dB(A). Leq, applies in 'areas of low background noise'. The parameter referenced in NG4 is a rating value (LAr), based on LAeq so the LA90 target noise limit is 43 dB(A), LA90 (45dB minus 2 dB to represent LA90).

The NVA author shows in Table 12-5 that in the Evening this reduces to 40 dB(A), Leq (38 dB(A), L90) and at night the criterion reduces to 35 dB(A), Leq (33 dB(A), L90).

NG4 also has recommended criteria for Quiet Areas and properties surrounding this development comply with a designation of 'Quiet Areas' for their location. Under these circumstances the criteria changes to noise from the proposed development to be at least 10dB below the average daytime, evening and night time background noise levels measured during the long-term baseline noise survey.

NVA section 12.5.2 use NG4 as a reference document to suggest noise criteria for the proposed wind farm that are at least 10 dB higher than NG4 recommends at night for both Quiet Areas and 'areas of low background noise'.

Likewise, the proposed daytime noise limit of 40 dB(A), L90 is 7 dB higher than the evening period for 'areas of low background noise' and at least 10 dB higher than the NG4 criteria for Quiet Areas.

If WEDG 2006 is to apply to this proposed development then the lower day time noise limit of 35 dB(A), L90 should apply and, in addition, consideration must be given to any significant increase in noise levels.

The NVA suggests that: "In line with ETSU-R-97 guidance (see Section 12.3.5.1), a fixed lower threshold of 45 dB LA90 or a maximum increase of 5 dB above background noise (whichever is the higher) is proposed for NSLs identified as being involved in the project."

However, WEDG 2006 does not differentiate between NSLs involved in a wind farm project or not, it states: "In the case of wind energy development, a noise sensitive location includes any occupied dwelling house, hostel, health building or place of worship and may include areas of particular scenic quality or special recreational amenity importance." WEDG 2006 noise limits apply to *any* occupied dwelling whether they are associated with the project or not.

The NVA has listed several dwellings as being derelict, yet, these properties could be occupied in the future. It is not appropriate for the NVA to set daytime and night time noise limits at 55 dBA for these properties. The NVA predicts noise levels above 40 dB for 'derelict' dwellings H005, H034. H035, H045, H046, H199, H206, H207 and H209.

In the NVA, section 12.5.2 it has been incorrectly interpreted that when background sound levels become greater than 30 dB(A) at higher wind speeds that the lower range of noise limits suggested in WEDG 2006 (35 to 40 dB(A), L90) do not apply and the limit suddenly reverts to 45 dB(A) L90. This is incorrect.

The test of a quiet area is made at lower wind speeds (below 5 m/s according to BS4142 and NG4 where wind-induced noise on a microphone is minimised) and once determined applies at all higher wind speeds.

Section 12.5.3 of the NVA confirms that background sound levels at low wind speed, when there is no corruption from the Slieveacallan Wind Farm, demonstrate that the NSLs can be defined as areas of low background noise.

As wind farms operate 24/7 the limiting criterion for this development should be 35 dB(A), L90 during the day time (WEDG 2006 includes 'evening' into the description of 'day time') and predicted noise levels must be compared to this limit to assess if the development is acceptable.

A 35 dB(A), L90 noise limit during the day is based upon a day time background level of 28.1 dB(A), L90 at 10 m/s measured at H162.

Thus, the lower limit should be set at 35 dB(A) in wind speeds at or below 10 m/s.

In summary, the noise criterion suggested in the NVA for the proposed development at 8 m/s is too high by 10 dB during the daytime period if the WEDG 2006 limits are to be applied correctly. Additionally, for associated landowners the proposed limit at night is 2 dB too high.

Dwellings associated with the proposed development should have the same target noise limits as other non-associated NSLs.

Under these circumstances the predicted sound levels from the NVA at many dwellings exceed the appropriate recommended noise limit and ACP will be justified in refusing the proposed development.

The predicted sound levels for this development are overly optimistic. With appropriately set noise model inputs to reflect a conservative assessment the degree of non-compliance is greater by at least another 2 dB.

The NVA (12.4.4.2) has suggested hopefully and naïvely that:

A warranty will be provided by the manufacturer of the selected turbine to ensure that the noise output, including tonality, is controlled.

NOISE PREDICTIONS

Cumulative noise contour predictions in the NVA (Appendix 12-4) are made for the 8 m/s wind speed case.

For the 9 m/s wind speed case the predictions are the same.

Appendix 12-5 lists cumulative predicted sound levels at different NSLs for integer wind speeds up to 9 m/s.

The NVA does not explain why the sound power levels for the Slieveacallan Wind Farm wind turbines have only 1.5 dB added for uncertainty rather than 2 dB that was applied for the Illaunbaun and Slieveacurry wind turbines. The additional 0.5 dB will translate to higher predicted cumulative noise levels.

The test from WEDG 2006 for a low noise environment is not separated into that during the Day or Night.

At 10 m/s the day and night background noise level is less than 30 dB(A) that justifies the area to be classified as a 'low noise environment'. The noise limit at this wind speed should be 35 dB(A), not 45 dB(A).

A lower limit from the range 35 to 40 dB(A) from WEDG 2006 is recommended as it matches recommendations in NG4 for the evening.

At 8m/s the NVA is suggesting that a higher noise limit of 45 dB(A) should apply, based on background measurements, all of which the NVA admits have been affected by noise from the Slieveacallan Wind Farm. I strongly disagree.

The NVA is suggesting a target noise limit of 40 dB(A) or 45 dB(A) during the Day, dependent on corrupted background sound levels, and 43 dB(A) at night. Again, I disagree.

The target noise limit during the day should be 35 dB(A) at 10 m/s and below, not 45 dB(A) as claimed in the NVA for all noise sensitive locations.

The NVA predicts a sound level at NSL H039 of 43.2 dB(A) at 8 m/s, when applying the optimistic noise model inputs used in the NVA. This exceeds the NVA suggested night time limit by 0.2 dB.

However, if more conservative noise model inputs are used where the receiver height is 1.5m and the ground absorption value, G, is 0 then the predicted sound level for this dwelling becomes 45.2 dB(A).

Under both noise model prediction scenarios, the predicted sound level at NSL H039 exceed the correct 35 dB(A) daytime noise limit at 10 m/s and below.

The NVA has used very optimistic noise modelling and assumed that the sound from the proposed wind farm will not be tonal, impulsive or have any significant amplitude modulation characteristics that, in my experience, often occur.

The NVA (12.5.3) does not provide any noise predictions for the substation and defers to future detailed design. It is common knowledge that substation noise has tonal characteristics and the NVA should have included noise predictions for the substation to compare against the recommended 35 dB(A), LAr noise criterion. The NVA has suggested a target level of 35 dB(A), Leq, rather than LAr

LA90 statistic or LAeq

Use of the LA90 statistic does not capture short term noise events that are often observed from wind farms. Such noise events are often referred to as 'whump' or 'thump' type sounds are thought to be caused by wind flow delamination across the rotor blades when wind conditions change.

The benefit of a condition requiring the LAeq is that such events can reflect the extent of intermittent louder sounds that the LA90 statistic cannot.

However, if an LA90 level is specified as a noise condition then an added provision to prevent impulsive noise or tonality could be applied.

Such a condition was applied for the Cloghan Wind Farm in Offaly, as follows:

Noise levels emanating from wind farm noise when measured at the nearest noise sensitive properties, i.e. dwelling houses, shall not exceed 43 dB(A) $L_{A90(10\ minutes)}$. There shall be no tonal or impulsive noise and measurements shall be made in accordance with ISO recommendations R1996-1 (Acoustics-description and measurement of environmental noise, part 1; basic qualities and procedures).

BEST PRACTICE

WEDG2006 is outdated and not currently 'best practice'.

The most recent (29 July 2025) review of best practice in setting wind farm noise limits has been completed by the EPA of Tasmania, Australia, that has revised its wind farm noise guideline limit and set 35 dB(A), Leq as the appropriate base noise limit to be met. A copy of the Policy is in Appendix D.

Current best practice in wind farm noise guidance is also provided in the Australian States of New South Wales and Queensland where night time target noise limits are set at 35 dB(A) Leq or background plus 5 dB with additional penalties for special audible characteristics such as tonality, impulsiveness, and amplitude modulation.

Germany also has for a long time had a night time noise level limit of 35 dB(A) Leq.

Wind farms have been approved under these target noise limits and a good balance has been struck to provide renewable energy and protect the nearby population.

A target noise limit of 35 dB(A), Leq approximates to 33 dB(A), L90 that lies 2 dB below the lowest recommended day-time absolute limits in WEDG 2006 for quiet areas and reflects modern expectations for the protection of a nearby community.

NOISE MODEL

The NVA has used the ISO 9613-2 noise model that includes ground absorption and used manufacturer's data from Vestas for the V150. Vestas manufacturer's data normally includes a clause for 'Limitations', as follows:

These values as stated in the present document are to be regarded as "best estimates" for the octave band performance for the turbine. The values are to be regarded as informative and cannot in any way be used as guaranteed for any projects.

Given such *limitations*, it would be expected that uncertainty values greater than 2 dB would be appropriate.

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[4] 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 NVA.

The NVA 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 between 1.2m to 1.5m).

The peculiarities of the ground effect calculation in ISO 9613-2 show that predicted sound levels for a receiver height of 4m there is a 2 dB difference in predicted sound levels depending on whether G=0 or G=0.5 is used. G=0 produces typically 2 dB higher predicted sound levels than when G=0.5 is used and 4 dB higher compared to G=1.

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[5] 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 NVA has not accounted for any site effects that can increase wind turbine sound power levels.

Furthermore, the NVA *assumes* that there will be no special audible characteristics from whatever wind turbine is chosen to be used in the wind farm. Only test results can confirm this assumption but none have been supplied in the NVA.

[4] 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

[5] Bass, J.,Sloth, E., Bullmore 'Development of a Wind Farm Noise Prediction Model,' JOULE project JOR3-CT95-0051, 1998

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.

