8 NOISE

8.1 Introduction

8.1.1 This chapter provides an assessment of the noise and vibration impact of the Proposed Development. The operational noise assessment has been carried out according to the Energy Technology Support Unit (ETSU) report ETSU-R-97 and the Institute of Acoustics Good Practice Guide. This is the approved assessment method stated in Welsh Government guidance[1] for onshore wind turbines. The ETSU guidance advises on noise limits for wind turbines which are thought to *"offer a reasonable degree of protection to wind farm neighbours, without placing unreasonable restrictions on wind farm development"*.

8.1.2 This chapter has been prepared by Gavin Irvine from Ion Acoustics Ltd for Convatec Ltd. Gavin Irvine is a Member of the Institute of Acoustics and has worked on wind turbine noise assessment for 30 years.

8.1.3 The proposed turbines are south-west of an existing wind farm known as Pen Bryn Oer which features three Vestas V90 2MW wind turbines. There are other wind turbines in the area, but these are much further away. ETSU-R-97 advises: *"…that absolute noise limits and margins above background should relate to the cumulative effect of all wind turbines in the area which contribute to the noise received at the properties in question"*. Therefore, this assessment considers the cumulative noise impact of the Proposed Development with Pen Bryn Oer Wind Farm.

8.1.4 Noise predictions for operation of the Proposed Development are presented here based on noise data for Enercon E-138 wind turbines with an 81m hub height (150m to blade tip). The predictions have been carried out according to ISO 9613-2 with input parameters and limitations specified in the Institute of Acoustic's Good Practice Guide (IoA GPG). The predicted noise levels are compared with the lower fixed noise limit in ETSU-R-97 (35 dB L_{A90} for wind speeds up to 10 m/s at 10m height) to demonstrate compliance. However, there is a possible option to carry out a background noise survey and this would potentially enable ETSU-R-97 limits for the scheme to be derived relative to the background noise. Such a survey would allow a daytime limit of 35 dB L_{A90} or 5 dB(A) above the background noise. whichever is the greater and this limit would vary according to the wind speed.

1 https://www.gov.wales/assessing-wind-turbine-noise

8.1.5 Various electrical equipment associated with solar farms can also make a noise including transformers and inverters. However, this noise is rarely audible beyond the boundary of the solar farm sites and no formal assessment is carried out of the solar farm. The wind turbines will tend to be heard over a greater distance as the source levels are higher and in an elevated position. A noise limit of 35 dB L_{Aeq} is however proposed for the solar farm.

8.1.6 Noise can also be generated during the construction period from the excavation of the turbine foundations and trenches for cables, the construction of new access tracks, hard standings and solar panel frame supports, and from the erection of the turbines themselves. Most of these activities will occur within the main site far from residential properties. Noise from the transportation of construction materials and turbine and solar farm components will also occur on local roads.

8.1.7 In view of its remote location, a formal construction noise assessment is not included here. However, a Construction Environmental Management Plan will be prepared for agreement with the local authority. This will detail how construction noise can be controlled using best practicable means. Best practicable means involves using all measures to reduce noise subject to practicality and cost.

8.1.8 Noise during the decommissioning phase will be similar to the construction phase and again no numerical assessment is proposed.

8.2 Methodology and Guidance

8.2.1 The following information sources have been consulted in the preparation of this report:

- TAN 11 Noise 1997
- Welsh Government Online Guidance
- ETSU-R-97 The Assessment and Rating of Noise from Wind Farms
- Institute of Acoustics Good Practice Guide (2013)
- International Standard ISO 9613-2 / BS ISO 9613-2: 2024

8.2.2 The various guidance documents listed above are discussed below:

Local Authority Guidance

8.2.3 The Scoping response from Caerphilly County Borough Council identified that a noise assessment should be undertaken, but did not provide any specific guidance.

Therefore, we have prepared this desktop assessment to demonstrate that the project will comply with ETSU limits. The assessment applies the more stringent fixed limits on noise immissions which do not require a background noise survey to be carried out.

