

8. Noise and Vibration

8.1 Introduction

- 8.1.1 An assessment will be undertaken of the likely significant effects of the Proposed Development on the environment with respect to operational noise. This section of the scoping report summarises the proposed scope for the noise assessment. The chapter has been prepared by Ion Acoustics Ltd for the Applicant.
- 8.1.2 Operational noise from wind turbines includes aerodynamic noise from the movement of the blades and mechanical noise from the turbine components, such as the generator and the gearbox. Turbine manufacturers have been able to control most of the mechanical sources, so they are now less significant. Aerodynamic noise is restricted by control systems which regulate the pitch and rotational speed of the blades.
- 8.1.3 The sound from wind turbines rises quickly from the cut-in wind speeds and then remains at the same level from close to the rated power to the cut-out speed. The background noise, such as that from wind blowing through trees and vegetation, is typically low at low wind speeds and increases steadily with wind speed. Background noise at high wind speeds can mask the sound from wind turbines.
- 8.1.4 Wind farms are often situated in rural environments where there are few other sources of noise. Therefore, at residential distances, wind turbine sound can be audible at a low level and noise limits are recommended to protect amenity and prevent sleep disturbance. Appropriate noise limits which vary with wind speed can be derived using ETSU-R-97 (The Working Group on Noise from Wind Turbines, 1996) and the Institute of Acoustics' Good Practice Guide (IoA GPG) (Institute of Acoustics (IoA), 2013). These documents are specified as the appropriate assessment methodology in Welsh planning guidance.
- 8.1.5 There will also be a short-term noise impact from the construction of the wind turbines and associated access tracks and borrow pits (if required). Vibration can also be associated with some construction activities. Similar noise and vibration impacts can occur during decommissioning. Noise will be generated from traffic movements associated with the delivery of construction materials and turbine components. However, construction and decommissioning works are temporary effects carried out at substantial separation distances from residential properties and generally during daytime hours only.
- 8.1.6 The Proposed Development will require a grid connection. Audible noise (corona discharge noise) is a feature of high voltage overhead lines although mostly only within a 100m of the line. Construction noise can occur from other construction of overhead lines and buried cables. At present, there are no details of the grid connection route. However it is proposed to assess any potential operational or construction noise from grid connection in the noise chapter for the Proposed Development.

8.2 Legislation and Guidance

Future Wales: The National Plan

8.2.1 The Welsh Government's overarching planning policy document is Future Wales: The National Plan 2040 (Welsh Government, 2021). Policy 18 on renewable and low carbon energy provides planning guidance relevant to renewable and low carbon energy proposals, including those brought forward under the Significant Infrastructure Projects (SIP) regime.

8.2.2 It also notes that: *The cumulative impacts of existing and consented renewable energy schemes should also be considered.*

Planning Policy Wales – Edition 12 (February 2024)

8.2.3 The Planning Policy Wales (PPW) (Welsh Government, 2024) also sets out planning policies and states:

Planning authorities should also identify and require suitable ways to avoid, mitigate or compensate adverse impacts of renewable and low carbon energy development. The construction operation, decommissioning, remediation and aftercare of proposals should take into account:

- *the need to minimise impacts on local communities, such as from noise and air pollution, to safeguard quality of life for existing and future generations;*

8.2.4 Section 6.7 of PPW considers air quality and soundscape and paragraph 6.7.15 on the location of commercial, industrial and other potentially polluting development states:

For the purposes of this section, potentially polluting development includes commercial, industrial, energy [164] and agricultural or transport infrastructure. Such development should be located in areas where there is low potential for public exposure, or where its impact can be minimised. Novel or new development types may potentially cause pollution and should be carefully considered, and where appropriate, decisions should be based on the precautionary principle.

8.2.5 The footnote No. 164 states (with hyperlinks removed):

Further guidance on wind turbine noise assessment can be found in ETSU-R-97 and further good practice guidance published by the Institute of Acoustics.

8.2.6 Welsh planning policy does not set fixed numerical criteria for wind turbine operational noise. Welsh Government guidance directs users to ETSU-R-97 and to good practice guidance published by the Institute of Acoustics for wind turbine noise assessment. Currently, Welsh Government online guidance on assessing wind turbine noise (Welsh Government, n.d.) states simply:

We encourage use of the Institute of Acoustics good practice guide on wind turbine noise assessment.

8.2.7 The Institute of Acoustics Good Practice Guide (IoA GPG) is more formally titled 'A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind

Turbine Noise. Accordingly, ETSU-R-97 will be used for the assessment with the refinements and enhancements described in the IoA GPG. These documents are described below.

ETSU-R-97

8.2.8 ETSU Report ETSU-R-97 published in September 1996, was the result of deliberations of the Working Group on Noise from Wind Turbines, which was set up by the Government to derive guidelines for assessing wind turbine noise.