The NVA has not commented on 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 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 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 for by adding the standard deviation of 0.004dB/m measured in the JOULE study, in which case the predictions in the NVA would be increased by about 3 dB for the nearest dwellings.

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 use the IEA model output plus 4dB (0.004dB/m at 1000m).

The American National Standards Institute (ANSI) published ANSI/ACP 111-1[6] to ensure predictions of sound from wind farms are repeatable, uniform, and more easily understood by all interested parties.

ANSI/ACP 111-1 draws on existing standard methods in ISO 9613-1, ISO 9613-2, and IEC 61400-11 to establish a uniform method of predicting future project sound levels such that predevelopment sound assessment results and predictions used in research can be readily compared. The standardisation of predictions ensures a robust and repeatable process that improves regulatory confidence in the results and reduces potential confusion.

The apparent wind turbine model-specific sound power level should be determined in accordance with IEC 61400-11 for the downwind location. Using this sound power level as the basis, propagation modelling should be conducted in accordance with the ISO 9613-2 standard (Acoustics—Sound Attenuation During Propagation Outdoors Part 2: General Method of Calculation) using either of two sets of parameters, identified as Option 1 and Option 2:

Option 1

A. Ground factor of G=0.

B. Receptor height of 1.5 meters for consistency with existing standards.

C. Turbine modelled at hub height using vendor's apparent downwind sound power level specified consistent with IEC 61400-11.

D. No other model adjustments.

Option 2

A. Ground factor of G=0.5.

B. Receptor height of 4 meters.

C. Turbine modelled at hub height using vendor's apparent downwind sound power level specified consistent with IEC 61400-11.

D. A model adjustment of + 2 decibels.

Option 1 and Option 2 produce the same result only when the correction factor of +2 dB is added to predicted sound levels using Option 1.

As there is now (2022) a National Standard, rather than an outdated guideline (IoA GPG, 2013) to standardise ISO9613-2 noise model inputs I urge An Coimisiun Pleanála to only consider the recommendations of ANSI/ACP 111-1 when assessing wind farm noise predictions.

When applied to this proposed development the predicted sound levels offered are all 2 dB too low.

Another issue that can arise is the reflection from certain structures that ISO9613-2 does not consider.

A 50 m high escarpment shown in Figure 1 can enhance sound levels through reflection for the NSLs shown.

[6] American National Standards Institute (ANSI). April 2022. Standard ACP 111-1, Wind Turbine Sound Modeling.

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.

A general outline of site layout considerations has been provided by Suzlon Energy. A summary of site effects from Suzlon is provided in Appendix C that suggests the *minimum* wind turbine separations to be 3r-5r, depending on wind direction. Fow a wind turbine layout that is exposed to wind from multiple directions the design limit is 5r.

In the current layout of the Slieveacurry Wind Farm, the distance between the nearest neighbouring wind turbine towers is typically less than 420 m.

The V150 wind turbines have a rotor diameter, 'r', of 150 m. The spacing between the turbines is 2.8 times the rotor diameter (2.8r), which is significantly less than the recommended 8r spacing to reduce wake turbulence effects from SEDA and 5r spacing suggested by Suzlon.

An increase in wake turbulence from the wind turbines will lead to higher noise emissions and lower efficiency of the wind farm.

The NVA has not considered the potential increase in sound power caused by wake effects.

AMPLITUDE MODULATION (AM)

The NVA discusses AM at length in the NVA (section 12.3.5.11) but reaches no conclusion on a penalty scheme to account for this special audible characteristic. Section 12.7.4.1.1 suggests that the UK IoA 'Preferred Method' is a reliable and robust method to assess AM. This is not true; the reference method greatly underestimates the occurrence of AM for peak to trough levels exceeding 3 dB and it fails to properly assess multiple wind turbines.

With some modifications it has been used in IEC 61400-11-2 but that is for a single wind turbine, not many turbines in a wind farm.

NG3 describes AM under the heading of 'Temporal Characteristics' and states for AM that:

"*The mechanism behind this is not clearly understood. However, features which are*

thought to enhance this effect are:

- *close spacing of turbines in linear rows* *tower height to rotor diameter ratio less than approximately 0.75*

stable atmospheric conditions

topography leading to different wind directions being seen by the blades at different points in their rotation"

Note that the tower height (100m) to rotor diameter (150m) ratio is 0.66. (V150)

It can safely be assumed that AM *will* be an observable effect at NSLs because the turbine spacing is too close, the tower height to rotor diameter ratio is 0.66 (less than 0.75), and stable atmospheric conditions will occur from time to time.

An Coimisiun Pleanála should consider that AM is to be expected for this wind farm configuration that would warrant an additional penalty to predicted sound levels that have not been applied in the NVA.

A recent research paper by Colas et. al.[7] published in 2025 quantifies the amount of increased AM and sound power caused by increased wake turbulence resulting from wind turbines spaced too close together.

Colas simulated wind turbines with large-eddy simulation (LES) plus an aero acoustic model and parabolic-equation sound propagation. They compare three layouts: aligned (downstream in the wake), side-by-side, and staggered with the following results for downstream in the wake:

- Wake-induced flow focusing and turbulence increase downwind sound pressure levels (SPL) by several dB relative to a single turbine.
- AM depth increases by several dB in regions where the downstream turbine's wake-modified emission dominates.
- AM is highly sensitive to the relative rotor phase; certain angular offsets maximize constructive interference in the modulated component.

While Colas et al. focus on configuration rather than explicit "rotor diameter-spacing rules," the aligned case corresponds to a downstream turbine placed within the strong part of the wake (typical farm spacings of order 4–7 rotor diameters). The fact that they see "several dB" increases in both SPL and AM depth is a direct quantification of the effect of wake-enhanced inflow non-uniformity on AM.

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 intrusive sound characteristic of wind turbines and that tonality and impulsiveness also occur at many wind farms.

The current UK IoA 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.

[7] Colas, J. Emmanuelli, A. Dragna, D. Stevens, R. J. A. M. "Modeling wind farm noise emission and propagation: effects of flow and layout" arXiv:2508.13128v2 [physics.flu-dyn] 19 Aug 2025

The following figures illustrate A-weighted sound levels over a 10-minute period that were 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 2 shows the 100ms 'short' LAeq values and a single $L_{A95,10min}$ level for the data.

LA95 was calculated for this figure because the limit for this wind farm is in terms of LA95.

However, the LA90 would only be slightly higher at approximately 38 dB(A).

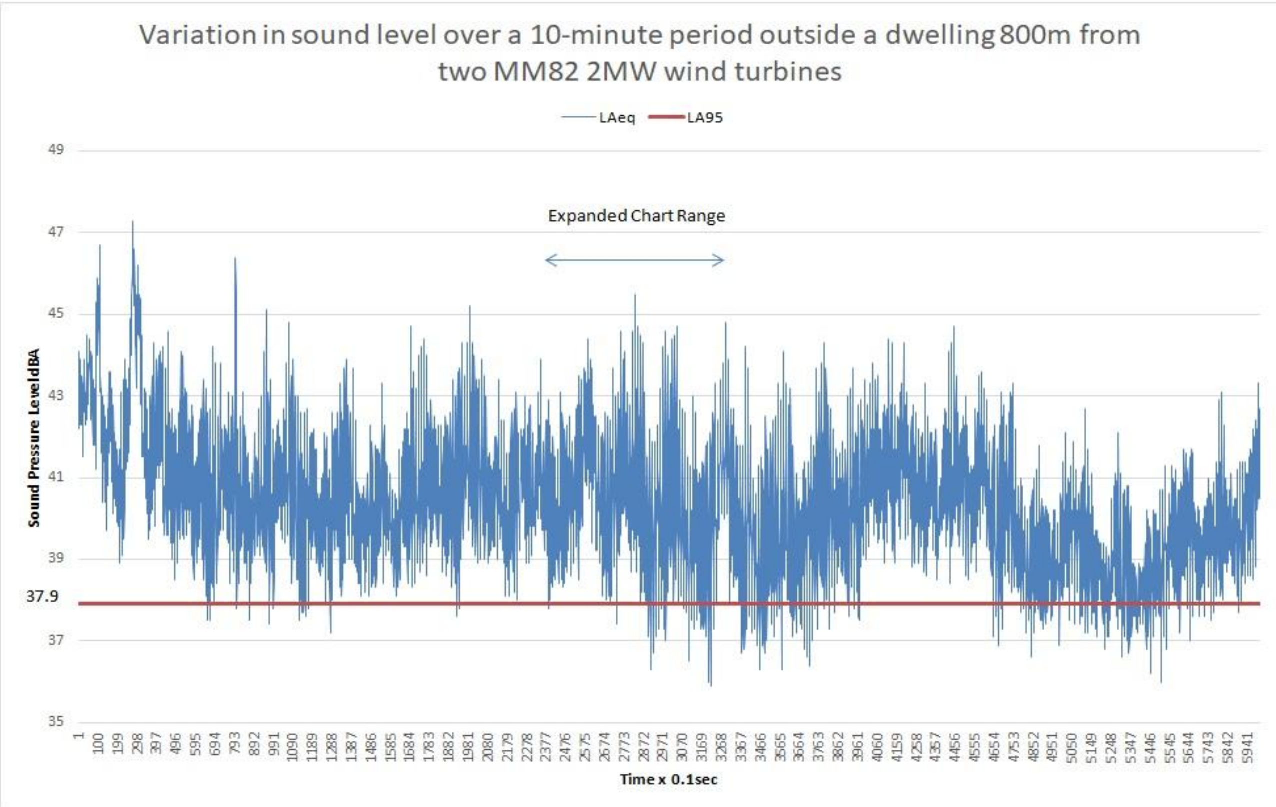


Figure 2

An expanded range from Figure 2 is shown in Figure 3 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 shows the interacting 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.