Welsh Government Advice

8.2.4 The Welsh Government's general advice on noise and land use planning is set out in TAN 11 Noise[2] from 1997. For noise from wind turbines, the document refers to TAN 8 (1996). This document was revised and replaced with TAN 8 (2005). However, this document has also been withdrawn following the publication of the Future Wales plan. Currently, Welsh Government online guidance on assessing wind turbine noise states simply:

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

8.2.5 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 is used in this assessment with the refinements and enhancements described in the IoA GPG. These documents are described below.

ETSU-R-97

8.2.6 ETSU Report ETSU-R-97[4] published in September 1996, was the result of deliberations of the Working Group on Noise from Wind Turbines, which was set up in 1993 by the Government to derive guidelines for assessing wind turbine noise.

8.2.7 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.

2 Technical Advice Note (TAN) 11 Noise https://www.gov.wales/technical-advice-note-tan-11-noise
4 https://assets.publishing.service.gov.uk/media/5a798b42ed915d07d35b655a/ETSU_Full_copy__Searchable_.pdf

- 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.

8.2.8 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.

8.2.9 The ETSU-R-97 limits set relative to the background noise are derived separately for 'amenity hours' daytime periods and for the night-time periods, 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)

8.2.10 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 LA90 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

8.2.11 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}.

8.2.12 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'[5] 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, or 40dB L_{A90} when applied to wind turbine noise. Therefore, there is an argument for reducing the ETSU-R-97 external noise limit to 40 dB L_{A90} to protect sleep.

8.2.13 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".* However, for locations where the wind speed has been measured, the ETSU-R-97 noise limits derived from the background noise can apply.

8.2.14 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 day-time and night-time periods. Cwm Carno Farm is a land-owner associated with the development and therefore the higher noise limit will apply here.

8.2.15 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.

Institute of Acoustics Good Practice Guide (2013)

8.2.16 In May 2013, the Institute of Acoustics (IoA) published the 'Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise[6]. The document was prepared with the purpose of agreeing current good practice in the

5 Berglund, B., Lindvall, T., Schwela, D & World Health Organization. Occupational and Environmental Health Team. (1999). Guidelines for community noise. World Health Organization. https://apps.who.int/iris/handle/10665/66217
6 "A good practice guide to the application of ETSU-R-97 for the assessment and rating of wind turbine noise" http://www.ioa.org.uk/pdf/ioa-gpg-on-wtna-issue-01-05-2013.pdf

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.

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

8.2.18 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 10m 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. Therefore, if a survey were to be carried out in the future it would be necessary to install a tall (hub-height) mast or use a Lidar or Sodar for the anemometry.

8.2.19 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.

8.2.20 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.

8.2.21 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 this assessment follows this guidance.

International Standard ISO 9613-2

8.2.22 ETSU-R-97 does not prescribe a calculation method for predicting wind turbine noise. However, in accordance with the Institute of Acoustics Good Practice Guide described above, this study has used ISO 9613-2 'Attenuation of sound during propagation outdoors'[7]. The standard has recently been revised and adopted as a British Standard (BS EN ISO 9613-2: 2024) but it should be noted that the Institute of Acoustics Good Practice Guide uses the older standard with specified input parameters and refinements and therefore ISO 9613-2: 1996 and the IoA GPG is used in this assessment in accordance with Welsh Government advice.

8.2.23 The propagation model, described in Part 2 of the ISO 9613 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. When the wind is blowing in the opposite direction, that is when a house is upwind of the turbine, noise levels will be reduced by as much as 10dB.

8.2.24 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 ISO 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:

$$\text{Predicted Noise Level } L_{90} = L_{W\,(eq)} + D - A_{geo} - A_{atm} - A_{gr} - A_{bar} - A_{misc} - 2\text{dB} \qquad (1)$$

8.2.25 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. Distance loss (or A_{geo} in the equation above) is the most significant factor. The correction of 2 dB 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. The attenuation factors in the calculation are described in Appendix 8.1.

8.2.26 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 1 below.