8.2.9 The basic aim of ETSU-R-97 is to provide:

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

8.2.10 The ETSU limits are set in terms of the L_{A90} noise parameter. This is defined as the noise level exceeded for 90% of the measurement time. It is taken to represent the ‘background noise’, that is the underlying noise level in the absence of short-term events. This unit was chosen to assess turbine noise, which is fairly steady, because extraneous short-term events such as discrete car passes, and aircraft do not usually affect the L_{A90} index. For wind turbine noise, the L_{A90} noise parameter is typically 2 dB less than the L_{Aeq} parameter. The L_{Aeq} can be regarded as an average noise level over a time period.

8.2.11 The ETSU report provides a method for assessing wind turbine noise and in particular, the setting of external noise limits which are either:

- relative to the background noise (L_{A90} dB), or
- fixed when background noise levels are otherwise very low.

8.2.12 In most rural locations, the background noise depends on the wind speed. For rural environments, the "fixed" part of the ETSU limit usually applies at low wind speeds. At high wind speeds, noise from wind in the trees and flowing over local features such as roofs can be considerable and is often sufficient to mask the sound of wind turbines. Therefore, it is often at lower wind speeds that the turbines are more audible.

8.2.13 The ETSU-R-97 limits set relative to background noise levels are derived separately for 'amenity hours' daytime periods and for the night-time, defined as 11pm to 7am. The amenity hours daytime periods are chosen to reflect periods when people might be outside in their gardens and are defined as:

- All evenings from 6pm to 11pm
- Saturday afternoons from 1pm to 11pm and
- All day Sunday (7am to 11pm)

- 8.2.14 For the daytime amenity hours periods, the suggested noise limits are 35 to 40 dB L_{A90} or 5 dB above the prevailing background, whichever is the greater. A degree of judgment is required in determining the fixed limit within the 35 to 40 dB L_{A90} range and ETSU-R-97 states that this will depend on:
- The number of dwellings in the neighbourhood of the wind farm
 - The effect of noise limits on the number of kWh generated
 - The duration and level of exposure
- 8.2.15 For night-time periods, the ETSU noise limit is 43 dB L_{A90} or 5 dB above the background, whichever is the greater. The 43 dB L_{A90} limit was derived from a sleep disturbance limit of 35 dB L_{Aeq} (internally) with an allowance of 10 dB for the attenuation of an open window to derive the corresponding external noise level and with 2 dB subtracted to account for the use of the L_{A90} noise index rather than the L_{Aeq} .
- 8.2.16 The ETSU-R-97 night-time limit was partly based on the previous World Health Organisation (WHO) internal noise standard of 35dB L_{Aeq} . Since the publication of ETSU-R-97, a later WHO document 'Guidelines for Community Noise' (World Health Organisation (WHO), 1999) reduced the internal night-time noise standard to 30dB L_{Aeq} "to avoid negative effects on sleep". The same WHO guidelines recommend that "at night-time, outside sound levels approx. 1 metre from facades of living spaces should not exceed 45dB L_{Aeq} , so that people may sleep with bedroom windows open". This was based on a reduction of 15dB for the sound level difference between the inside and outside with an open window. The WHO 45dB L_{Aeq} external noise limit at 1m from a façade translates to a limit of 42dB L_{Aeq} in free-field conditions, away from the façade, and is equivalent to 40dB L_{A90} for wind turbine noise. The operational noise assessment for the Proposed Development will be undertaken in accordance with ETSU-R-97, applying the refinements set out in the IoA Good Practice Guide, with noise limits derived in accordance with the ETSU-R-97 framework..
- 8.2.17 For single turbine schemes, or for remote sites a long way from residential properties, ETSU-R-97 reports the opinion of the noise working group that:
- "if the noise is limited to an L_{A90} , 10min of 35 dB(A) up to wind speeds of 10m/s at 10m height, then this condition alone would offer sufficient protection of amenity and background noise surveys would be unnecessary".*
- 8.2.18 ETSU-R-97 allows for a higher limit where the residents are 'financially involved' with the wind turbine development. The suggested limit is 45 dB L_{A90} , or 5 dB above the background noise, whichever is the greater, for both the daytime and night-time periods. Properties which are financially involved with the proposed development will be confirmed in the ES.
- 8.2.19 Where audible tones are present in the noise spectrum, ETSU-R-97 stipulates that a tonal penalty of up to 5 dB be added to the turbine noise levels. The magnitude of the tonal penalty depends on the audibility of the tone.

8.2.20 At the time of writing (May 2026), a revision to ETSU-R-97 is understood to have been prepared and is awaiting publication by the UK Government following a public consultation in 2025. The ES will adopt any new guidance issued during the assessment phase of the project.