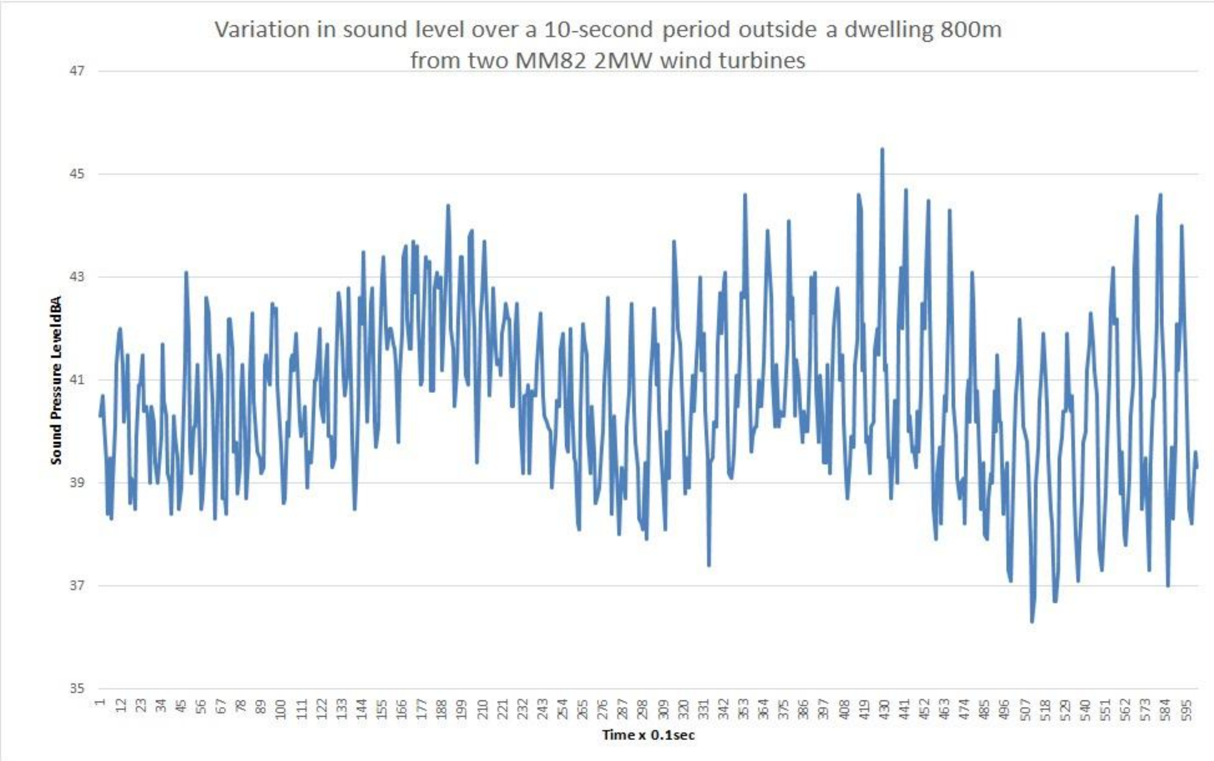


Figure 3

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. Placing wind turbines too close to each other will increase wind turbulence and increase AM[8,9] and the instances of 'whump and thump' sounds.

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.

[8] Sinayoko, S. 'On predicting wind turbine noise and amplitude modulation' 6th Int. conf. wind turbine noise, 2015
[9] Buck, S. et al 'Experimental validation of a wind turbine turbulent inflow noise prediction code', AIAA Journal 2016

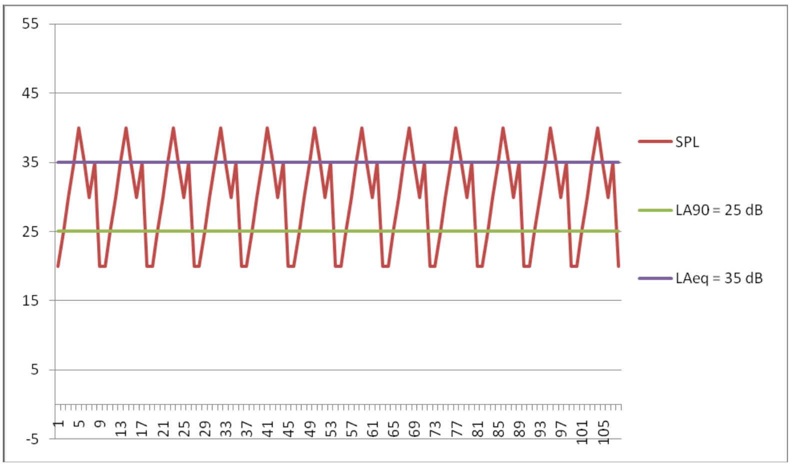
Sound levels vary throughout the measurement period in the 10-minute duration of the chart above (Figure 1) ranging from a maximum level of just over 47 dB(A) to a minimum level of about 36 dB(A). From the 6000 sound level samples the single statistical L95 parameter obtained from this chart is 37.9 dB(A), 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 dB(A) for up to 9 minutes that would have no bearing on the calculated L95 value of 37.9 dB(A) or L90 of 38 dB(A).

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[10] 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 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.



[10] NANR277 "Wind farm noise statutory nuisance complaint methodology DEFRA (2011)

Figure 13 $L_{Aeq,t}$ and $L_{A90,t}$ values of an indicative time varying noise signal"

The current GPG also explains in section 7.1 that the guide cannot provide a definitive set of AM 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 broadB(A)nd 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."

An Coimisiún Pleanála may wish to consider Condition 20 of the Denbrook Wind Farm as a model AM condition for any future wind farm that they approve.

Conditions referencing the IoA AM Preferred Method should be avoided for wind farms.

INFRASOUND, LOW FREQUENCY NOISE (ILFN) AND HEALTH EFFECTS

The EIAR (Chapter 5) has referred to the Health Service Executive (HSE) Position Paper on Wind Turbines and Public Health (2017) but only insofar that published scientific evidence is inconsistent and sparse. So, some published research supports there being adverse health effects and other research does not support there being adverse health effects from wind turbines.

Chapter 5 of the EIAR lists several other references to health effects, many of which are outdated. For example, Chapter 5 section 5.5.1(3) refers to a 'A Rapid Review of the Evidence', NHMRC 2010 but neglects to note that the NHMRC subsequently awarded AU$3,300,000 to two universities to investigate the issues, recognising that there was not enough evidence to base a conclusion upon.

The NVA (12.3.5.9) has cited several references from the UK Institute of Acoustics (UK IoA) generally supporting the idea that low frequency and infrasound from modern wind farms are insignificant and that there is no need to consider these effects in any noise impact assessment.

However, it is now recognised that infrasound and low frequency sound is emitted from wind turbines and that the infrasonic pulses are unlike any other environmental sound source.

Furthermore, advice from the UK IoA to its Members has no relevance to the assessment process in Ireland. For example, the UK IoA's guidance conflicts with Limerick County Council's planning requirements for wind farms, which specifically calls for a low-frequency noise assessment.

Figure 4 shows the change in infrasound levels near to the Cape Bridgewater wind farm measured inside a nearby stone dwelling during changes in operation from stopped to 15% and 45% power generation.

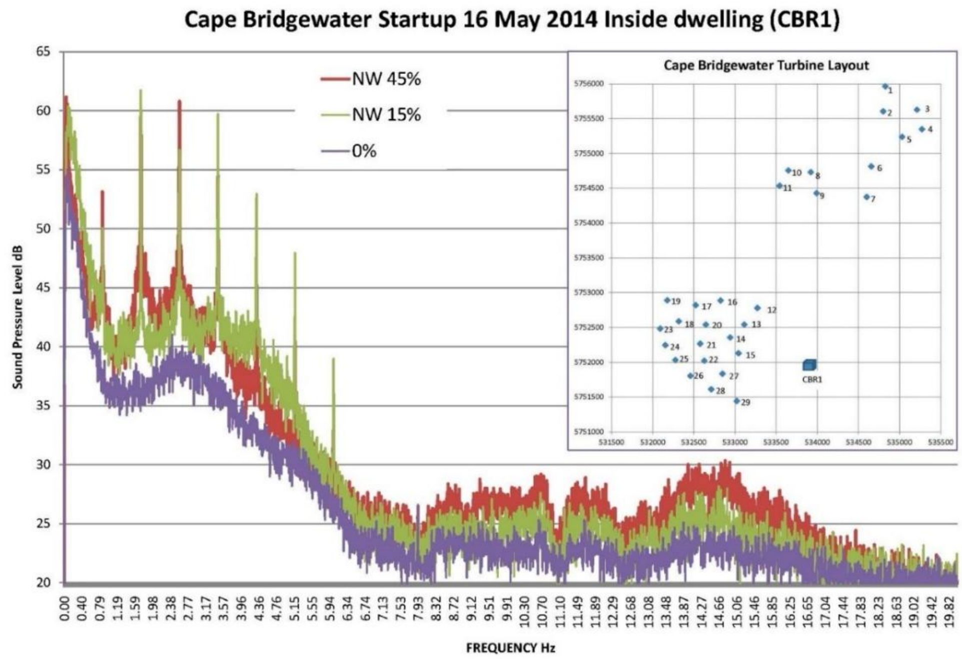


Figure 4

References that have used the dB(G) filter to assess wind farm ILFN are not credible because the G weighting filter attenuates the blade pass pulses and the harmonics associated with those pulses (<5Hz).

The WHO 2018 Environmental Noise Guidelines completed the most comprehensive peer review of studies in this area and states: "Five low-quality systematic reviews of wind turbine noise effects on mental health and well-being have been carried out (Ellenbogen et al., 2012; Kurpas et al., 2013; Merlin et al., 2013; Onakpoya et al., 2015; Schmidt & Klokker, 2014). These reviews differed in their conclusions and delivered inconsistent evidence that wind turbine noise exposure is associated with poorer quality of life, well-being and mental health."