7 ISO 9613-2 International Standards Organisation Acoustics - Attenuation of Sound during propagation outdoors – general method of calculation

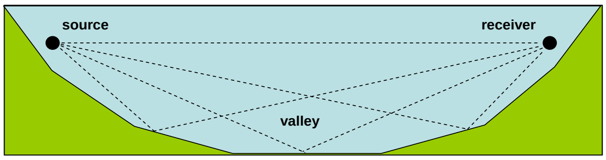


Figure 1: Multiple reflection paths for sound propagation across concave ground

8.2.27 To compensate for this, the GPG recommends a +3dB valley correction be applied to the noise level of a turbine when a certain criterion is met, defined by Equation 2 below:

$$h_m \geq 1.5 \text{ x } (\text{abs } (h_s - h_r) /2) \qquad (2)$$

where h_m is the mean height above the ground of the direct line of sight from the receiver to the source, and h_s and h_r are the heights above local ground level of the source and receiver respectively.

8.3 Baseline Noise Levels

8.3.1 The site is in a semi-rural area on the outskirts of Rhymney. The nearest buildings are industrial premises, but the nearest noise-sensitive receptors are farmhouses. There is likely to be a contribution from traffic noise to the locations in Rhymney and possibly some noise from the industrial estates. The noise levels at the farmhouses will be affected by road noise to some extent, but to a lesser extent than those in Rhymney.

8.3.2 If appropriate, a noise survey may be carried out at three locations representing receptors to the north, east and west of the proposed turbines. This, if implemented, would enable alternative limits to be imposed on the scheme.

8.3.3 Possible noise monitoring positions are as follows:

- Cwm Carno Farm to the north
- At a location near Rose Cottage to the west
- At a location near Carno Bute Farmhouse to the east.

The local authority will be consulted in the event a noise survey is carried out so that the monitoring positions and methodology can be agreed.

8.4 Predicted Operational Noise Effects

1.1.1 Computer noise modelling software (IMMI) implementing the ISO 9613-2 methodology described above has been used to predict noise levels from the wind turbines. The following modelling assumptions have been made in line with the current agreed best practice described in the Institute of Acoustics Good Practice Guide:

- Downwind propagation to reflect the worst case in terms of propagation;
- A 1.7dB margin is applied to the turbine sound power data to account for uncertainty;
- mixed ground absorption (G=0.5) is assumed with a receiver height of 4 metres;
- ambient air temperature of 10°c and 70% relative humidity;
- barrier attenuation is limited to 2 dB;
- Predictions to key receptors have been checked to determine whether the valley correction applies.

1.1.2 To carry out the modelling, the terrain information has been obtained from Ordnance Survey data at a 50m resolution and imported into the model.

Turbine Noise Levels

8.4.1 A candidate turbine for this site is an Enercon E-138 TES wind turbine with an 81m hub height. The turbine blades are fitted with Trailing Edge Serrations (TES) to reduce noise levels. The E-138 TES turbine is available in various noise modes to reduce noise levels. The predictions in this assessment have been based on the 101dB Operating Mode (OM101 dB) with 3MW rated power.

8.4.2 The variation in the A-weighted sound power levels with wind speed for this mode is set out in Table 8.1.

Table 8.1 Turbine Sound Power Levels dB L_{WA} Including Uncertainty

	Sound Power Level dB L_{WA} at Standardised Wind Speeds at 10m Height						
	4	5	6	7	8	9	10
Enercon E-138 OM101 TES	98.7	101.2	101.6	102.1	102.6	102.7	102.7

8.4.3 The values in Table 1 include +1.7dB uncertainty factor which has been added to the values to account for uncertainty in accordance with Enercon's data sheet.

8.4.4 The maximum sound power occurs from 9-10 m/s at 10m height. Above this, there is no increase in noise as the turbine blades are pitched to reduce energy and maintain the rated power output. The datasheet for the turbine is presented in Appendix 8.2. In the event that a different turbine is selected it must be designed to meet the same noise limits.

8.4.5 To carry out the predictions, a frequency spectrum must be used. The octave band frequency spectrum of the turbine at 9-10 m/s has been obtained from the manufacturer. The spectrum used in the calculation is shown in Table 8.2 below including uncertainty.