Institute of Acoustics Good Practice Guide (2013)

8.2.21 In May 2013, the IoA published the 'Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise. The document was prepared with the purpose of agreeing current good practice in the application of the ETSU-R-97 methodology to wind turbine schemes. The document was prepared by a specialist working group and reviewed by a peer group of professionals working in a variety of relevant disciplines. A discussion of ETSU-R-97 noise limits was excluded from the remit of the working group as these are a matter of Government policy.

8.2.22 The Good Practice Guide clarified a number of issues relating to noise surveys, noise predictions and on assessing cumulative noise levels.

8.2.23 For noise surveys, the document requires wind shear to be taken into account in the assessment. The preferred method of ensuring this is to measure the wind speed at the turbine hub-height and then convert the data to 10 m height using the standard log-law equation. This ensures that the turbine sound power levels are referenced to the background noise levels derived using the same wind shear assumption. The baseline survey to be carried out will follow this guidance.

8.2.24 The IoA GPG also confirms that ISO 9613-2 should be used for wind turbine noise predictions, with certain stipulations and limitations. This standard is discussed below with supplementary information on the attenuation factors provided in Appendix 8.1.

8.2.25 The GPG identifies various strategies for cumulative assessments. The following principles apply:

- Where a new wind farm is predicted to have noise levels within 10dB of an existing wind farm, then a cumulative assessment is necessary;
- For existing wind farms, the cumulative predictions must consider the consented limits under which the scheme can operate; and
- Whenever a cumulative situation is encountered, the noise limits for an individual wind farm should be determined in such a way that no cumulative excess of the total ETSU-R-97 noise limit would occur.

8.2.26 A cumulative noise assessment will be included in the ES. The cumulative assessment will consider operational wind energy developments within the defined cumulative study area and, where relevant, consented schemes will be represented using their consented noise limits.

- 8.2.27 The IoA GPG should be regarded as a refinement of the ETSU-R-97 guidance to ensure consistency. The Welsh Government recommends the use of the document for assessing wind turbines and the operational noise assessment will follow this guidance.

BS ISO 9613-2: 2024

- 8.2.28 ETSU-R-97 does not prescribe a calculation method for predicting wind turbine noise. However, the noise assessment will use BS ISO 9613-2: 2024 (British Standards Institution, 2024) with modifications and input parameters described in the IoA GPG. The Standard allows noise levels to be predicted for short-term downwind conditions, i.e. for wind blowing from the proposed turbine towards the houses. This provides a typical worst-case scenario.

- 8.2.29 Noise from wind turbines is reduced by distance, atmospheric losses, screening effects and other “miscellaneous” losses. Noise levels can be increased or reduced by the interaction of the sound waves with the ground. The propagation model calculates the predicted sound pressure level at a specified distance by taking the sound power level in octave frequency bands and subtracting a number of attenuation factors according to the various losses and the ground effect as described above. The noise level in each octave band can be represented by the equation:

$$\text{Predicted Noise Level } L_{90} = L_{W(\text{eq})} + D - A_{\text{geo}} - A_{\text{atm}} - A_{\text{gr}} - A_{\text{bar}} - A_{\text{misc}} - 2\text{dB}$$

- 8.2.30 The calculation is carried out for each octave frequency band and then the predicted octave band levels are summed together to give the overall A-weighted predicted sound level for downwind conditions. Distance loss (or A_{geo} in the equation above) is the most significant factor. The correction of 2 dB is not part of the standard, but is used to convert the L_{Aeq} levels, as used to describe the turbine sound power, to the L_{A90} parameter, used in the ETSU assessment.

- 8.2.31 The Institute of Acoustics Good Practice Guide also includes for a valley correction of +3dB when a certain criterion relating to the mean height of propagation is met. Essentially, multiple ground reflections can occur for propagation across concave ground (such as across a valley), and this can result in increased noise levels. The latest 2024 version of ISO 9613-2 was published after the IoA GPG and includes a valley correction formula in Annex D. However, this differs slightly from the IoA GPG version. The IoA version is slightly more conservative and will be implemented in these calculations unless alternative guidance is agreed.

- 8.2.32 The attenuation factors in the calculation and the valley correction are described further in Appendix 8.1.

Guidance on Construction Noise and Vibration

- 8.2.33 The following legislation and standards are of particular relevance to construction noise and vibration:

- The Control of Pollution Act 1974 (CoPA 1974) (UK Parliament, 1974);

- BS 5228: 2009 Code of Practice for Noise and Vibration Control on Construction and Open Sites (British Standards Institution, 2009).
- The Calculation of Road Traffic Noise (CRTN) Department of Transport (Department of Transport, 1988)
- The Design Manual for Roads and Bridges LA 111 - Noise and vibration (Design Manual for Roads and Bridges (DMRB), 2020)

8.2.34 CoPA 1974 provides local authorities in Wales, England and Scotland with powers to control noise and vibration from construction sites. Section 60 of the Act enables a Local Authority to serve a notice to a contractor of its requirements for the control of site noise. Section 61 of the Act allows for those carrying out construction work to apply to the Local Authority in advance for consent to carry out the works.