Because there were differences of opinion from the research that was cited the WHO rated this work of low quality: "Therefore, the evidence for no substantial effect of wind turbine noise on quality of life, well-being or mental health was rated very low quality".

However, it is incorrect to suggest that there is *no* evidence that wind farm noise can cause adverse health effects. The WHO rate the research demonstrating no adverse health effects as low quality.

The meaning embedded in the WHO's phrasing is critical to how its guidance is interpreted.

The WHO refers to a lack of evidence for no adverse effect, not a lack of evidence for an adverse effect.

Research is ongoing but 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 of 85 dB(G).

Although the G-weighted filter significantly attenuates the blade pass and associated harmonics from a wind turbine it is worth noting that the 2006 Hayes McKenzie report show the result of an on/off test in that report, shown below (Figure 12 from reference).

An extract from this report explains that "Wind turbine noise may result in internal noise levels within a dwelling that is just above the threshold of audibility," that was assumed to be 85 dB(G).

The 2019 Flinders University research changes the threshold of audibility of wind farm noise to 48 +/- 2 dB(G) which would change the conclusion in the Hayes McKenzie DTI report; 'The measurement of low frequency noise at three UK wind farms', URN no. 06/1412 from 2006.

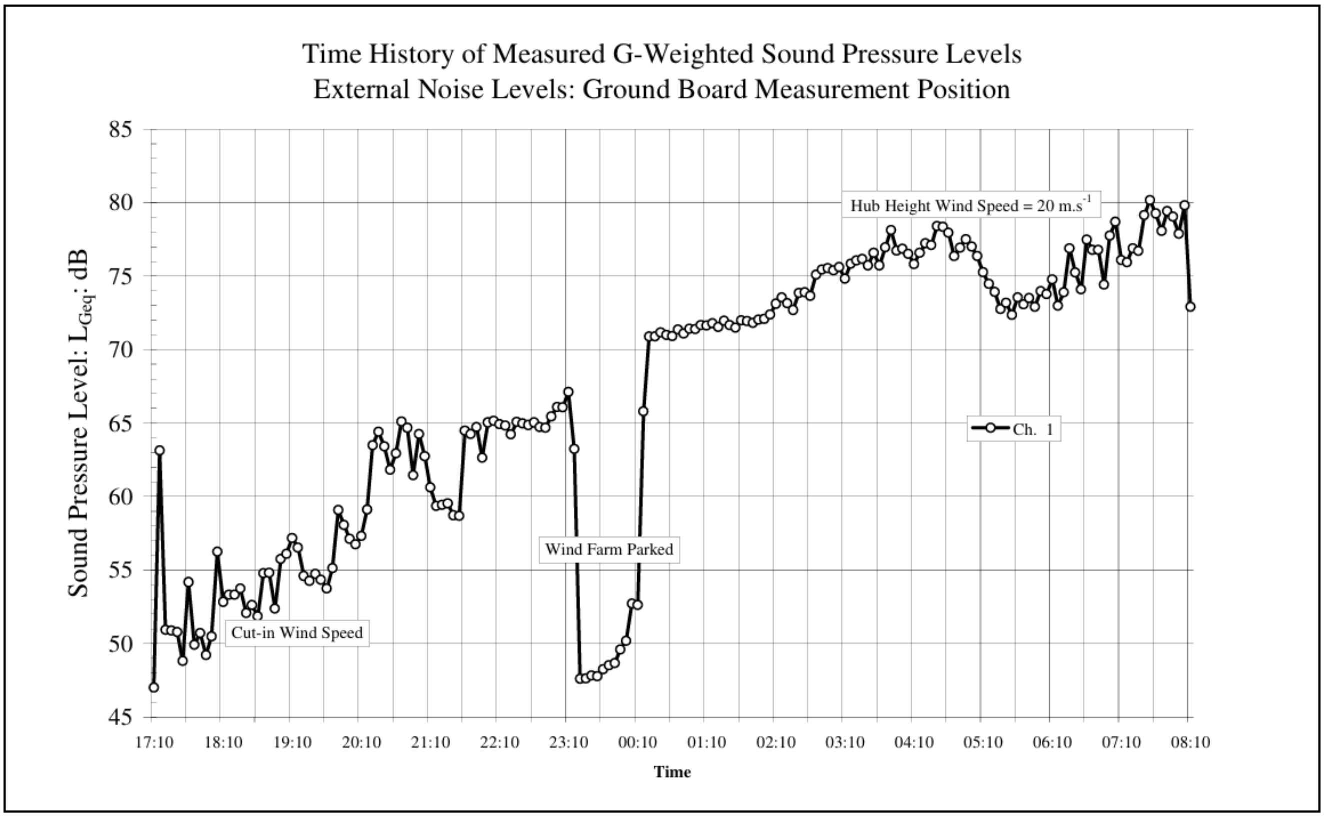


Figure 12: Time History Figure of G-Weighted Sound Pressure Levels for a Wind Farm

Much of the recent research into human response to wind farm generated infrasound has been based on *synthesised* wind farm sound played to subjects in a laboratory"

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.

My own measurements at the Cape Bridgewater Wind Farm, also confirmed by S Cooper in his 2014 study[11], showed that low frequency sound from the output shaft of the gearboxes to the generators exceeded DEFRA NAN-R-45 indoor recommended guideline values at 32 Hz.

Furthermore, the 32 Hz tones were modulated in frequency and random in level.

The NVA has not considered low frequency noise impacts. The A-weighting filter significantly attenuates low frequency noise, which is why DEFRA NAN-R-45 uses unweighted one third octave sound levels in the frequency range from 10 Hz through to 200 Hz.

Low frequency sound is an important issue that should be reported in an EIAR. An example requirement has been implemented in Planning by the Limerick County Council that applies the Danish low frequency guideline limits.

I have recently measured low frequency sound outside a dwelling during on/off testing near to a newly constructed wind farm. Figure 5 shows the results of measurements at the dwelling that is approximately 2 km from the nearest 3.6 MW wind turbine.

Measurements of the 40 Hz, 50 Hz, 63 Hz and 80 Hz one third octave unweighted sound levels before, and after the shutdown period, just prior to midnight, show that the threshold values of DEFRA NAN-R-45 were exceeded. Outside measurements were corrected to indoor levels for typical building façade attenuation according to Downey and Parnell (2017).

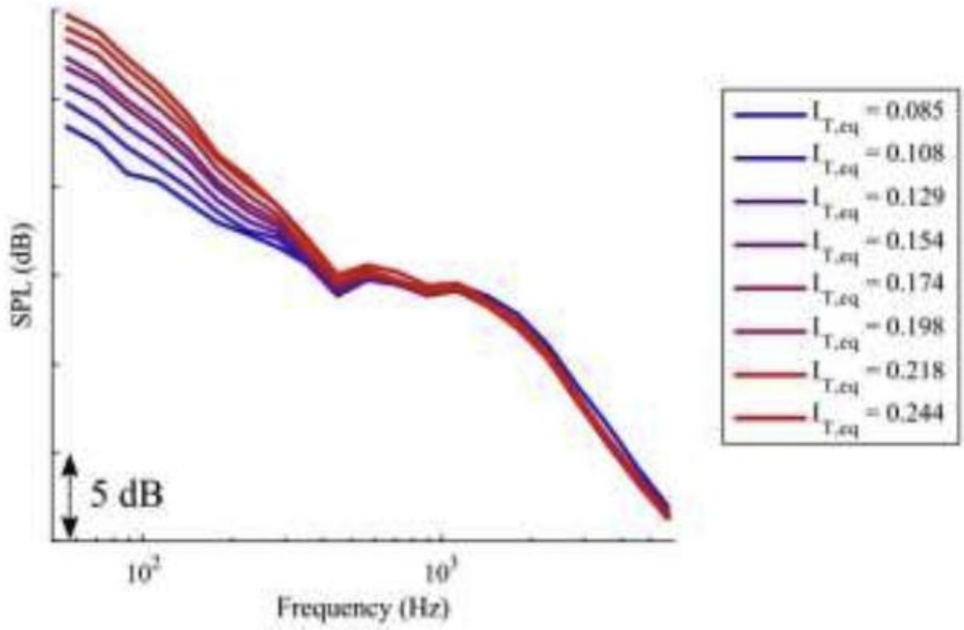
The occupants of the dwelling had complained about low frequency noise nuisance from the nearby wind farm and in this instance, the complaints were justified.

Both Colas and Buck show that wake turbulence from wind turbines spaced too close together cause increase in low frequency sound from downwind turbines.

Buck et al.[12] studied the turbulent inflow noise experimentally on a full-scale wind turbine with a 108 m diameter and 2.3 MW capacity. The purpose of the study was to assess the effect of inflow turbulence on wind turbine noise. Fifty hours of sound data were collected by 12 microphones mounted at different angles. The results showed a high correlation between turbulence intensity and noise levels. Buck shows the correlation between turbulence intensity and sound pressure level in the following chart:

[11] Cooper, S. "The results of an acoustic testing program - Cape Bridgewater Wind Farm" The Acoustic Group Report 44.5100.R7MSC, Nov 2014

[12] Buck, Steven & Oerlemans, Stefan & Palo, Scott. (2016). Experimental characterization of turbulent inflow noise on a full-scale wind turbine. Journal of Sound and Vibration. 385. 10.1016/j.jsv.2016.09.010.



The correlation between turbulence intensity and sound pressure level [Steven Buck]

The NVA has mistakenly dismissed ILFN as an issue.