Table 8.2 Enercon E-138 TES Octave Band Sound Power dB L_{WA} at 9-10 m/s

Turbine	Overall Sound Power Level dB $L_{WA (eq)}$	A-Weighted Sound Power Levels dB $L_{WA(eq)}$ at Octave Band Centre Frequencies, Hz							
		63	125	250	500	1k	2k	4k	8k
Enercon E-138 OM101 TES	102.7	82.7	88.8	92.9	96	99.1	95	86.1	68.7

Noise Sensitive Receptors

8.4.6 The nearest noise-sensitive receptors have been identified from scoping inspection of various mapping sources. These are stated below together with the distance from the three turbines. In addition, five receptors are added to assess cumulative noise from Pen Bryn Oer Wind Farm. These five positions are the locations specified in the Pen Bryn Oer planning conditions which have specific noise limits.

Table 8.3 Nearest Receptors

Location	Easting	Northing	Distance (m) to the Turbines (in Plan)		
			T1	T2	T3
Cwm Carno Farm	310290	208753	850	566	686
Trecatti House	308950	208490	741	1097	1389
Rose Cottage	309033	208494	667	1017	1311
Blaen Carno Farm	309024	208711	791	1097	1405
Nos 1 and 2 Gypsy Castle	309381	208897	733	907	1218
Upper Ras Farm *	311780	209121	2330	1960	1839
Susannah Cottage *	311353	208868	1839	1465	1345
Princetown *	311451	209940	2507	2209	2213
Lechryd *	310963	209627	1941	1664	1706
Merthyr Road*	312518	210381	3608	3279	3224
Carno Bute Farmhouse	310750	208546	1164	784	676
Old Brewery Lane	310935	208001	1316	948	665
Llys Joseph Parry	310920	208191	1284	900	659
Lower Row Bute Town	310401	209102	1175	928	1043
* Receptors Listed in Pen Bryn Oer Planning Consent					

8.4.7 All receptor locations are over 500m from the turbine from the nearest turbine. A minimum separation distance of 500m from turbines to residential receptors was recommended in the old Tan 8 guidance although this has been withdrawn. It can be seen that the Pen Bryn Oer receptors are at a considerable distance from the Rhymney scheme.

Prediction Results

8.4.8 The noise predictions have been carried out in the first instance as a noise contour plot for the E-138 TES turbine in 101dB Mode. The contour plot is shown in Figure 8.1. It can be seen that all locations are outwith the 35 dB L_{A90} contour with the exception of Cwm Carno Farm which is financially involved.

8.4.9 Predictions have also been carried out to the individual receptors identified above. The results are shown in Table 8.4.

Table 8.4 Prediction Results at Rated Power

Location	Noise Level at Rated Power dB L_{A90}
Cwm Carno Farm	36.4
Trecatti House	32.8
Rose Cottage	33.8
Blaen Carno Farm	32.3
Nos 1 and 2 Gypsy Castle	33.6
Upper Ras Farm *	24.0
Susannah Cottage *	27.6
Princetown *	22.2
Lechryd *	25.7
Merthyr Road*	15.8
Carno Bute Farmhouse	34.5
Old Brewery Lane	33.7
Llys Joseph Parry	34.0
Lower Row Bute Town	31.9
* Receptors Listed in Pen Bryn Oer Planning Consent	

8.4.10 As before, the 35 dB L_{A90} limit can be met at all locations except for the financially involved property.

8.4.11 Predicted noise levels at the Pen Bryn Oer Receptors are no greater than 28 dB L_{A90} which is very low. In the Pen Bryn Oer planning consent (Appeal Reference APP/K6920/A/14/2221852) the lowest noise limit at any of these receptors for the operational range of wind speeds is 38.5 dB L_{A90} at Lechryd. Since the predicted noise levels from the Proposed Development are more than 10dB below this, the proposed turbines cannot cause an exceedance of the planning limit at these receptors.

8.4.12 A more detailed cumulative assessment is provided in Section 8.8.

Noise from the Solar Farm

8.4.13 Noise from the solar farm is not expected to be audible beyond the site boundary. Nonetheless a noise limit of 35 dB L_{Aeq} could be imposed to ensure that a reasonable limit is imposed to protect amenity.

8.5 Other Potential Noise Effects

Tonal Noise

8.5.1 The predictions above exclude any penalties for tonality. Modern wind turbines have been designed to reduce tones to levels below perception thresholds, even though tones are sometimes measurable.