8.2.35 Construction noise can be assessed using British Standard BS 5228 which provides a calculation method and general guidance on controlling noise and vibration from construction sites. This standard:

- Refers to the need for the protection against noise and vibration of persons living and working in the vicinity of and those working on construction sites;
- Recommends procedures for noise and vibration control in respect of construction operations; and
- Stresses the importance of community relations, stating that early establishment and maintenance of these relations throughout the site operations will go some way towards allaying people's fears.

8.2.36 There are no noise limits within the main text of BS 5228 and in fact, the preferred approach is to use best practicable means to reduce noise rather than setting limits. This means that everything practicable should be done to reduce noise. This strategy will be adopted here. A Construction Environmental Management Plan (CEMP) will set out best practicable means measures to reduce noise.

8.2.37 However, Annex E of the BS 5228-1 gives "example criteria for the assessment of the significance of noise effects" e.g. for use in Environmental Statements. For quiet areas, where the existing ambient noise levels are low, a significant noise effect is deemed to occur if the construction noise (plus the ambient noise) exceeds the following threshold values:

- 65 dB L_{Aeq} Daytime (07.00-19.00) and Saturdays (07.00-13.00)
- 55 dB L_{Aeq} Evenings and Weekends (19.00-23.00 Weekdays, 13.00-23.00 Saturdays and 07.00-23.00 Sundays)
- 45 dB L_{Aeq} Night-time (23.00-07.00)

- 8.2.38 These values can be used in preliminary assessments to assess the significance of any construction works. In our experience the daytime threshold (65 dB L_{Aeq}) would not be breached for activity on the wind farm site.
- 8.2.39 The acceptability of construction noise is likely to be affected by the location of the site relative to the noise sensitive premises; existing ambient noise levels; the duration and working hours of site operations; the characteristics of the noise produced and the attitude of local residents to the site operator. Given that construction noise is not expected to exceed the 65 dB L_{Aeq} daytime threshold and that it is a short-term effect, typically occurring in the daytime, it is not always necessary to consider construction noise and vibration within the scope of an Environmental Impact Assessment. It is proposed that a construction noise and vibration assessment for activity on the main wind farm site is excluded from the ES as there will be no significant effects due to the large distances to the residential properties. Noise and vibration during decommissioning are also proposed to be excluded. The CEMP will describe measures to control noise using best practicable means.
- 8.2.40 Noise can also occur during construction from traffic on local roads include the transportation of construction materials and turbine components. Where traffic data is available the increase in noise due to construction traffic can be calculated according to the Government guidance “The calculation of road traffic noise” (CRTN). Significance criteria relating to the change in traffic noise are available in the Design Manual for Roads and Bridges LA 111.
- 8.2.41 An assessment of construction traffic noise will be provided in the ES. It may also be necessary to assess construction noise and vibration from the grid connection depending on the route chosen. This will be included where appropriate.
- 8.2.42 Depending on the nature and route of the grid connection, there may be a requirement to assess construction noise associated with the grid connection. This might include buried cable routes and the construction of pylons for the overhead lines. This will be reviewed when details of the route become available.

Local Authority Guidance and Consultation

- 8.2.43 The local authority, Ceredigion County Council will be fully consulted on the noise and vibration assessment and on the noise monitoring positions selected for the noise survey. If possible, the precise measurement positions would be agreed with them in person during the survey set up. The proposed methodology and proposed survey locations are set out in subsequent sections.

National Grid Guidance on Corona Discharge Noise

- 8.2.44 The National Grid has a policy on noise from overhead lines documented in National Grid Policy Statement PS(T)1343 (2021) Operational Audible Noise Policy. This document will be used to assess the impact of potential corona discharge noise alongside National Grid

Technical Guidance Note TGN(E)322 (2021) “Operational Audible Noise Assessment Process for Overhead Lines (New Build, Reconductoring, Diversion and Uprating)” which allows for the noise impact (and hence significance of the effect) to be assessed for EIA reports.

8.3 Study Area

- 8.3.1 The Institute of Acoustics Good Practice Guide defines a study area for the baseline survey to be those properties within the 35 dB L_{A90} noise contour. The preliminary scoping 35 dB L_{A90} noise contour for a 27-turbine layout with Nordex N163 6.X MW turbines for this scheme is shown in Plate 8-1. This turbine is noisier than some alternatives including the Vestas V162 / V150 and therefore gives a more conservative assessment of the extent of the study area.
- 8.3.2 However, it is necessary to increase the overall study area in this case to allow for changes in the layout and to allow for cumulative noise issues. In practice this results in a study area of around 4km from any turbine. Although this may be increased if there are any proposed or consented wind farms which need to be assessed.
- 8.3.3 A separate study area will be defined for the grid connection when details are available.