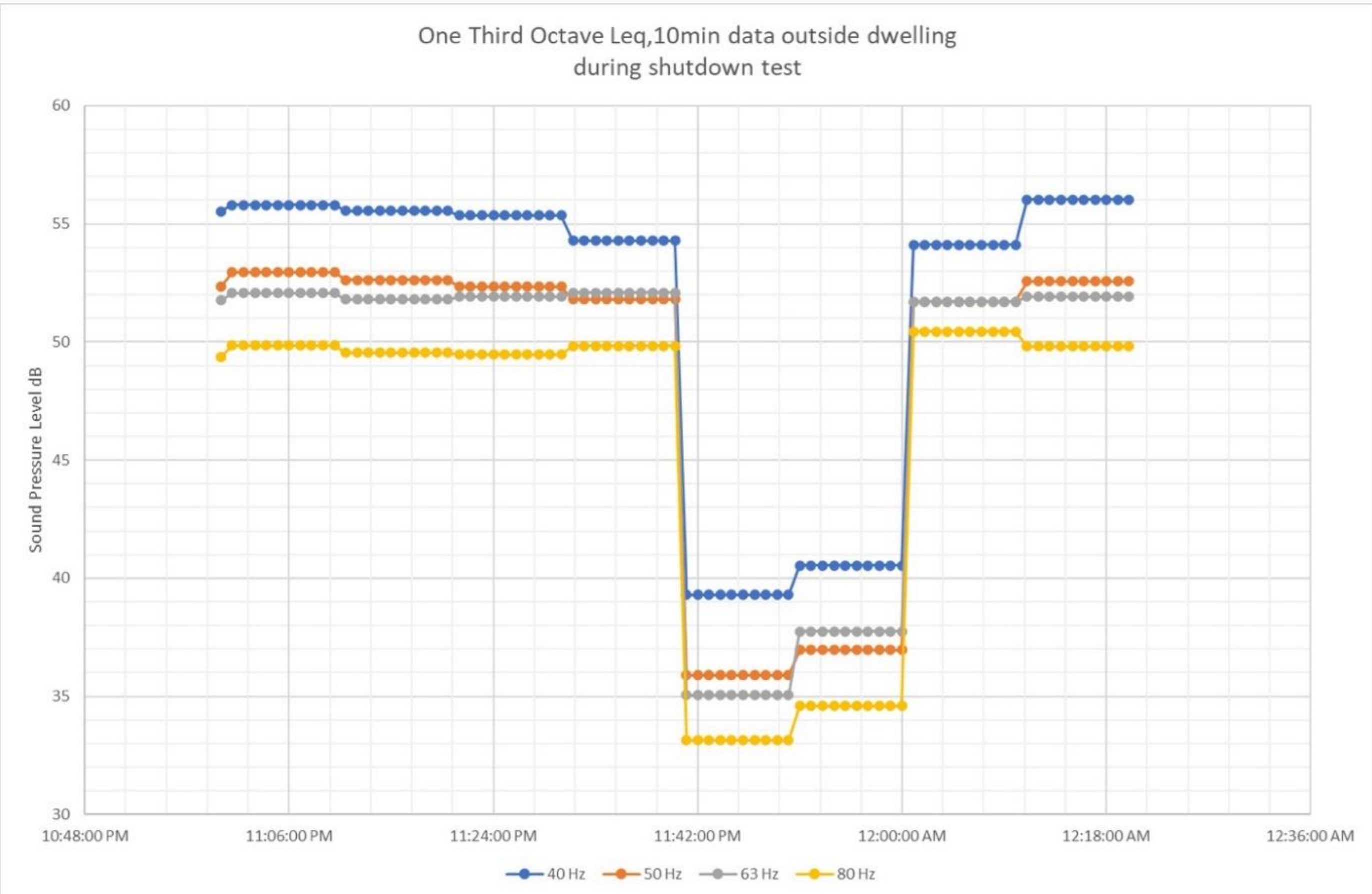


Figure 5

It would be advisable to measure current ambient ILFN at the NSLs to supplement A-weighted Background survey results.

Low frequency noise predictions should also be completed in frequencies below that which ISO9613-2 allows. ISO9613-2 is only applicable for the octave bands from 63 Hz through to 8 kHz.

The NVA is deficient in the assessment of ILFN.

SETBACKS

The NVA has mentioned in section 12.3.7 that dwelling H033 is 529m from a wind turbine.

The HSE position paper also refers to best practice for setback distance from any turbine to a dwelling of 10 times the rotor diameter. This equates to a best practice setback distance of 1.5 km for the proposed candidate wind turbine rotor diameter of 150m.

Wind turbines are proposed to be less than 530 m from the nearest dwelling so best practice according to the HSE position paper has not been applied.

Clare County Council (CCC) reasons for refusal

CCC list four reasons for refusal dated 20 January 2022, of which only Reason 2 refers to noise, as follows:

"It is an objective of the Clare County Council Development Plan, 2017-2023, as varied, as set out under Objective CDP 8.40 € to strike an appropriate balance between facilitating renewable and wind energy related development and protecting the residential amenity of neighbouring properties. Having regard to the scale and height of the turbines as proposed, the location of the site on this open landscape and the proximity to existing residential properties, it is considered that the consequential noise and disturbance generated from the proposed wind turbines in combination with existing and permitted windfarms would seriously injure the amenities of residential property in the vicinity. Furthermore it is considered that the proposed turbines would be visually overbearing on existing properties and thus depreciate the value of property in the vicinity. The proposed development would therefore be contrary to Objective CDP 8.40 of the development plan and be contrary to the proper planning and development of the area."

Most of the deficiencies highlighted in this peer review of the EIAR and NVA are reflected in the concerns of the CCC that provided its reasoning for refusal.

The Appeal to An Coimisiun Pleanála was also dismissed.

The main difference between this and the earlier application is the addition of an extra wind turbine (T9).

CONCLUSIONS

The NVA does not provide any confidence that an acceptable noise impact will result from the proposed development.

An Coimisiun Pleanála should dismiss/refuse the Slieveacurry Wind Farm application.

The NVA within the EIAR does not consider site effects or audible characteristics such as low frequency, tonality or amplitude modulation.

The assessment methodology adopted in the NVA follows guidelines that have been shown to be deficient and are currently under review.

The WEDG 2006 guidelines recommend a range of acceptable sound levels during the day but the NVA has elected to choose the highest noise limit in the range that could be applied, based upon what I consider to be an incorrect evaluation of the test for a low noise environment.

The NVA predicts optimistic sound levels that demonstrate increases in noise of more than 10 dB for the surrounding residents that conflicts with the objectives of WEDG 2006.

The impact assessment approach from IEMA for operational noise from the development has not been applied correctly.

If it was properly applied then the development would have an impact described as 'Very Substantial Effect' according to IEMA Guidelines and 'Very Significant' and 'Profound' effect according to 'Guidelines on the Information to be contained in Environmental Impact Assessment Reports' (EPA, 2022). This is contrary to the suggestion in the NVA (12.6.3.1.1) that operational noise is 'not significant'.

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.i-ince.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 a 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 35 years I have worked in Australia as a noise and vibration consultant and have operated through my own consultancy firm for the past 29 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.

I have also prepared the Brisbane Noise Survey in 1998 for the Brisbane City Council and was the author of the Noise Impact Assessment Planning Scheme Policy for Brisbane City Council's City 2000 Planning Scheme.

Of relevance to wind farm related assessment 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; "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 thirteen 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 and the UK. 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

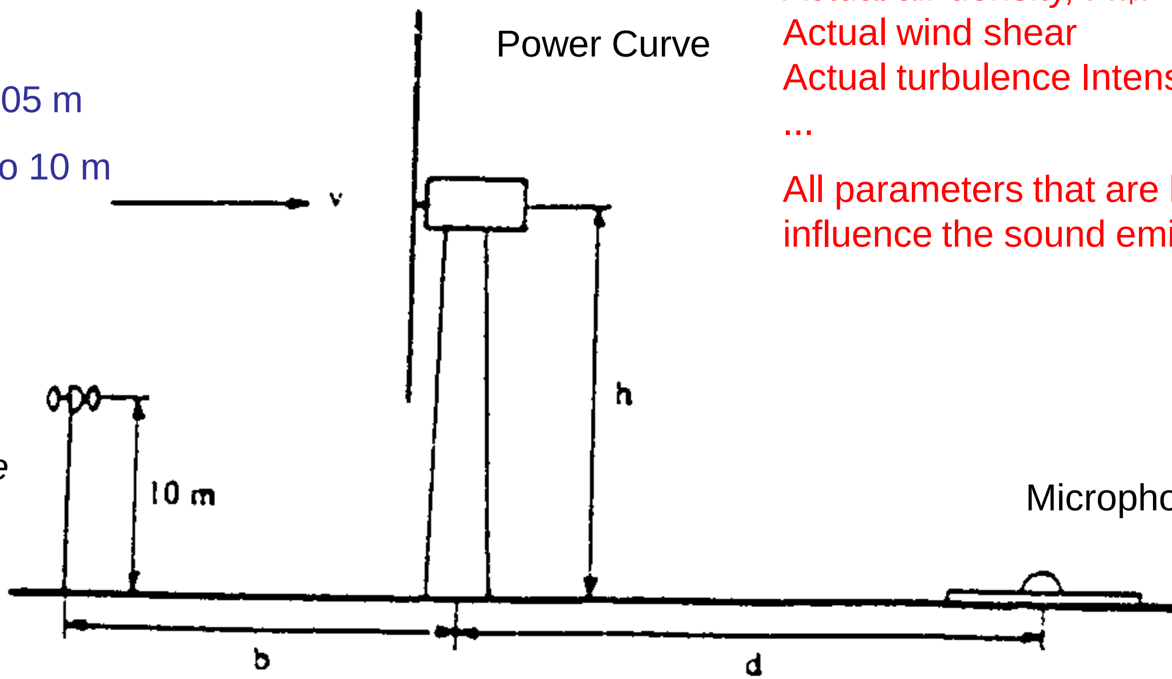
All recalculated to 10 m
wind speed

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

Power Curve



Anemometer
For background noise only

Microphone

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.