Vibration

8.5.2 Vibration from wind turbines has been measured by extremely sensitive measurement equipment such as seismic arrays but in terms of human perception, measured vibration levels are well below perception thresholds even on the actual wind turbine sites. There is, therefore, no impact from vibration as a result of wind turbine developments.

Low Frequency Noise and Infrasound

8.5.3 Infrasound, low frequency noise and vibration are often reported as noise issues in the media. Infrasound is usually defined as sound below 20Hz, whereas the frequency range for low frequency sound is often taken to be from 10Hz to 200Hz. It is noted that natural sources such as the wind and waterfalls are also a source of low frequency noise.

8.5.4 Infrasound and low frequency noise can be measured from wind turbines. However various studies have not found any evidence of health effects from infrasound or low frequency sound.

Amplitude Modulation

8.5.5 Since 2005 / 2006 a phenomenon known as Amplitude Modulation (AM) has been found to be a factor in some noise complaints in ways not anticipated by ETSU-R-97. ETSU-R-97 described blade swish, which is a form of AM, but is only heard relatively close to the turbines. The term Other Amplitude Modulation (OAM) is sometimes used to differentiate low frequency, far-field amplitude modulation from blade swish, but it is not necessary to make a distinction when considering the effect at residential properties.

8.5.6 AM is defined as periodic fluctuations in the level of audible noise from a wind turbine (or wind turbines), the frequency of the fluctuations being related to the blade passing frequency of the turbine rotor(s). For a three-bladed turbine rotating at 20 revolutions per minute (rpm), this equates to a fluctuation in noise once per second. The wind industry trade body, Renewable UK, in December 2013 published research into AM. This included theoretical research on mechanisms causing the problem and subjective tests to determine a dose-response relationship. More recently, the IoA has published an agreed numerical rating method and a further Government-commissioned report by WSP PB has considered how the issue might be addressed in respect of planning.

8.5.7 The IoA AM rating method has been adopted in the WSP report, with recommendations on how a penalty mechanism might be incorporated into a planning condition. The wording of a possible planning condition was agreed between various noise consultants and published in Acoustics Bulletin; however, the form and application of any penalty scheme is not agreed, and the wording of a planning condition has yet to be approved in any Government guidance.

8.5.8 Although, at present it is not possible to assess the likelihood of AM occurring at the planning stage, the published IoA rating mechanism and the emergence of a possible planning condition provides some comfort it can be controlled.

8.6 Mitigation

Operational Noise

8.6.1 Predicted operational noise levels are very low and are well below the applicable limits. The turbine blades will be provided with trailing edge serrations and low noise modes are proposed. These are example of embedded mitigation designed into the scheme. The manufacturer of the wind turbines procured for the site will be required to provide a warranty to ensure sound power levels will not exceed a certain value. There is no requirement for further mitigation.

8.6.2 Noise from the solar farm is not expected to audible beyond the site boundary. No mitigation is necessary.

Construction Noise

8.6.3 Construction Noise including noise from the transportation of construction materials and electrical components on local roads will be controlled in the CEMP which must be agreed with the local Council.

8.7 Residual Effects

8.7.1 It is possible that turbine noise will be just audible under certain downwind conditions but there will be no residual significant effects.

8.7.2 There will be no residual significant effects from construction or decommissioning activities.

8.8 Cumulative Effects

8.8.1 To assess noise levels from Pen Bryn Oer, separate predictions have been carried out for this wind farm using noise data for the installed Vestas V90 2MW wind turbines. A sound power level 105.5 dB L_{WA} has been used including uncertainty. Predicted noise levels using this value result in a maximum noise level of 41.5 dB L_{A90} at rated power (8 – 12 m/s) at the closest property, Upper Ras Farm. This property has a noise limit of 43 dB L_{A90} at night at 8 m/s which indicates that there is some headroom, and the turbines could be 1.5 dB noisier and still comply with their planning limit. A greater margin of compliance occurs at other locations but in this case Upper Ras Farm is the "controlling property" according to the Institute of Acoustics Good Practice Guide as noise levels here determine the effective output of the Pen Bryn Oer turbines.