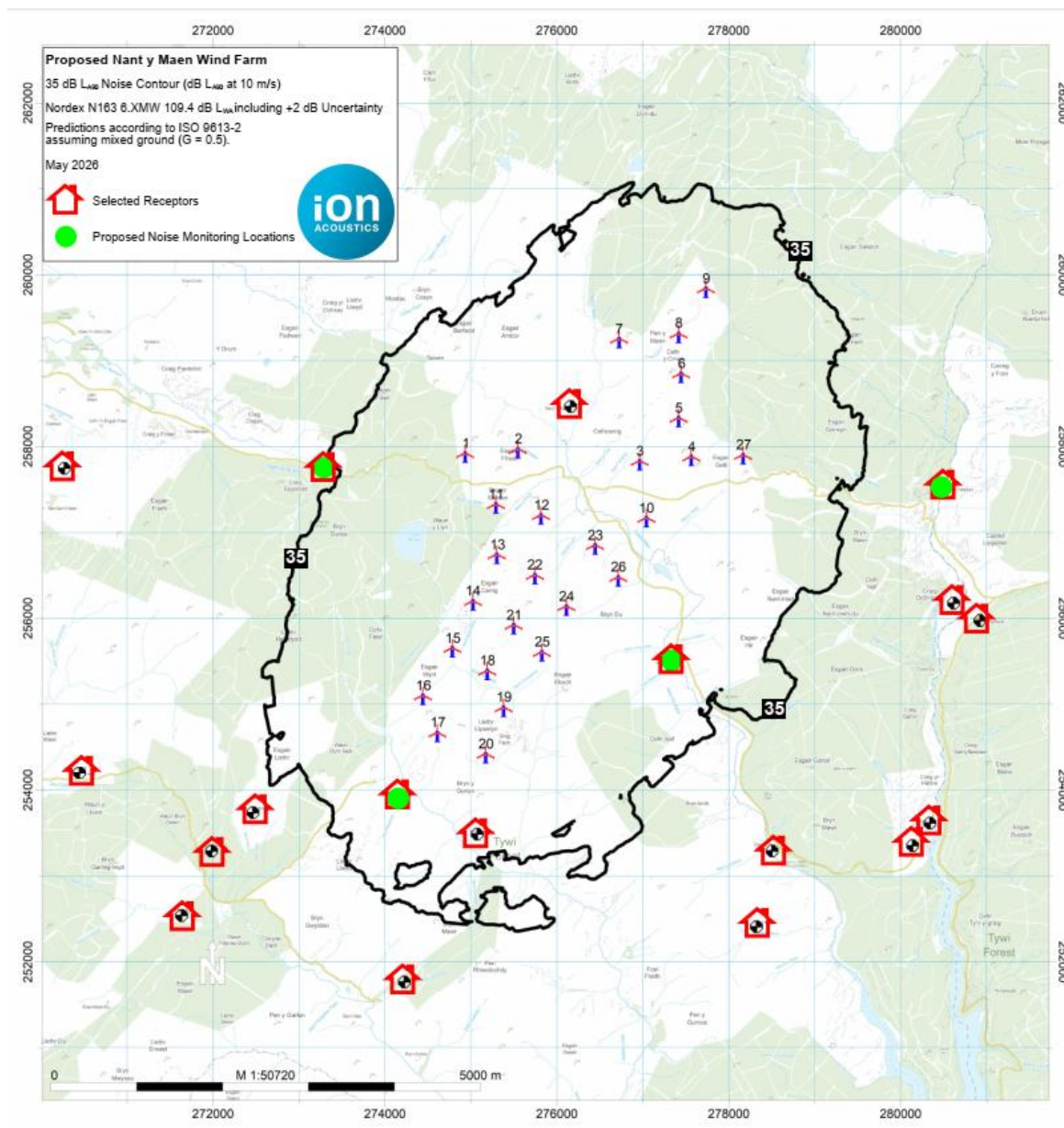


Plate 8-1 - 8.1-35 dB L_{A90} Noise Contour for an indicative 27-turbine layout

8.4 Baseline Context

8.4.1 The site is in a rural area. The noise climate is likely to be determined by natural sounds such as bird song, water courses and the noise of the wind blowing through trees and other vegetation. Traffic noise will be heard close to roads but generally noise levels are anticipated to be fairly low.

8.5 Embedded mitigation and design assumptions

8.5.1 For the purposes of scoping the following design assumptions have been made:

- The site layout will undergo various design iterations where noise is considered alongside other disciplines. Layouts will be reviewed in terms of the impact on any identified noise-sensitive receptors.