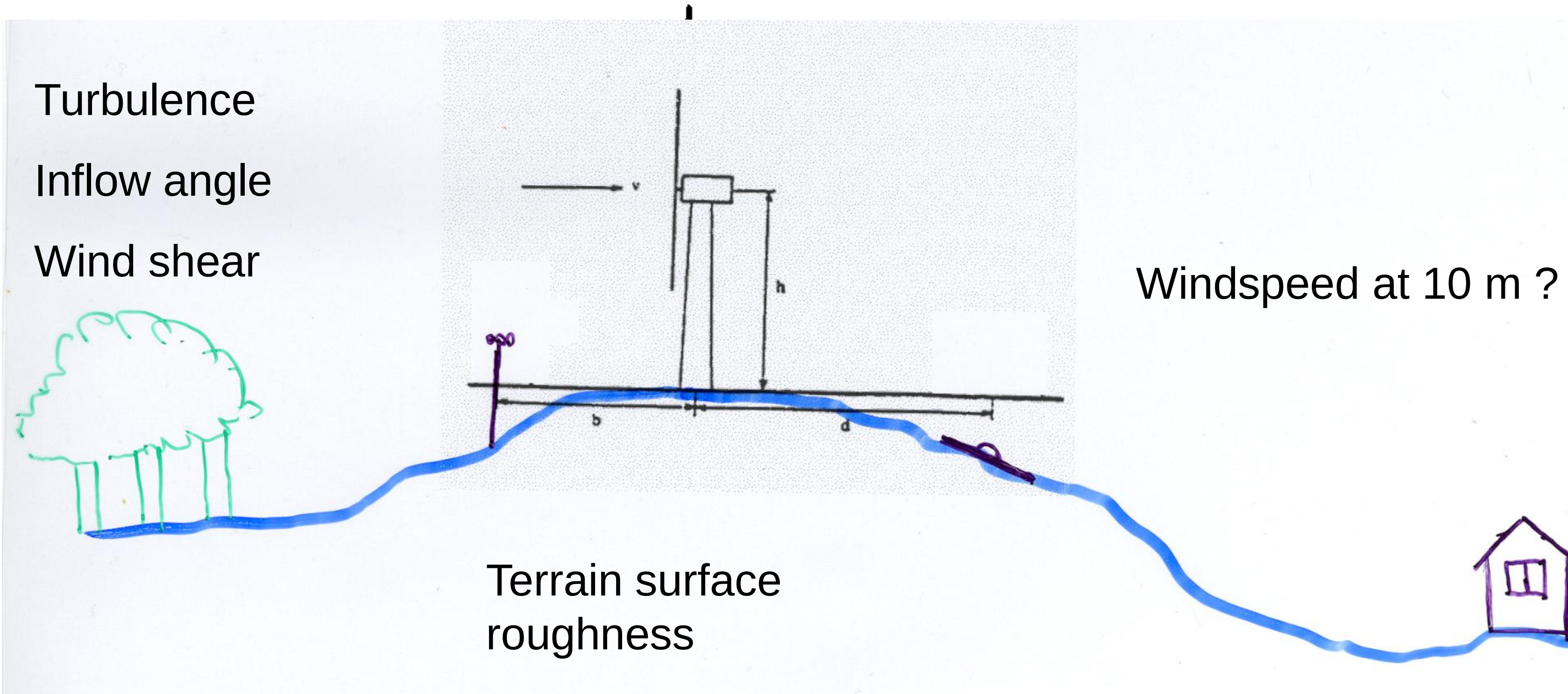
- Further we see different air density
- different wind shear
- different turbulence in inflow air
- different inflow angles

- 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

$$\sigma_{res} = \sigma_{method} + \sigma_{source} = \sigma_{method} + \frac{\sqrt{\sum(\sigma_i \cdot 10^{L_i/10})^2}}{\sum 10^{L_i/10}}$$

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

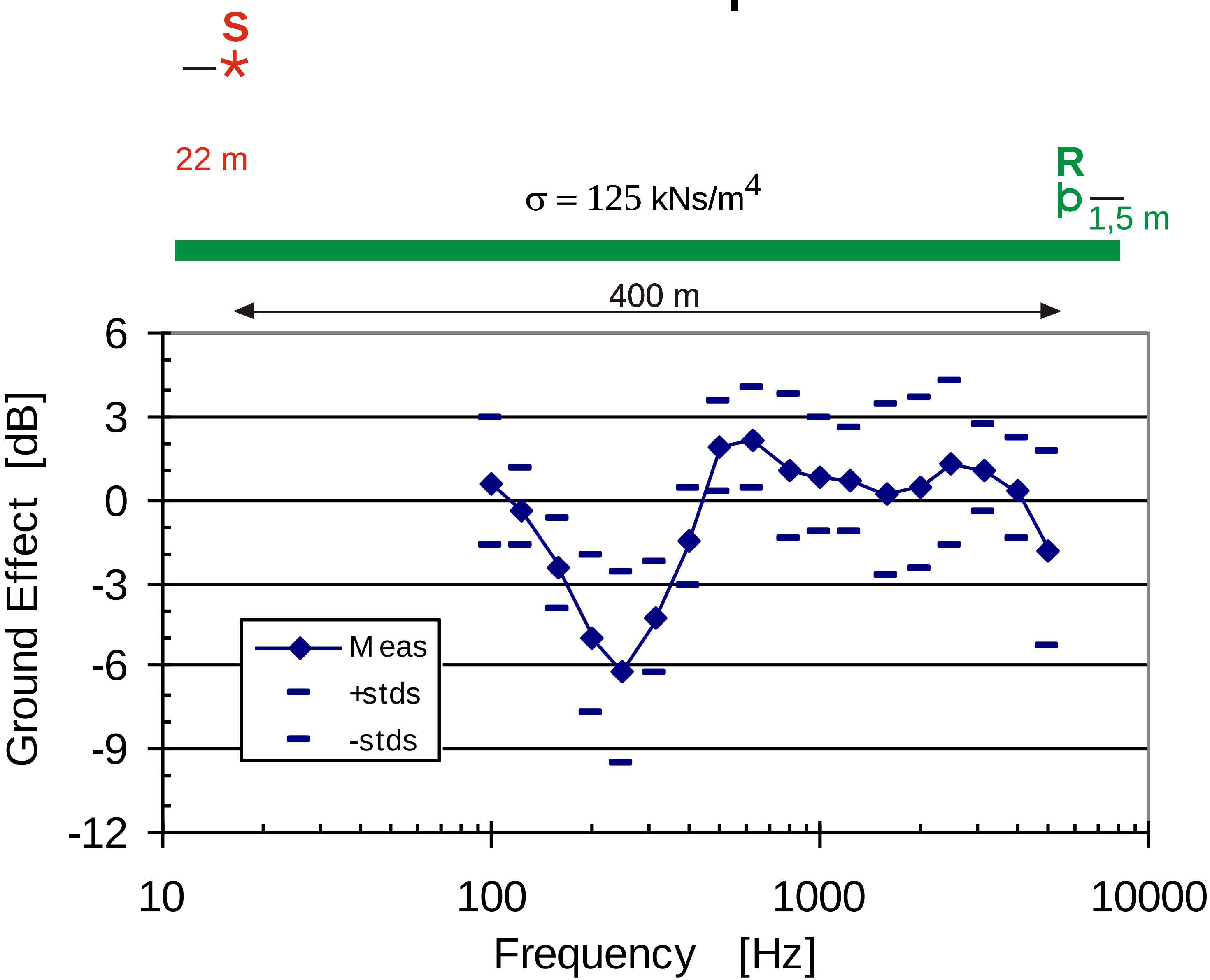
- There are lots of different noise level calculation models:
  - ISO 9613-2 which is the model that we see the most
  - VDI 2714
  - Concawe
  - BS 5228
  - General Prediction Method (Danish)
  - Danish EPA Guidelines
  - Netherlands Guidelines 1999
  - Swedish method (land/sea)
  - .....