8.8.2 Accordingly, an additional margin of 1.5 dB has been added to the sound power level of the V90 turbines and noise levels from Pen Bryn Oer predicted on this basis (effectively 107 dB L_{WA}). The predicted noise levels at the selected receptors for Pen Bryn Oer using this value is set out below for rated power. A cumulative noise level is also calculated based on logarithmic addition. The predictions assume downwind propagation for all wind turbines. A contour plot for both schemes is provided in Figure 8.2.

Table 8.5 Predicted Cumulative Noise Levels at Rated Power

Location	Rhymney Wind Farm dB L_{A90}	Pen Bryn Oer dB L_{A90}	Cumulative Noise Level dB L_{A90}
Cwm Carno Farm	36.4	28.8	37.1
Trecatti House	32.8	22.1	33.1
Rose Cottage	33.8	22.6	34.1
Blaen Carno Farm	32.3	23.3	32.8
Nos 1 and 2 Gypsy Castle	33.6	24.7	34.1
Upper Ras Farm *	24.0	43.0	43.0
Susannah Cottage *	27.6	36.6	37.1
Princetown *	22.2	37.6	37.7
Lechryd *	25.7	34.0	34.6
Merthyr Road*	15.8	36.4	36.4
Carno Bute Farmhouse	34.5	30.1	35.8
Old Brewery Lane	33.7	29.8	35.2
Llys Joseph Parry	34.0	30.4	35.6
Lower Row Bute Town	31.9	30.0	34.1
* Receptors Listed in Pen Bryn Oer Planning Consent			

8.8.3 For the receptors listed in the Pen Bryn Oer planning consent, the effect of the Proposed Development is very small with a maximum increase of 0.6 dB predicted (at Lechryd). The planning limits imposed on Pen Bryn Oer will not be exceeded.

8.8.4 For the closest receptors to the west of Proposed Development, the effective is also small with cumulative noise levels below 35 dB L_{A90}.

8.8.5 For the receptors to the east of the development, specifically those in Rhymney, there is a potential cumulative effect with predicted noise levels up to 36 dB L_{A90}. Note however such an increase cannot occur in practice as the predictions assume downwind propagation for all turbines and these receptors are generally in between the two schemes so cannot be downwind at the same time. In addition, noise levels in an urban environment are expected to exceed 35 dB L_{A90} most of the time.

8.8.6 In summary cumulative effects from the two schemes are negligible.

8.9 Conclusions and Significance

8.9.1 An assessment has been made of the noise impact of the Proposed Development during the operational phases. The operational noise assessment has been undertaken according to ETSU-R-97 and the IoA GPG. These are the guidance documents recommended in online Welsh Government planning advice for onshore wind turbines. In terms of operational noise, the development can meet the lower simplified limit stated in the guidance document ETSU-R-97. No significant environmental effects, including cumulative effects, are identified.

8.9.2 Noise from the operation of proposed Solar Farm will also be insignificant.

8.9.3 Noise during construction and decommissioning will be insignificant for activity on the main wind farm site. Some audible noise will occur from the transportation of construction material and wind farm components.