- Where required to achieve compliance with the derived ETSU-R-97 noise limits, the assessment will take account of available turbine noise-reduction features and operational low-noise modes.
- Most modern turbine types are available with the turbine blades fitted with serrated trailing edges (STE). These can reduce turbine noise levels by around 2dB compared with standard blades. It will be assumed that turbines are fitted with serrated trailing edges or other noise-reducing features.

8.6 Potential Significant Effects

Operational Noise

- 8.6.1 Operational noise will be considered in the Environmental Statement. Noise limits will be derived from the baseline survey in accordance with ETSU-R-97 and the IoA Good Practice Guide, and the Proposed Development design will incorporate mitigation where required to achieve compliance with those limits. The assessment will be fully described in the ES.
- 8.6.2 ETSU-R-97 states that the noise limits apply to the cumulative effect of noise from all wind turbines in the area. Therefore, all wind energy developments, either operational, consented or in planning, which may require consideration in the assessment process will be identified. A cumulative noise assessment with this scheme will be undertaken as part of the overall assessment.
- 8.6.3 Other potential noise and vibration impacts associated with wind turbines including tonality and amplitude modulation will also be discussed.
- 8.6.4 In December 2024, the Institute of Acoustics published a “Statement in Respect of Wind Farm Noise Assessment” (Institute of Acoustics (IoA), 2013). This concluded that there was no requirement for IoA members to assess (operational) Infrasound, Low Frequency Noise or Vibration as the absolute levels were too low to result in noise effects. Therefore, these topics are scoped out of the EIA.

Construction Noise

- 8.6.5 Construction and decommissioning effects are not often usually significant in EIA terms as any effect is temporary and the large source to receptor distances will result in low noise levels during the daytime which are temporary. It is proposed to scope out a quantitative assessment of construction and decommissioning noise for activity on the main Proposed Development site from the assessment. The proposed CEMP will set out mitigation and best practicable means measures to reduce construction and decommissioning noise.
- 8.6.6 An assessment of construction traffic noise will be carried out using the significance criteria set out in the DMRB LA 111.

Table 8.1 - Summary of Likely Significant Effects

Receptor	Potential Effects	Scoped In
Construction Phase		
Housing	Construction Traffic Noise	✓
Housing	Construction Noise	X
Housing	Construction Vibration	X
Operational Phase		
Housing	Operational Noise	✓
Housing	Infrasound, Low Frequency Noise and Vibration	X
Housing	Operational Traffic (Maintenance etc)	X
Decommissioning Phase		
Housing	Construction Noise	X
Housing	Construction Vibration	X

8.7 Scoping Assessment

- 8.7.1 Further to the above, Table 8.2 below provides details on the matters proposed to scope out of further assessment within the ES.

Table 8.2 - Matters to be scoped out of the assessment

Matters to be scoped out of the assessment	
Matter	Rationale
Construction Noise & Vibration	Construction noise and vibration is rarely significant in EIA terms because of the large source to receiver distances and the acceptable higher noise threshold for temporary construction work. Instead, construction noise and vibration can be controlled via a CEMP which could be conditioned with a suitably worded planning condition requiring agreement with the local authority before commencement of construction.
Infrasound, Low Frequency Noise and Vibration during Operation	Infrasound, Low Frequency Noise and Vibration from wind turbines, while detectable do not result in absolute levels which are significant at residential distances and the Institute of Acoustics advice to members is that they do not need to be assessed.
Decommissioning Noise and Vibration	As with construction noise and vibration, this is a temporary noise carried out during the daytime far away from residential properties.

8.8 Proposed Assessment Methodology

- 8.8.1 To carry out an operational noise assessment of the Proposed Development in accordance with ETSU-R-97 and the IoA Good Practice Guide, the following steps are required:
- Specify the number, candidate types and locations of the wind turbines;
 - Identify the locations of the nearest, or most noise sensitive, receptors;
 - Determine the background noise levels from measurements as a function of site wind speed at a representative sample of the nearest properties;

- Determine the quiet day time and night-time noise limits from the background noise levels identified at the nearest properties in consultation with the local authority and following ETSU-R-97 guidance;
- Calculate the noise levels owing to the operation of the wind turbines as a function of site wind speed at the nearest properties;
- Compare the calculated noise immission levels with the derived ETSU-R-97 noise limits and assess in the light of relevant planning requirements;
- Identify potential mitigation measures including changes to layout, turbine type and the use of low noise modes as required;
- Identify any cumulative noise issues associated with other existing, consented and schemes in the planning system and if necessary, reconsider mitigation.

8.8.2 The following noise monitoring positions are proposed:

- Diffwys
- Blaendoithie
- Maesglas
- Nant-ystalwyn

8.8.3 These locations are shown in Figure 8.1 above. It is proposed to monitor noise levels at these properties for a period of 4 weeks. Wind speed measurement at the turbine hub height will be carried out at the same time using one or more Lidar units installed on the Proposed Development. The noise data will be correlated with the wind speed measurements to determine the prevailing background noise level at the standardised wind speeds at 10m height.