- 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

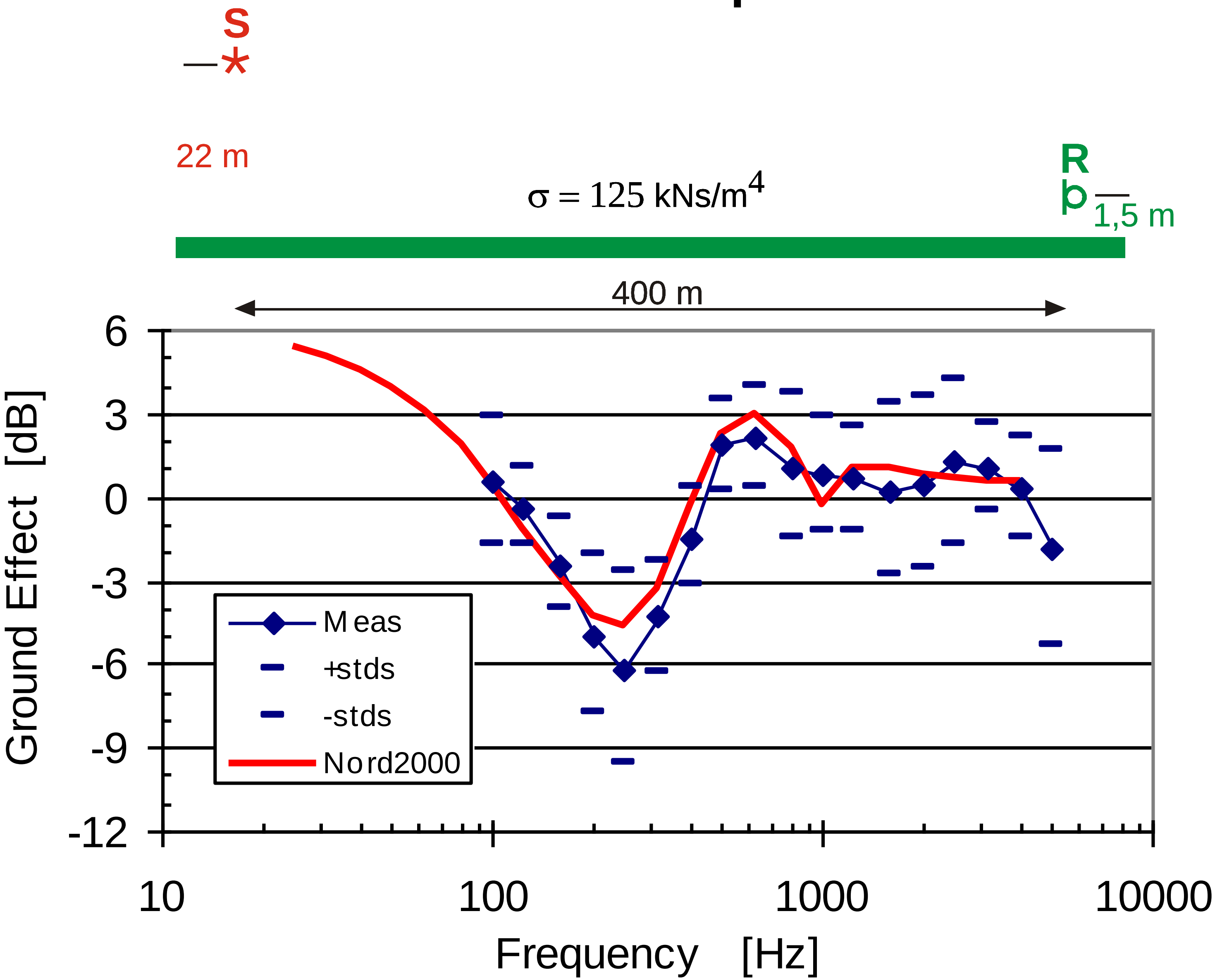
Noise calculation models

- 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*

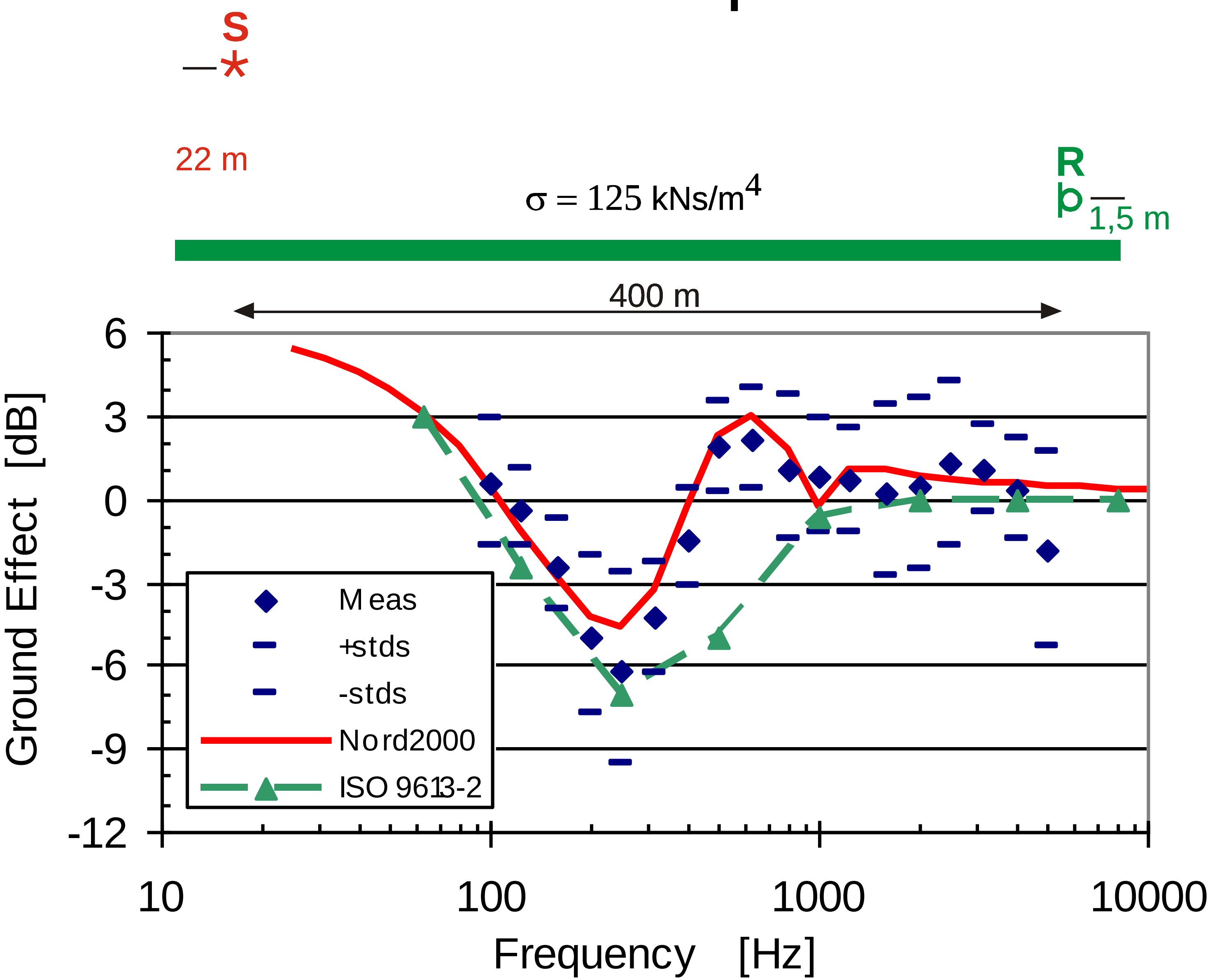
Nord2000 / WiTuProp vs. ISO 9613-2



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
  - ..

Questions ?

Appendix C

Suzlon Energy – Site effects

Siting of Wind Farms: Basic Aspects

When searching the internet for the definition of the word “layout” I came across following:

Layout in word processing and desktop publishing refers to the arrangement of text and graphics. The layout of a document can determine which points are emphasised and whether the document is aesthetically pleasing. While no computer program can substitute for a professional layout artist, a powerful desktop publishing tool can make it easier to lay out professional looking documents (source: www.webopedia.com)

In principle the same is valid for wind farm planning: The term layout in wind industry is used for choosing optimal locations for wind turbines. Tools like flow models help to identify the best positions, but cannot replace the engineer making the final decision by balancing interests.

So what is that engineering experience, what factors influence the decision?

Jessica Rautenstrauch, wind energy consultant from Anemos, Germany, at work.
© Paul Langrock (www.unendlich-viel-energie.de)

Wind resource

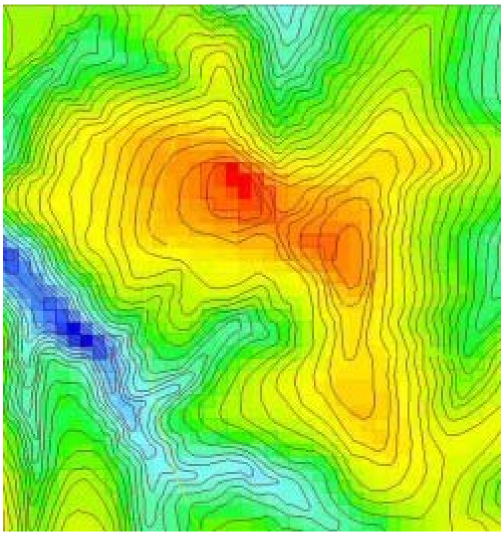
The wind resource is the most obvious factor to concentrate on when choosing a wind turbine location. We have a wide range of options to determine the wind resource of the site. The quality of the tools varies significantly and so does their price.

Common sense is a good starting point. Nature itself helps to guide us to suitable sites. Flagging of trees – permanent flagging and not the temporary bending in the wind – shows us the prevailing wind direction and is a good indicator for the strength of the wind.

However because of the uncertainty involved, using common sense as the only tool is of course insufficient. For any bankable estimate of the energy yield on-site wind speed measurements are required. The number of measurement masts required for a specific site depends next to the size of the project mainly on the complexity of the terrain. The measurement height should be minimum 2/3 of the expected future hub height. An increase in measurement height beyond this leads to a reduction of the uncertainty in the energy estimate. The measurement period must be one year or more to avoid any seasonal bias. Since the wind speed varies also inter-annually typically up to +/-12% a long-term correction is highly recommended.

The measured wind regime is extrapolated across the site to derive a resource map of the site using different flow models /4, 5/. A wind map like the one in Graph 1 can then be used to identify the windiest locations.

However additionally technical constraints should be taken into account when developing a layout /3/. A number of site specific wind load parameters can be extracted from the wind speed measurement. They are used to optimize the technical suitability of the chosen layout and the wind turbine type for the site specific wind regime.



Graph 1: Example Wind Resource Map. The colours denote the energy content of the wind, red high and blue low energy content.

Technical restrictions

Wind turbines are designed for specific conditions. During the construction and design phase assumptions are made about the wind climate that the wind turbines will be exposed to. In rough terms: For very complex sites with high wind speeds "heavy-duty" versions of wind turbines are available, which are sturdier but also more costly. Low wind speed sites in flat terrain do not put so high demands on the on the wind turbine structure, hence the construction can be more light-weight and hence cheaper. The different turbines have been classified by the IEC, class 1 being the highest wind speed class. The following table is a simplified summary of the IEC classification /1/.

IEC class	I	II	III	IV
V_{ave} (m/s) annual average wind speed at hub height	10	8.5	7.5	5
V_{ref} (m/s) 50-year maximum 10-minute wind speed	50	42.5	37.5	30

Table 1: IEC classes

But not only the wind speed but also other parameters play a role and have to be checked, when developing a layout for a specific turbine.

One of the most important parameters is the turbulence intensity. Turbulence intensity quantifies how much the wind varies typically within 10 minutes. Because the fatigue loads of a number of major components in a wind turbine are mainly caused by turbulence, the knowledge of how turbulent a site is of crucial importance.