Figure 8.1 Noise Contours

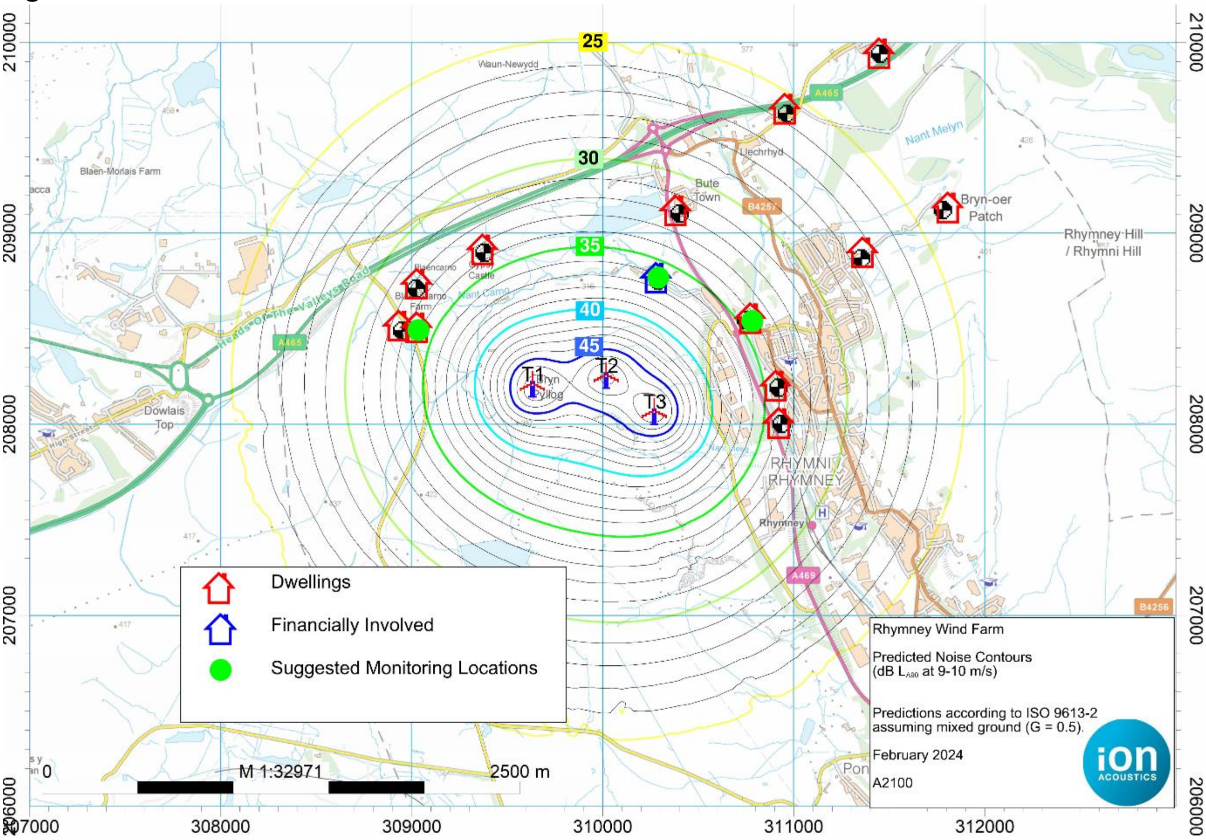
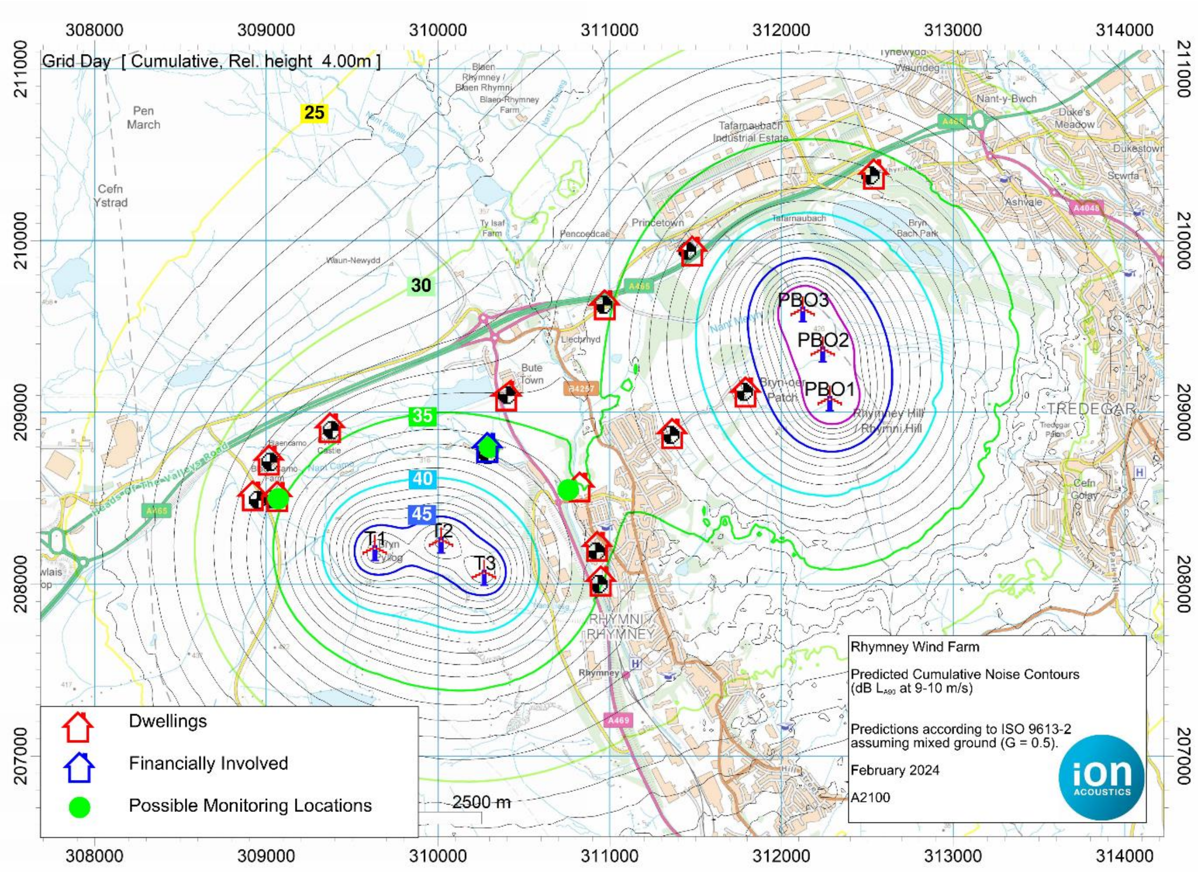