8.9 Summary of Scoping position

- 8.9.1 Likely significant effects can occur from operational noise from wind turbines. However appropriate noise limits can be derived from the baseline noise survey in accordance with ETSU-R-97 and the Institute of Acoustics Good Practice Guide. These limits will be derived to protect residential amenity and to avoid sleep disturbance, in accordance with ETSU-R-97 and the IoA Good Practice Guide.
- 8.9.2 It is not proposed to assess noise and vibration during construction or decommissioning for activity on the wind farm site. These issues are not significant for daytime activity owing to the large source to receiver distances. Noise and vibration can be controlled with a CEMP. An assessment of construction noise on local roads will be provided.
- 8.9.3 An assessment of noise from the grid connection route in terms of construction and operation will be carried out when a suitable route or alternative routes are available.

8.10 References

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Glossary of Terms

DeciBel dB

Unit used to quantify sound pressure levels or noise levels. 0 dB is the approximate threshold of hearing and 120 – 140 dB is the threshold of pain. A decibel is a logarithmic quantity and for sound pressure is calculated relative to a reference sound pressure of 20 μ Pa. A change of 1 dB is just detectable under carefully controlled listening conditions.

A weighted decibel dB(A)

The dB(A) unit used to describe a sound pressure level with the frequency spectrum weighted to account for the sensitivity of human hearing at different frequencies. Human hearing is less sensitive at low and high frequencies and most sensitive at speech frequencies, typically 500 Hz to 2kHz. The dB(A) weighting better describes the subjective effect. A change of 3 dB(A) is typically the minimum noticeable difference for noises with a similar character. A change of 10 dB(A) is equivalent to a subjective doubling or halving of loudness. A-weighted noise levels are denoted by a suffix 'A' as in LAeq, L_Amax etc.

Hertz, Hz

Unit used to describe frequency of noise equivalent to the number of cycles per second. Human hearing is normally taken to extend from 20 Hz to 20,000 Hz but with reduced sensitivity at lower and higher frequencies (see dB(A) above). The 'Noise Spectrum' is the distribution of the noise across different frequency bands.

L_{A90} dB

The L_{A90} noise parameter is A-weighted noise level exceeded for 90% of the measurement period. This noise index is widely accepted as a descriptor of 'background' noise levels which is the underlying noise in the absence of short-term events. A "fast" time weighting is used unless stated otherwise.

L_{Aeq,T} dB

The L_{Aeq} noise level is defined as the equivalent steady-state sound level over a specified measurement period with the same energy as the actual fluctuating noise over the same time period. This noise index is widely accepted as a descriptor of 'ambient' or average noise level. Note for wind turbine noise, the L_{Aeq} noise level is typically 2dB greater than the L_{A90} noise level. For other sources such as traffic, there is usually a greater variation.

Sound Power Level SWL or L_{WA} dB

The sound power level is the basic quantity describing the output of a noise source. Our ears hear sound *pressure*, but a source emits sound power. It is a decibel unit relative to a reference level of 1×10^{-12} Watts or 1 picoWatt (1pW). Noise from wind turbines can be rated in terms of the sound power level. Note this is an energy average in that it is derived from L_{eq} measurements. The sound power in terms of the L₉₀ parameter is 2dB less.

Appendix 8. 1 BS ISO 9613-2 IoA GPG Calculation Parameters

The ISO 9613-2 method calculates the sound pressure level at a specified distance by taking the source sound power level for each turbine in octave frequency bands and subtracting a number of attenuation factors. The noise level in each octave band can be represented by the equation:

$$\text{Predicted Level } L_{90} = L_{w(\text{eq})} + D - A_{\text{div}} - A_{\text{atm}} - A_{\text{gr}} - A_{\text{bar}} - A_{\text{misc}} - 2\text{dB}$$

The predicted octave band levels from each of the turbines are then summed together to give the overall 'A' weighted predicted sound level from all the turbines acting together. The correction of 2dB in the formula above is used to convert the L_{eq} levels, as used to describe the turbine sound power, to the background level L_{90} , used in the ETSU assessment. The various factors are described below.

Source Data - $L_{w(\text{eq})}$

The sound power level of a noise source is normally expressed in dB re 1 pW (1×10^{-12} Watts). The predictions have been made using the sound power data as detailed in the main report.

Directivity Factor - D

For some sources, a directivity factor, D, due to the source must be considered. However, for wind turbines, the sound power level is measured downwind and predicted in downwind conditions and therefore no directivity correction is necessary as any effect is inherent in the measurement. Therefore, D is taken as zero.