We have to distinguish between two different sources of turbulence. Turbulence is generated by terrain features – which is referred to as ambient turbulence intensity - as well as by neighbouring wind turbines – which referred to as induced turbulence (Figure 1). Sources of ambient turbulence are for example forests, hills, cliffs or thermal effects. Thus ambient turbulence can be reduced by avoiding critical terrain features. But the wake-induced turbulence has far more impact than the ambient turbulence intensity /2/. Decreasing the spacing increases the turbulence induced by the wakes of neighbouring wind turbines meaning that there are limits to how close you can space the turbines. As a general rule the distance between wind turbines in prevailing wind direction should be a minimum of the equivalent of five rotor diameters. The spacing inside a row perpendicular to the main wind direction should be a minimum of three rotor diameters.

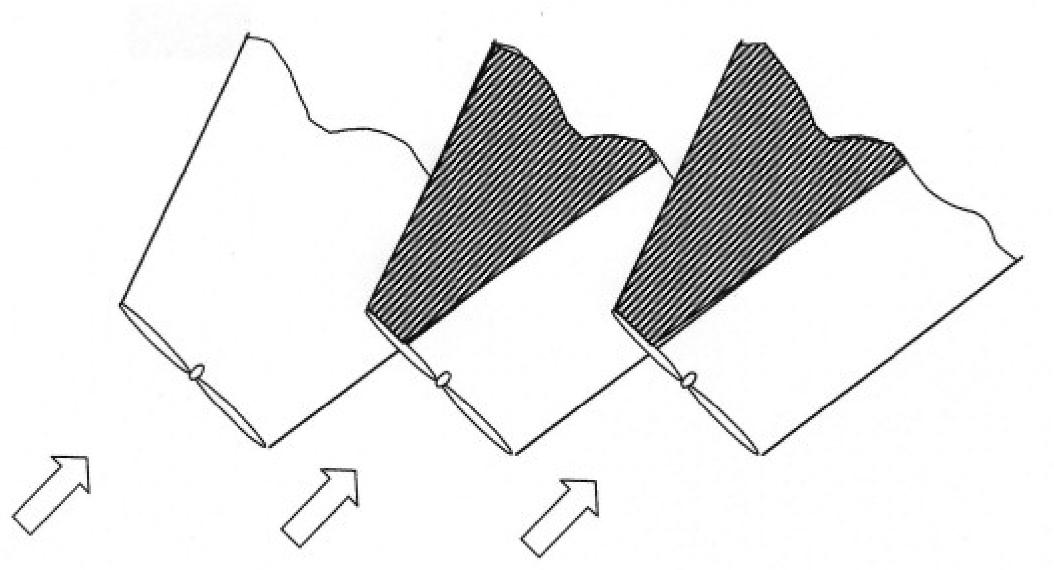


Figure 1: Shadowing in wind farm

If a layout is too close the resulting fatigue loads might be too high. In order to then ensure the lifetime of the main components wind sector management might have to be applied, meaning that some wind turbines might have to be switched off when they are operating in the wake of the neighbouring wind turbine.

Another parameter which has to be checked when developing a layout is the flow inclination, velocity tilt or in-flow angle. When wind turbines are to be placed on steep slopes or cliffs the wind might hit the rotor not perpendicular but at an angle. This angle is related to the terrain slope. With increasing height above ground level the effect of the terrain slope is normally reduced such that the terrain slope is only of indicative use to estimate the velocity tilt. A large in-flow angle will not only reduce the energy production but will also lead to an increased level of fatigue of some of the mayor components.

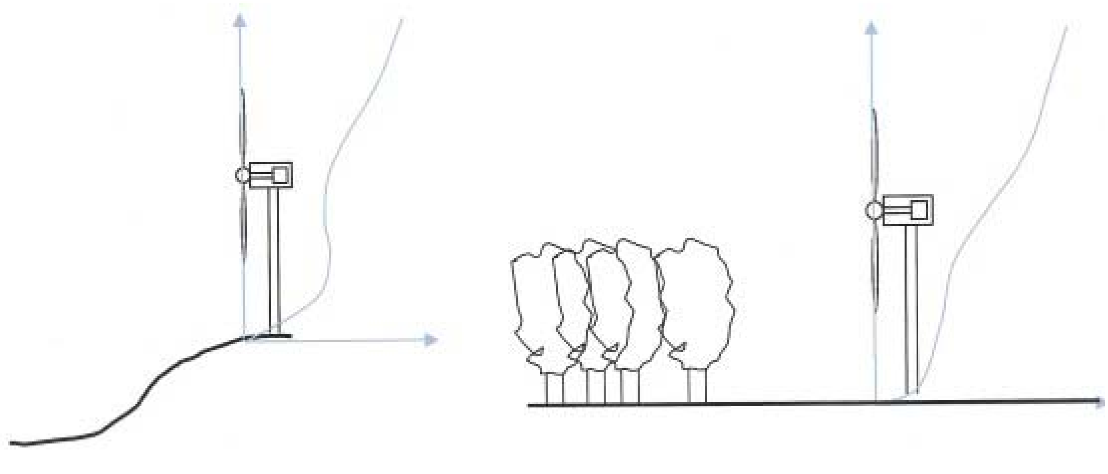


Figure 2: Distorted wind profile at steep slope (left) and behind a forest (right)

Furthermore a steep slope might cause a negative gradient across some parts of the rotor (Figure 2).

Normally the wind speed increases with increasing height. In flat terrain the wind speed increases logarithmically with height. In complex terrain the wind profile is not a simple increase and additionally a separation of the flow might occur, leading to heavily increased turbulence. The resulting wind speed gradients across the rotor lead to high fatigue loads particularly on the yaw system.

Obstacles like forest can have a similar effect on the wind profile and should be thus avoided.

Planning constraints

Next to the wind resource and technical considerations a good layout should also take planning constraints into account. The visual impact is course the most obvious. A layout that follows the shape of the terrain rather than straight rows of wind turbines appears to be less intrusive. Noise is another important parameter to take into account. Next to noise also the impact due to flicker at the nearest inhabited houses should be estimated. The accepted levels vary from country to country.

Electro-magnetic interference can cause problems. Hence placing wind turbines in a transmission corridor should be avoided.

Some areas on site might have to be excluded from development due to other factors related to fauna, flora and archaeology.

Jessica Rautenstrauch, wind energy consultant from Anemos, Germany, at work.
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Summary

A large number of parameters have to be taken into account when developing a layout. Some work can be done using tools, but in the end the balance between financial, technical and planning constraints can be best done by an experiences engineer.

Literature

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/2/ S. Frandsen, St.; L. Thøgersen, L.;: Integrated Fatigue Loading for Wind Turbines in Wind Farms by Combining Ambient Turbulence and Wakes; Wind Engineering, Vol. 23 No. 6, 1999
/3/ K. Kaiser, W. Langreder: Site Specific Wind Parameter and their Effect on Mechanical Loads, Proceedings EWEC, Copenhagen, 2001
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/5/ E. L. Petersen, N. G. Mortensen, L. Landberg, J. Højstrup and H. Frank: Wind Power Meteorology Part II: Siting and Models, Wind Energy, 1, 55-72 (1998)

Wiebke Langreder
Suzlon Energy: www.suzlon.com

Appendix D

EPA Tasmania wind farm noise policy

EPA Board Policy

Noise limits for wind energy projects

Application

This policy is adopted by the Board of the Environment Protection Authority (EPA Board) for the purpose of assessing wind energy projects and requiring conditions or restrictions in respect to wind farm noise under the *Environmental Management and Pollution Control Act 1994* (EMPCA).

This policy supersedes any previous policy of the EPA Board in respect to operational noise criteria for wind energy projects. This policy does not apply to construction noise.

This policy applies from 31 July 2025 and will apply to all wind energy projects currently under assessment. It remains in place until revoked.

Technical terms

L_{Aeq} means the A-weighted equivalent continuous sound level.

L_{A90} means the A-weighted sound level that is exceeded for 90% of the measurement period.

dB means decibel.

dB(A) means decibel when stating A-weighted sound pressure level.

Design Criteria

The predicted equivalent noise level at any noise sensitive premises should not exceed the greater of:

a) **35 dB(A) $L_{Aeq,\ 10\ min}$; or**
b) **Background (L_{A90}) + 5 dB(A).**

This design criteria applies to all noise emissions from the activity, inclusive of wind turbines and all ancillary infrastructure. It has been set for the protection of sensitive receivers during periods of low background noise.

The background noise for day, evening and night-time must be calculated separately to determine the applicable (lowest) background level, and is not to be averaged across a 24-hour period.

For predictive purposes, a difference of ~2 dB between measured $L_{A90,\ 10\ min}$ levels and $L_{Aeq,10\ min}$ emissions from the activity must be noted. The predicted noise levels should be adjusted for special audio characteristics and/or the applicable adjustment factors must be discussed.

The EPA South Australia *Wind farms environmental noise guidelines 2021* (or the most recent revised version of that document) is to be used for assessing whether a wind farm can meet this design criteria, except where that guideline may be inconsistent with this policy.

Noise Measurements

If approved, wind energy projects will contain conditions and restrictions to enforce the design criteria. The following guidance is provided for the interpretation of EPA Board wind energy project noise requirements:

1. It is generally acceptable for wind turbine noise to be measured in L_{A90}, but note that alternative techniques may be required (including measuring in L_{Aeq}) to better detect special audible characteristics (dominant and intrusive characteristics) and noise fluctuations or intermittent noise.

2. An appropriate conversion factor must be added to the measured L_{A90} level to derive the representative L_{Aeq} noise level. To be representative of L_{Aeq}, generally applying +2 dB(A) conversion factor to the measured L_{A90} level is acceptable.

3. Where special audible characteristics (dominant and intrusive characteristics) are detected from any wind farm noise, a correction factor must be applied in accordance with the *Tasmanian Noise Measurement Procedures Manual*.

4. The EPA South Australia *Wind farms environmental noise guidelines 2021* (or the most recent revised version of that document) is to be used for all wind farm noise measurements, except where that guideline may be inconsistent with this policy.

29 July 2025

Andrew Paul
Chair
Environment Protection Authority Board