Figure 8.2 Cumulative Noise Contours



Appendix 8.1 ISO 9613-2 Prediction 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:

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

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 - $L_{w(eq)}$

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:

$A_{div} = 20\log(d) + 11dB$, where d 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:

$A_{atm} = d\alpha$, where d is distance from the turbine (in metres), and α 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 10ºC 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 (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 - Agr

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

The ground conditions are described according to a variable G which varies between 0 for "hard" ground (which includes paving, water, ice, concrete and any sites with low porosity) and 1 for "soft" ground (which includes ground covered by 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 which in accordance with the Institute of Acoustics Good Practice Guide.

Barrier Attenuation - A_{bar}

When a source is not visible behind an imperforate 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 in practice 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.

8.9.4 Appendix 8.2 Datasheet for Example Wind Turbine

3.2 Calculated sound power levels – operating mode 101.0 dB

In operating mode 101.0 dB the wind energy converter operates in a power-optimised mode. The highest expected sound power level is 101.0 dB(A) in the nominal power range. All the sound power levels indicated apply taking into account the uncertainties described in ch. 2.2, p. 7. After reaching the nominal power, the sound power level will not increase further.

Tab. 5: Technical specifications

Parameter	Value	Unit
Nominal power (P_n)	3000	kW
Nominal wind speed	13.5	m/s
Minimum operating speed		
▪ E-138 EP3 E3-ST-81-FB-C-01	4.4	rpm
▪ E-138 EP3 E3-ST-99-FB-C-01	4.4	rpm
▪ E-138 EP3 E3-HST-111-FB-C-01	4.4	rpm
▪ E-138 EP3 E3-HST-131-FB-C-01	-	rpm
▪ E-138 EP3 E3-HT-160-ES-C-01	4.4	rpm
Speed setpoint	8.6	rpm

Tab. 6: Calculated sound power level in dB(A), based on wind speed at hub height v_H

v_H	Sound power level in dB(A)
5 m/s	95.6
5.5 m/s	96.8
6 m/s	98.1
6.5 m/s	99.4
7 m/s	99.5
7.5 m/s	99.6
8 m/s	99.8
8.5 m/s	100.0
9 m/s	100.1
9.5 m/s	100.3
10 m/s	100.4
10.5 m/s	100.6
11 m/s	100.8
11.5 m/s	101.0
12 m/s	101.0
12.5 m/s	101.0
13 m/s	101.0
13.5 m/s	101.0
14 m/s	101.0