Geometrical Divergence (Distance Loss) – A_{div}

Geometrical divergence is the name given to the distance loss which occurs as the source sound power is spread out over an increasing surface area as the distance from the source increases. This is the most significant loss associated with propagation and the loss rate is the same at all frequencies. A wind turbine is considered to be a point source and therefore there is a 6dB loss per doubling of distance. This is expressed mathematically according to:

$$A_{\text{div}} = 20\log(d) + 11\text{dB}, \text{ where } d \text{ is the distance from the turbine, in metres.}$$

Atmosphere Attenuation - A_{atm}

Atmospheric losses occur as the energy in the sound wave is converted to heat. This is a frequency-dependent process and high frequencies are more readily attenuated than low frequencies. The losses are dependent on humidity and temperature and are represented by the following equation:

$$A_{\text{atm}} = d\alpha, \text{ where } d \text{ is distance from the turbine (in metres), and } \alpha \text{ is atmospheric absorption coefficient (dB/m).}$$

Part 1 of ISO 9613 provides tables with the values of α corresponding to various temperatures and humidity. The calculations take a conservative approach as outlined in the Institute of Acoustics

Good Practice Guide, assuming a temperature of 10°C and a relative humidity of 70% which gives low levels of atmospheric attenuation, as shown in the table below.

Atmospheric Absorption Coefficients (dB/m) at 10°C and 70% RH

Octave Band Centre Frequency (Hz)	63 Hz	125 Hz	250 Hz	500 Hz	1kHz	2kHz	4kHz	8kHz
Atmospheric Absorption Coefficient α (dB/m)	0.0001	0.0004	0.001	0.0019	0.0037	0.0097	0.0328	0.117

It can be seen in the table that at low frequencies (63-125 Hz) atmospheric loss factors are very small compared with the values at higher frequencies. Over large distances, this has the effect of shifting the dominant sound of wind turbines downwards towards the lower frequencies.

Ground Effect - A_{gr}

This factor describes the effect of sound waves reflected off the ground interfering with the sound waves propagating directly from source to receiver. The ground effect depends on the source height, receiver height, the propagation distance between the source and receiver and, the ground conditions.

The ground conditions are described with a variable G which is set between 0 for “hard” ground (which includes paving, water, ice, concrete and any sites with low porosity) and 1 for “soft” ground (which includes grass, crops, trees and other vegetation). For propagation close to soft ground, significant attenuation can occur, but this effect is diminished for an elevated source such as a wind turbine.

The predictions have been carried out using a source height corresponding to the proposed hub height and a receiver height of 4m which corresponds to the height of a 1st floor window. Mixed ground attenuation ($G = 0.5$) has been used in accordance with the Institute of Acoustics Good Practice Guide.

Barrier Attenuation - A_{bar}

When a source is not visible behind a solid element, a loss occurs as the sound waves are refracted around the barrier. A barrier could include screening by topographical features as well as other man-made objects such as fences and buildings. For wind farms, the ISO 9613-2 barrier attenuation factor has been shown to over-estimate the attenuation measured under downwind conditions. The prediction method outlined in the Institute of Acoustics Good Practice Guide limits the barrier attenuation to 2dB.

Miscellaneous Losses - A_{misc}

Miscellaneous losses in the ISO 9613-2 calculation can be used to account for losses through propagation through trees and across housing and reflections off buildings. These losses are not considered in our calculations, however. Reflections off buildings are not considered because in

theory, the predictions (and baseline measurements as required by ETSU) are made in ‘free-field’ locations away from reflections.

Valley Correction

The basic ISO 9613-2 calculation formula described above has been shown to underestimate noise levels for propagation across valleys or for terrain with a concave ground profile. This is because multiple ground reflections can occur which combine at the receptor location to increase noise levels as shown in Figure A1 below.

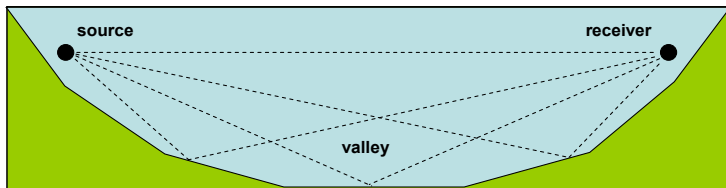


Figure A1 Reflection Paths in a Valley

To compensate for this, the GPG recommends a -3dB correction be subtracted from the ground attenuation (that is increasing the overall noise level) when the mean propagation height above ground (h_m) is 50% more than that over flat ground. This is now implemented in Annex D of BS ISO 9613-2: 2024 although there is a small difference in the formula. For this assessment the IoA GPG has been implemented with 3dB subtracted from the ground attenuation when the criterion below is met.

$$h_m \geq 1.5 \times (h_s - h_R)/2$$

Where h_s and h_R are the heights above local ground level of the source and receiver respectively.

